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IN MEMORIAM.

THE COLLECTED
SCIENTIFIC PAPERS

OF THE LATE

ALFRED HENRY GARROD, M.A., F.R.S.,

FELLOW OF ST. JOHN'S COLLEGE, CAMBRIDGE; FULLERIAN PROFESSOR OF PHYSIOLOGY
AT THE ROYAL INSTITUTION; PROFESSOR OF COMPARATIVE ANATOMY IN KING'S
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EDITED,

WITH A BIOGRAPHICAL MEMOIR OF THE AUTHOR,

BY

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PREFACE.

In consequence of a very generally expressed wish amongst the personal friends of the late Professor A. H. Garrod, to possess some permanent memorial of him, it was decided, at a meeting of the Zoological Club held on May 4th, 1880, to appoint a Committee to consider the best means of carrying this idea into execution.

As ultimately constituted, this Committee consisted of Professors Flower, Schäfer, Bell; Messrs. Sclater, Salvin, Balfour, Dobson, the late Mr. Alston, Dr. Günther, and myself, I agreeing to act as secretary to it.

After carefully considering the various forms that the proposed memorial might take, it was decided that the most appropriate and desirable one would be the publication, in a collected form, of all the papers published by Garrod in various scientific journals and periodicals, with a portrait and memoir of the author.

The list of subscribers to the present volume, including, as it does, the names of nearly all the leading English biologists as well as those of numerous private friends, shows that this decision of the Committee has been amply justified by the result.

The work of arranging and editing the papers in the present volume has in the main fallen on myself, though Professor E. A. Schäfer was kind enough to read through the proofs of the physiological part. As far as possible, the papers in each part have been kept in the order in which they were published: in a few cases, however, when several papers treating of the same or closely-allied subjects appeared at different periods, they have, where it seemed desirable, been placed together. The last paper in the volume, as explained in the biographical memoir, has not been published before anywhere.

Misprints and other clerical errors of the original have been corrected in this reprint, and in a few cases, where it seemed advisable, foot-notes have been added by myself. The pagination of the original papers has been preserved by the use of marginal figures.

The octavo lithographic plates of the original papers have been redrawn by Mr. J. Smit for the purpose of this reprint, and they will, I think, be found faithful copies of the originals. The stones of the quarto plates being still preserved have, with the necessary alterations in lettering, been used again, as have also the plates of the three diagrams in the second part. The three plates illustrating the first part have been redrawn, the first two being reproduced on a somewhat larger scale the better to suit the letterpress. The woodcuts in the text have been throughout printed from the original blocks, or from electrotypes of them, with the exception of that on p. 95, which was kindly drawn on wood, after the lithographed plate in the "Journal of Anatomy," for the purposes of this work by Mr. H. H. Johnston.

The etching which forms the frontispiece speaks for itself, both as a work of art and as a portrait. The readiness with which Mr. Herkomer undertook to execute it was itself extremely gratifying to the Committee, whilst the success of the result adds materially, they feel, both to the value and the interest of the present volume.

The biographical memoir has been written by me, partly from my own personal acquaintance with the author and his work, partly from facts supplied me by his family. The index to Part II, containing as it does the names of all the various species or groups of animals mentioned in it, will, it is hoped, prove useful as facilitating reference to the very numerous facts contained in these papers.

Finally, on behalf of the Garrod Memorial Committee, I have to express our best thanks to the Committee of Publication of the Zoological Society, and to the Editors of the "Journal of Anatomy and Physiology," the "Ibis," and "Nature," for the very generous loans, for the purposes of this reprint, of the various stones or blocks of the plates and woodcuts illustrating the present volume which originally appeared in their publications, as well as to the Council of the Royal Society, who kindly allowed us the use of electrotypes of the diagrams published in the "Proceedings" of that Society.

W. A. FORBES.

June 24th, 1881.

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BIOGRAPHICAL NOTICE.

Any account of the life of the author of the papers contained in the present volume must be brief. Not only was his career cut off at a time when most men are but just entering on life, but it was also, in some senses of the word, uneventful. Born and educated under circumstances which obviate any of those struggles which have made the lives of many naturalists interesting, his subsequent life was one series of unbroken successes. Nor was it marked by any of those episodes of foreign travel which have fallen to the lot of many other scientific men, before they have settled down to a life of work at home.

Alfred Henry Garrod was the eldest child of Dr. A. B. Garrod, F.R.S. He was born in London, on May 18th, 1846, at No. 9, Charterhouse Square, where his father had commenced to practise as a physician a few years before. From 1856 to 1860, his father having meanwhile removed to Harley Street, he was being educated in general subjects at All Souls' Grammar School, Regent's Park, and after the latter date entered University College School, Gower Street. At both these schools the classical authors of Greece and Rome were at that time the chief subjects of study. For them Garrod never developed any special taste, though in mathematics and drawing he took a greater interest, gaining a prize for perspective drawing at University College School.

Garrod's life, however, in so far as it can be of any interest to those who were not members of his family and private circle, commenced with his entry at University College about October, 1862. Here he first began his acquaintance with the Natural Sciences, by attending the lectures, amongst others, of Prof. Sharpey, on physiology, and of Prof. Oliver, on botany, as well as those of Prof. De Morgan, on mathematics. From the latter, no doubt, and from his earlier education in the same subject, was derived that predilection for mathematical and mechanical studies which evinced itself so strongly in his after life. Those who knew him at that time date the commencement of his scientific enthusiasm, which was always afterwards very marked, from the first term of his attendance at Prof. Sharpey's lectures, and he himself always spoke of that teacher with affectionate and admiring regard.

In 1864 Garrod matriculated at the University of London, passing in the first class. In the autumn of the same year he began his career at King's College, London, having gained one of the Warneford entrance scholarships there, notwithstanding the fact that a considerable knowledge of classics was required for that competition. In the summer of 1865, whilst still a student at King's, Garrod succeeded in obtaining the first medal in Prof. Oliver's course of botany, at University College, a success of which he was always afterwards very proud; for it probably proved to him that, conscious as he must have been for some time of original power and grasp, he also possessed that capacity for steady application without which the former gifts are so often useless. Still working with indefatigable energy, he succeeded in obtaining the first, second, and third year's scholarships for medical students at King's, the highest success he could attain there. He remained working at King's College Hospital till 1868, in which year he obtained his Licentiateship of the Apothecaries' Society. It was during this period that his interest in the subject of the circulation of the blood, to which he subsequently devoted so much time and work, commenced. In the summer of 1868, in company with a younger brother, he made a trip to Marseilles by steamer, touching *en route* at Vigo, Lisbon, and Gibraltar, and returning by the same way, after a cruise of about eight weeks. This trip Garrod enjoyed greatly, especially his visit to Vigo and Lisbon, about both of which places he was enthusiastic afterwards. While on board ship he devoted a good deal of his leisure to working at questions connected with the temperature of the body. Three years afterwards he again visited Spain, going to Cadiz, Seville, and Gibraltar, in company with a college friend, but these two Spanish trips, and a flying visit to Switzerland in 1869, were almost all his experiences of foreign travel, for which indeed he often expressed a positive dislike in after years.

In 1868 Garrod went to Cambridge. Though he had put his name on the books of Caius College, and indeed appears in the University calendar for that year as a member of the College, he never actually entered there, having had awarded him in the same year an exhibition for Natural Science at St. John's, the first offered in that subject by the College. He commenced residence at Cambridge in the October term of 1868.

At that time the opportunities and methods of biological teaching at Cambridge were not so perfect as they now are, and with his already existing anatomical and physiological knowledge, Garrod soon found out that he could very well dispense with a good amount of the ordinary routine of College and University education. Indeed the greater part of his Tripos work was done by him at home, in London, during the vacation, for at Cambridge he devoted himself largely to the enjoyment of the social life of the place. His scientific work there consisted more of original research than of the usual course of study, for it was during his residence at Cambridge that he carried on, in great part, the series of experiments on the causes of the varying temperatures of the human body, the results of which were subsequently made public. The circulation of the blood, too, he studied energetically, by means of the sphygmograph and other appliances, which he improved in various ways by his great mechanical genius. Photography likewise took up some part of his attention, and when the new chapel at St. John's was opened, in 1869, he succeeded in taking, from the rooms of a friend overlooking the scene, an instantaneous view of the procession as it passed though the first court. It was whilst still an undergraduate that his first physiological papers were published in the "Journal of Anatomy and Physiology," and in the "Proceedings of the Royal Society." He devoted considerable time also to the study of zoology, working in the University Museum, where he laid the foundation of his knowledge in the subject which was afterwards to chiefly occupy his life. His maiden zoological paper "On the Telson of the Macrurous Crustacea" (*infrà*, p. 93) was indeed written and published during his undergraduate career at Cambridge.

His College had meanwhile not been blind to the ability of their undergraduate member, for in 1870 he was elected a foundation scholar, and in the "May" examinations in Natural Science of that and the subsequent year, his name appears in the first class on each occasion.

In December, 1871, Garrod "went out" senior in the Natural Science tripos, his companions in the first class being three in number, R. Lydekker—who has since distinguished himself as a palæontologist in the work of the Geological Survey of India—Lewis, and Warrington, in the order given.

At this time the office of Prosector to the Zoological Society of London was vacant, owing to the resignation of its former occupant, Dr. Murie. Through the influence of his Cambridge friends, Garrod was brought forward as a candidate for this post, to which he was elected, on June 20th, 1871, though he had not at that time finished his "Tripos." On the conclusion of that examination he returned to London, and immediately began to devote himself, with his accustomed energy and ability, to the adequate performance of the duties of his new post. He commenced his attendance at the Gardens a few days before the close of the year 1871. Up to this time, as already stated, Garrod's work and interest in biological science had been chiefly physiological, and his knowledge of zoology generally little more than that of an ordinary "Tripos" student. But thanks to the opportunities of his position, and his own genius and diligence, he was enabled in a very short time to sufficiently master the main outlines of the comparative anatomy of the highest Vertebrata—Birds and Mammals—to present his first paper to the Zoological Society, one written in conjunction with Mr. Frank Darwin, whom he had known at college, in little more than two months after commencing his prosectorial duties. This paper was succeeded in the course of the year by four others. From this point indeed, zoology became the main study of Garrod's life, though he still retained his interest in physiology. Indeed he had hoped, and intended no doubt, when he became Prosector, to carry on his physiological researches on a still larger scale, as evidenced by some experiments made during the earlier part of his work at the Gardens. But the accumulation of material, and the fascination of new lines of research, gradually but surely drew him away from further active physiological work, and after his appointment as Prosector, we find but three or four original papers from his pen on purely physiological subjects, the last being one read before the Royal Society in April, 1874.

Physiology, indeed, was his "first love," and towards the close of his life, he often, in conversation with his friends or relatives, insisted that he was, primarily, a physiologist, and only became a zoologist by the accident of his being appointed to the Prosectorship. Nothing gave him greater pleasure during his last illness than the fact that conclusions the same as some of his own most cherished ideas and discoveries, connected with the circulation of the blood, had been arrived at independently by an American physiologist (Keyt) with no knowledge of his previous work on the same subject.

In his new departure, the anatomy of birds soon became Garrod's favourite study. This was a subject that had not at all kept pace with the rapid advance made of late years in most other branches of biological science. With the exception of some important papers by our countrymen, Professors Parker and Huxley, by M. Alphonse Milne-Edwards, and by the great German naturalist, Johannes Müller, little had been done either at home or abroad in this department of ornithology, since the decease of the illustrious German, Nitzsch. With the large amount of material at his disposal, Garrod was soon able to work out, on a far more extensive scale, many of Nitzsch's observations, as well as to add a great number of entirely new facts. The myology of birds in particular attracted his attention, and about two years after his appointment to the Prosectorship, he drew up the paper on the classification of birds, in which the taxonomic value of the now-celebrated "*ambiens*" muscle was brought forward for the first time. This paper was read before the Zoological Society in the session of 1873–4, and published in their "Proceedings": an abstract of it, doubtless from his own pen, may be found in "Nature," Feb. 12, 1874, pp. 290—2.

In November, 1873, Garrod was elected to a Fellowship at his College, the first time that such an honour had been given there to a Natural Science man; and in the summer of the succeeding year (1874), he was elected Professor of Comparative Anatomy at King's College, London, in succession to Prof. Rymer Jones, F.R.S., and this post he continued to hold till within a few weeks of his death. A report of his introductory lecture to the evening class of Zoology at that institution in the winter session of 1874 may be found in "Nature" for Oct. 8th of that year. Garrod had for some time past acted as one of the sub-editors to the last-named journal, and he continued to do so for some years. Many of the articles and reviews dealing with biological subjects published in the columns of that paper, during that period, were from his pen.

In 1875 Garrod was appointed Fullerian Professor of Physiology at the Royal Institution. His connection with that establishment had commenced at least as far back as 1874, when he delivered, on Feb. 6th, an address on "The Heart and the Sphygmograph," an account of which appeared in the number of "Nature" for the 26th of that month. Again, in March of the following year (1875) he gave a short course of lectures at the same institution on "Animal Locomotion," in one of which he exhibited and explained an ingenious model of a boat propelled by a screw, constructed on a plan similar to that of the dorsal fin of the pipe-fish.* Another dealt with the action of the Horse, giving an account of Marey's experiments with the graphic method on that subject, which was then exciting a good deal of attention in England, on account of Miss Thompson's celebrated picture of the "Roll-Call," exhibiting at that time.

Garrod commenced his duties as Fullerian Professor in the spring of 1876, when he delivered a course of twelve lectures on the "Classification of Vertebrate Animals." In these and his subsequent lectures at the same institution, his great mechanical ingenuity and extraordinary fertility of resource in devising and carrying out experiments, stood him in good stead. For he was enabled, by his numerous models and other simple though ingenious contrivances, to illustrate or explain many of the phenomena of animal life, in a way that always instructed at the same time that it entertained his audiences. These powers, aided by very considerable fluency as an extempore speaker, and great facility of lucidly explaining even complicated topics to a general audience, soon gained him a reputation as an accomplished lecturer. Many of those who attended these or his other lectures, must remember some of his ingenious models, which were all the more admirable often, because of their great simplicity. Such were his arrangements to show the mechanism of the protrusion and the retraction of the claws in the great Carnivora, of the power of rolling-up into a ball possessed by the Hedgehog, &c. Other instances of his mechanical powers that might be cited were his models of the bird's wing, of the mechanism of the gizzard in birds, and of the action of the lips of the Manatee when feeding, exhibited in illustration of his papers on those subjects before the Zoological Society.

In the summer of 1875 Garrod delivered several of the Davis Lectures at the Zoological Gardens, choosing as his subjects the various groups of Ruminating Animals, the Camels, Deer, Antelopes, &c. This group of Mammals had for some time past been

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* *Vide* "Nature," April 1, 1875, p. 429.

the subject of his close attention, for but little regarding their structure had been put on record by previous anatomists, whilst he, thanks to his prosectorial advantages and the living collection around him, was enabled to study them, with every facility, both in a dead and a living state. The most important of his scientific results, regarding these animals, were embodied in a paper "On the visceral anatomy and osteology of the Ruminants," read before the Zoological Society on Jan. 2, 1877. In this paper, besides many important conclusions arrived at with regard to the classification of this group of animals, Garrod broached his views on a subject that for some time had been more and more impressing itself upon him. This was the inadequacy of the ordinarily used system of binomial nomenclature to indicate properly the new views on the classification of animals rendered necessary by the general adoption of the theory of evolution—an inadequacy that was the more evident to him from his previous knowledge of chemistry. It was his desire to devise, if possible, some system of formulæ which would enable the biologist to express, in one term, both the nature and the affinities of the creature it represented. This effort to give taxonomic conclusions a more exact expression had been already partly adopted in the formulæ used by Garrod in his various papers on the classification of birds, as well as in the lecture on "Evolution and Zoological Formulation," delivered at King's College in 1874, and already alluded to. In that lecture he had selected a particular group of birds, the Parrots, to which to apply his views: in his paper on the Ruminants these are still further expounded, and worked out for that group of animals.

Meanwhile Garrod had been steadily going on amassing facts as regards the anatomy of Mammals and Birds at the Zoological Gardens, and hardly a scientific meeting of the Zoological Society passed without some paper from him, dealing either with some of his newly-discovered lines of research or with an account of the anatomy of some hitherto unknown form. Some idea of the amount of material that passed through his hands may be gained from the fact that at various periods in his career he dissected no less than five specimens of Rhinoceroses, belonging to three different species—an anatomical experience probably quite unique. He worked remarkably quickly, both with his scalpel and with his pencil—for he was no mean artist—but yet with such certainty and accuracy that a re-examination of his objects rarely rendered necessary any change in his original description. His anatomical work was as a rule directed rather to the discovery of new points bearing on questions of classification than to detailed description of forms only interesting for their rarity, and agreeing in most points with the typical species. His method was to examine as large a number of species of any particular group as possible, to note the characters in which they differed, and from these considerations to endeavour to arrive at some conclusions regarding their general position or mutual affinities.

When the Royal Commission appointed by the Government to examine into the question of vivisection was conducting its inquiries in 1875, Garrod was, with most of the other leading physiologists of England, examined before it, and a report of his evidence will be found on pp. 106—108 of the Blue-book that contained the results of their inquiries. Amongst other things, he narrated how he had, on one occasion, performed "probably the largest operation in anæsthetics" ever effected, by chloroforming a Giraffe. Garrod had been very anxious to utilise the opportunity afforded by having to kill one of these animals some time previously, by taking tracings of the blood-pressure in its carotid arteries, which, after a considerable struggle with the great animal, much expenditure of chloroform, and a good deal of difficulty in properly fixing the necessary instruments, he succeeded in doing.

In 1876, being then just 30 years of age, he was elected a Fellow of the Royal Society.

At this time the expediency of preparing a general work on the "Anatomy of Birds" was suggested to Garrod by some of his friends. This work was to be, in his own words, "exhaustive," and to contain the results of all his previous papers and subsequent experience. For the completion of this he soon set to work with great vigour, and on two occasions he received sums of money from the Government Grant to aid him in the publication and preparation of this book, which, unfortunately, he was not destined to finish.

In 1876 Garrod was appointed examiner in Zoology for the Natural Science Tripos at Cambridge, a post which he continued to fill for the next two years, and which again brought him into intimate connection with Cambridge life.

The subject of his Fullerian lectures in 1877 was "The Human Form: its structure in relation to its contour." In them it was his object to describe to a general audience those parts of the structure of the body which affect its external form in various attitudes. Several ingenious working models were devised especially to illustrate these lectures, as well as a colossal *papier-maché* model of a disarticulated human skeleton. The attendance, more than half of which consisted of ladies, on this course of lectures was very large, and fully proved the success of his experiment. In the following year he chose as the subject of his last course "The Protoplasmic Theory of Life, and its bearing on Physiology," in it explaining the nature of the modern cell-theory, and the conclusions deducible from it. These lectures were likewise numerously attended.

Meanwhile Garrod maintained as actively as ever his researches into the anatomy of Mammalia and Birds, and his projected work on the latter group occupied much of his attention. The anatomy and classification of the enormous group of Passerine Birds especially attracted him, and he published four important papers on that subject in the Zoological Society's Proceedings, propounding in them a new division of the entire group, based on his own and others' observations. About this time he took in hand the production of an English edition of Johannes Müller's celebrated paper on the vocal organs of Passerine Birds. This had originally appeared in the "Abhandlungen" of the Berlin Academy; but, although containing results of the greatest importance, was hardly at all known in England. It was translated into English by F. Jeffrey Bell; and edited, with an appendix containing much additional information on the same subject, arrived at from his own researches, by Garrod. Early in 1879 it was completed and published, the publication having been undertaken by the delegates of the Clarendon Press, Oxford.

Another piece of work that may be mentioned was the section on the "Ruminantia" in Cassell's "Natural History," in which he still further elaborated his investigations into the natural history and anatomy of his favourite group. Being based on original observations and study of specimens, its value must not be measured by that of certain other portions of the same book, for it undoubtedly gives the best general account of this group of animals yet published in our language.

During the three years' cruise of H.M.S. "Challenger," the naturalist staff had made a considerable collection of birds in spirit, which was especially rich in oceanic birds, particularly in the group of Petrels and Albatrosses (*Tubinares*). With the examination of these Prof. Garrod was entrusted on the return of the expedition, and the specimens so obtained were the more valuable to him, because they helped to supply him with what had hitherto been a great desideratum.

Not content with his own labours, Garrod was always anxious to induce others to work at his favourite studies. His rooms at the Zoological Gardens became gradually a centre for many other young men, who either aided him in his own work, or carried out further researches under his directions, or at his instigation. Those whom he thus helped were not all zoologists, for many artists could also testify to their indebtedness to him for the help in material, or the instructions in questions of anatomy, which he always freely gave when in his power. The society of artists, indeed, had particular attractions for Garrod, and until his death he was a member of the Arts Club in Tenterden Street.

These multiple and various occupations, added to an almost feverish activity of temperament, and an entire forgetfulness of self, proved, alas! before long too much for Garrod's physical strength. Perpetually occupied in his scientific work, with new ideas opening out as every day brought fresh material and knowledge, taking little or no holiday, and with the Italian Opera during the season as almost his sole relaxation, his health at last gave way. With hardly a premonitory symptom, Garrod was seized, in the early part of June, 1878, with a severe attack of pulmonary hæmorrhage, which completely prostrated him for some time, and to those who knew caused apprehension of the gravest kind for the future. However, after some time he rallied somewhat, and became again capable of carrying on his prosectorial work. Although urged to leave England and try the remedial effects of a better climate, his love of London and work induced him to remain, heedless of the representations of his friends, and through the rest of the summer and autumn he continued to work in his usual enthusiastic manner, though his health was obviously failing him. In the October of that year he delivered, without a note, the introductory address at the commencement of the winter session of the King's College Medical School, and in the course of the next month he paid a visit to Cambridge, to take part in a meeting of the Fellows of his College to decide on the new Professorships, which it was proposed that institution should endow. Garrod himself was strongly in favour of founding a Professorship of General Biology—a chair, as he insisted justly, greatly wanted in the University, but his opinion was not shared by the majority of his colleagues, and, as he had not prepared any very definite scheme as to the functions of and qualifications for the new Professorship, his proposition fell through. In December, 1878, Garrod paid his last visit to Cambridge, when he came down to examine for the final part of the Natural Science Tripos. His friends there were all alarmed at the marked change in his looks and health now manifest. Yielding at last to the pressure put upon him by his family and friends, Garrod was induced to leave London and try the more genial climate of the Riviera for the winter. Accordingly he left England about the middle of December, and went, accompanied by one of his brothers, to Mentone, where he stayed till the end of January. During this period he was for some time confined to his bed, and the change, partly because the season was wet and dull there, did but little good.

Returning to London, he still continued, whenever strong enough, to work, visiting the Gardens when the weather was fine enough to allow him to do so, and directing from his home, as far as possible, his work there. But his health was gradually failing, and he grew almost daily weaker and weaker, as the phthisis and its accompanying maladies increased. Unfortunately for himself, he was far too well aware of his own danger, and indeed from the first seizure, or shortly afterwards, he considered his own case as practically hopeless. Nevertheless, he never ceased for an instant from his zoological studies. The subject of the conformation of the trachea in the different groups of birds was in particular at this time attracting his attention. At these windpipes, being conveniently-sized objects, he constantly worked, whenever able to be up, at his own home, and one part of his observations, dealing with the trachea of the Gallinæ (*infrà*, p. 477), he sufficiently completed to be enabled to publish it. This was his last published contribution to that anatomy of birds which he had advanced so greatly and loved so well.

In the summer of 1879 there was for some time an apparent change for the better in Garrod's condition. He seemed stronger and more sanguine than he had been for some time past, and was enabled to go again to his rooms at the Gardens with some regularity. But it was only temporary. The last time, so far as the writer is aware, when Garrod visited the Gardens, was about the middle of August. Shortly afterwards, about the commencement of September, he became again worse, and rapidly began to sink.

Almost to the last he continued to work, and only a few weeks before his death busied himself in correcting the proofs of his paper " On the Brain and other parts of the Hippopotamus," which had been read at the concluding meeting of the Zoological Society in the preceding June, but this, his last scientific paper, he was not himself destined to see published. During the later phases of his illness, which he had throughout borne with exemplary patience and courage, laryngitis, causing a nearly total loss of voice and great difficulty in swallowing, had developed itself, together with a severe cough. Under this complication of disease, he at last succumbed, in the perfect possession of all his faculties, though physically fearfully weakened, surrounded by his family, and regretted by all who had ever known him, on October 17th, 1879, aged 33.

Of the worth of Garrod's scientific work, the papers contained in the present volume must be the criterion, and the full value of some of them, as he himself was the foremost to believe, will only in all probability be properly appreciated in the future. This is not the place or the occasion to attempt to form a final conclusion on that score. His own confidence in his physiological work remained unshaken, and the partial confirmation of some of his ideas that he lived to see was, as we have already said, a cause of the most lively pleasure to him on his death-bed.

Whatever may be the verdict of posterity on Garrod's physiological work, no doubt can exist as to the value of his zoological labours. The facts alone recorded in his various papers on this subject must always remain as a great and incontrovertible addition to our knowledge of the highest Vertebrata. His published papers only represent a portion of the work he had done in zoology, for he had accumulated in notes and drawings, as well as in his memory, an immense amount of information on the structure of both Mammals and Birds, parts only of which had been utilised in his various papers. These notes and drawings fill several volumes of note-books, and have fortunately been preserved intact. Of his work on the " Anatomy of Birds," which was originally to have been published in three fasciculi, the MS. of the two portions commenced has been also fortunately preserved. As originally planned, the first fasciculus of this book was to contain a detailed account of the anatomy of the common fowl, as a type of birds in general. The second fasciculus was to be devoted to a comparative account of the " soft parts " of the different families of birds in systematic order, whilst the third was, we believe, to have been devoted to the osteology, and a general *résumé* of the results arrived at as regards classification. Of these fasciculi, the MSS. of the first and second were well advanced at the time of Garrod's death; the first part indeed is nearly completed, whilst the second is about half done, and it is hoped that at no very distant date these may be completed and published by his successor in the Prosectorship.

Besides these MSS. one or two incomplete papers have been left, though hardly any sufficiently finished for publication, except the one herein contained, and now published for the first time, on the anatomy of the Diving Petrel (*Pelecanoïdes*).

There are in addition a very large number of detached notes and drawings, many of the latter, depicting the conformation of the trachea in different groups of birds, being the more interesting as having been made during his lingering illness when not too weak for such occupation. Of his zoological papers indeed, the ornithological ones must probably, on account of their more novel character, and as affording entirely new data for the solution of the various problems connected with the classification of Birds, which he revolutionised, be considered of the greater importance. No future worker in that group can neglect the facts or ideas concerning it that we owe to Garrod, and they alone suffice to put his name in the very first rank of those who have ever studied these creatures, and to stamp his work on Birds as truly "*Epochmachende.*"*

A final word may be said on Garrod's character as a man. The universal regret which his premature death has caused amongst all who knew him, whether intimately or casually, naturalists or not, is the surest sign of the esteem in which he was held. Unselfish and generous, he was always ready to help anyone as far as possible, with advice or material. Always cheerful, and with a wide range of information and interest, he was a companion of whose society one never wearied. A man of strong character, with great energy and pronounced views on many subjects, he yet did not make enemies. Those who knew him best loved him most, and feel deeply how little is the chance of their meeting with his like again.

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* A more detailed review of Garrod's ornithological work, by the editor of the present volume, will be found in the "Ibis" for 1881, pp. 1–32.

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PART I.

PHYSIOLOGICAL PAPERS.

1. ON THE CAUSE OF THE DIASTOLÉ OF THE VENTRICLES OF THE HEART.* Page 390.

THE existence of an active diastolé of the ventricles of the heart following each systolé has been long recognised by physiologists, and there have been several explanations given of the phenomenon; but they are all subject to grave objections, and fresh methods of research have overthrown them one after another.

The object of the present article is to show that this active diastolé is mainly dependent on the turgescence of the walls of the heart, consequent on the flow of blood into the coronary arteries immediately after the systolé.

The experiments of Vaust in 1821, together with the known anatomical arrangement of the commencement of the aorta, strongly favour the supposition that during the ventricular systolé the circulation in the walls of the heart ceases on account of the close relation between the segments of the aortic valve and the orifices of the coronary arteries.

Immediately the aortic valve is closed the impediment to the flow of blood into the coronary vessels is removed, and the sudden repletion thus caused, directly after the closure of the valve, produces an equally sudden turgescence of the walls of the ventricles, the auricles from their thinness not being similarly affected. This turgescence of the tissue of the heart produces an active opening out of the cavities of the ventricles, and in a very short time they reach their maximum size.

The following experiment supports this theory:—take a sheep's heart which has at least two inches of the aorta left on; attach the cut end of the aorta to a pint syringe full of water and inject; the first effect of this operation is the closure of the aortic valve, immediately after which water enters the coronary arteries, the ventricular walls swell, and the cavities of the ventricles open out to their full extent. Page 391. It will be then found that the heart is tough and not easily compressible, and if it be cut in two between the apex and base, the halves show the cavities fully dilated, and they remain so until the water has escaped from the cut orifices of the vessels. The shortness of the coronary arteries and the sudden way in which they break up into minute ramifications favours the rapid turgescence of the heart walls.

If this theory be correct it follows that there must be an absorptive

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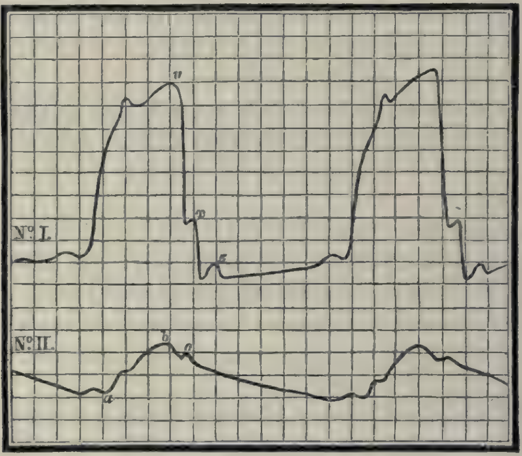
* "Journal of Anatomy and Physiology," III. pp. 390–3. May, 1869.

force exercised in both the ventricles immediately after the closure of the aortic valve, and Marey found that to be the case when he placed in either ventricle an ampoule registering negative pressures only.

The relation between the cardiograph traces from the ventricles and aorta throw so much light on the point under consideration that a detailed description of them will not be out of place.

The diagram is taken from Marey's work *De la Circulation du Sang*, p. 189.



No. I is the trace from the left ventricle.
No. II is from the aorta.

Simultaneous events are recorded in the same longitudinal line, and the traces by their rise and fall indicate alterations of pressure in the ventricle and aorta respectively.

Page 392. No more reference will be here made to the systolic than is necessary to explain the diastolic movements.

Towards the end of the cardiac systolé, the pressure which continues to increase in the ventricles (v) diminishes in the aorta (b), because then the latter receives less blood from the heart than it transmits to the capillaries.

After this, it is considered by Marey that the undulation x in the upper trace corresponds with c in the lower, and that they are both caused by the closure of the aortic valve; he also thinks the fall between x and z in the upper trace to be due to the relaxation of the ventricle, and, without explaining why, states that at that moment the pressure falls ordinarily below zero. But on carefully looking at his own diagram, as copied above, it is clearly seen that the undulation c in the aortic slightly precedes x in the ventricular trace, and this, together with the results obtained by Chauveau, by means of his combined hæmadromometer and sphygmoscope, and confirmed by Lortet, leads me to doubt the correctness of Marey's explanation, and to advance the following.

During the main ventricular descent the aortic pressure increases (*c*), probably from the rise of the base of the heart after its contraction, just as at the commencement of the systolé it falls (*a*) from the opposite cause.

When all contraction has ceased, the only impediment to regurgitation from the arteries is the passive resistance of the ventricular walls, which is comparatively slight; so that blood flows back to the heart, compressing the ampoule in the ventricle and causing the elevation *x* in the upper trace, while it necessarily produces a similar depression in the lower one.

When the reflux of blood has become sufficiently rapid, the aortic valve closes, and in so doing puts an abrupt stop to the ventricular rise *x*. Immediately after this the coronary repletion and consequent turgescence commences, as shown above, and by opening out the cavities of the ventricles, diminishes the pressure on the contained ampoule, and so depresses the trace below zero.

The tendency to the formation of a vacuum, together with the associated raising of the base of the heart, causes so great a rush of blood from the auricles, which as Mr. Bryant has shown are then quite full, that a slight undulation is produced in the ventricular trace *z*. Page 393.

The increase in bulk of the ventricular walls, consequent on the coronary repletion, takes place in all directions, and by expanding the whole conical heart, pushes the base up into the cavity previously occupied by the full auricles, which it simultaneously empties by the absorptive force.

This theory being true, the heart is a machine in which simplicity of action and economy of force are most marked. The systolic movements fill the reservoirs which are to feed the cavities they empty; and all the diastolic forces are expended in active preparation for the succeeding systolé; the circulation in its walls, besides its primary object, even aiding its mechanical function.

Page 419. 2. ON SOME OF THE MINOR FLUCTUATIONS IN THE TEMPERATURE OF THE HUMAN BODY WHEN AT REST, AND THEIR CAUSE.*

The author's object in the following communication is to show that the minor fluctuations in the temperature of the human body, not including those arising from movements of muscles, mainly result from alterations in the amount of blood exposed at its surface to the influence of external absorbing and conducting media.

In the following Tables, when not otherwise mentioned, all the temperatures are taken under the tongue, the thermometer remaining in the mouth for five minutes, except when the observations were made each two-and-a-half minutes, on which occasions the temperature of the bulb was not allowed to fall below 85° F.

It may be remarked that in no case mentioned below was the temperature of the air above 65° F., and that on all occasions the skin was dry, whereby any complications from the presence of perceptible moisture were avoided; and the arguments based on the facts necessitate an approximation to those conditions.

The Tables have been selected from a great number of observations; and *no* results have been obtained which are not easily explained on the theory given.

Page 420. The temperatures were taken on one subject, aged 22, male, thin.

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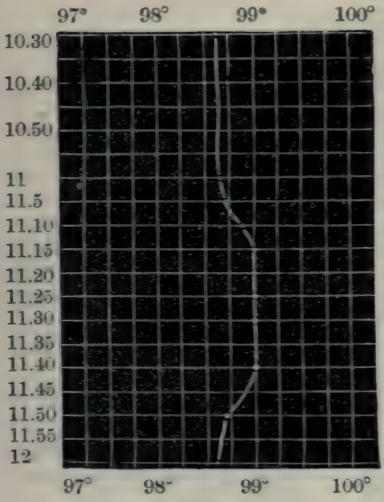
* "Proceedings of the Royal Society," XVII. pp. 419–26. Read May 13, 1869. Communicated by Dr. Beale.

Page 420.

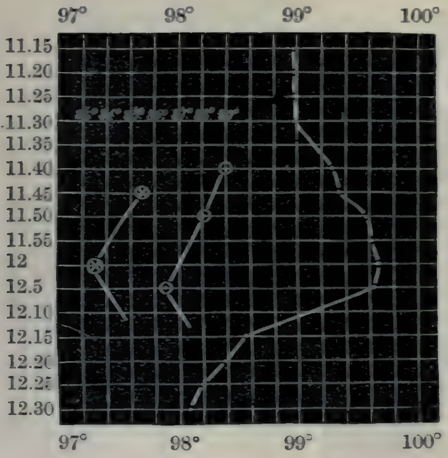
No. I.—*From* 10.30 P.M. *till* 12 *night.*



Sitting in a room (temp. of air 66° F.) all the time. Fully clad till 11, when stripped in a minute, therefore nude at 11.1. Warm when dressed, but got cold when nude. At 11.40 covered body all over with a thick blanket, soon followed by a slight skin-glow. In the blanket until 12 night.

When body covered, pulse much more bounding than when not covered.

No. II.—*From* 11.15 P.M. *till* 12.30 *night.*



Standing from 11 till 12.5 in a room with the thermometer at 47° F., warmly clad till 11.30, when stripped in two minutes, so nude at 11.32. Fairly warm all the while. Got to bed at 12.6, and lay closely wrapped by bedclothes for the rest of the time. A decided glow came on at 12.11¼, lasting a minute, after which feet became a little cold, but skin of body quite warm.

Whilst standing nude pulse small, but bounding when dressed and when in bed.

⊙ Indicates the temperature of the pectoral region, two inches above the nipple, taken by placing, for five minutes, a flat spiral thermometer on the part.

⊕ Indicates the temperature of the front of the thigh, with the same instrument as the last.

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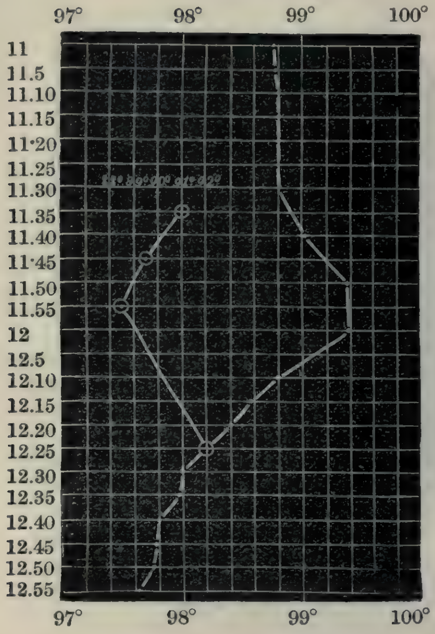
No. III.—*From* 11 P.M. *till* 1 A.M.

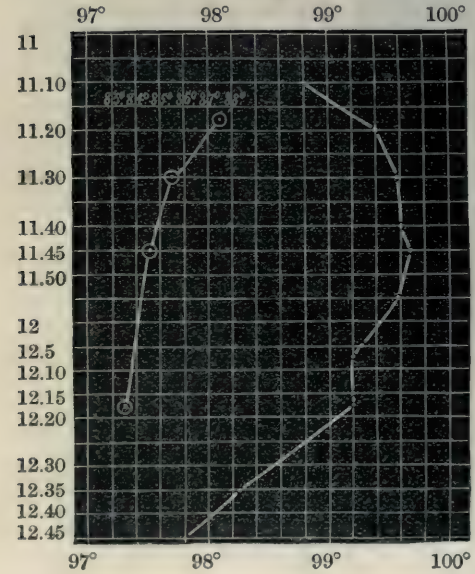


Standing in room (temp. of air 52° F.) from 11 until 12. Fully clad until 11.30, and then stripped in two minutes, so nude at 11.32. Warm in body all the while. At 12.2 got to bed, and there the rest of the time, closely wrapped. A glow came on at 12·8½, lasting half a minute, after which feet became coldish.

Pulse not so bounding when nude as when body covered.

⊙ Indicates the temperature of the pectoral region, found by placing a spiral flat thermometer on it, and keeping it there five minutes.

No. IV.—*From* 11 P.M. *till* 12.45 *night.*

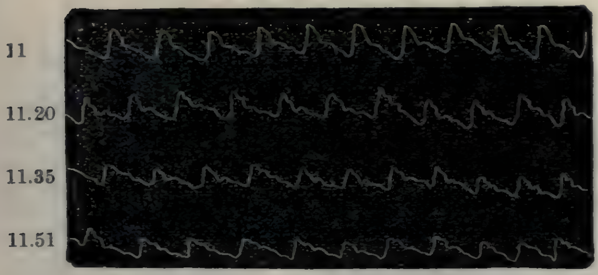


Nude at 11.11 in a room (temp. of air 56°). Standing from 10.50 until 12.20 nude. At 12.21 got to bed, and remained there rest of time. At 11.45 began moving about and stooping, and whenever stooped felt a chill. Quite shivering from 11.57½ till 12·7½, when, leaving off moving, the shivering ceased.

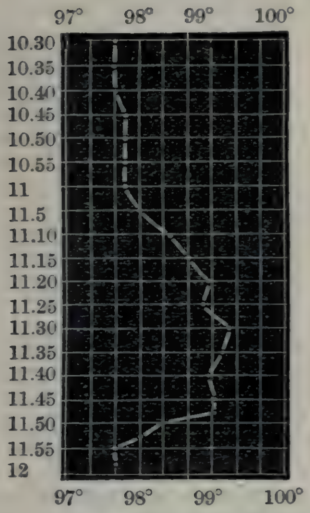
When in bed had no marked glow, and feet continued to be warm; skin of thighs not warm.

The following is the sphygmographic curve of radial artery at wrist: when in bed at 12.40, pulse same as at 11 (the same pressure was used on the sphygmograph-spring in all the traces) :—

Page 422.

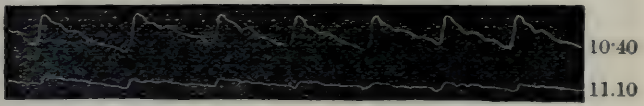


No. V.—*From* 10.30 P.M. *till* 12 *night.*

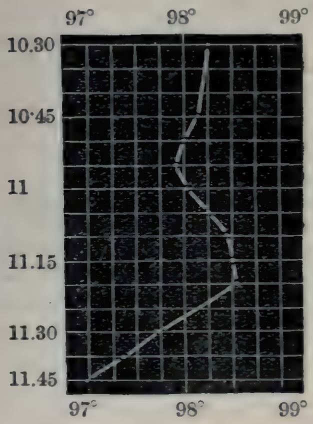


Sitting in a room (temp. of air 58° F.) all the time. Warmly clad till 11, when stripped in two minutes, so nude at 11.2. At 11.20 went for half a minute into a colder room. At 11·45 put on several flannel things, which had been warmed by the fire, and sat in front of a warm fire.

Took sphygmograph-trace from right superficialis volæ at 10.40 and at 11.10. Tried to do so at 11.40, but could not get any indication, from the smallness of its pulsation. At 12 the pulsation was as great as at 10·40.



No. VI.—*From* 10.30 P.M. *till* 11.45 P.M.



Sitting in a room (temp. of air 59° F.) from 9.30 until 10.40, quiet, cool, and warmly clad. From 10.40 till 10.55 moving about in the same room. Stripped at 10·55, and nude in two minutes. Remained nude until 11.24, when got to bed, and remained there for the rest of the time.

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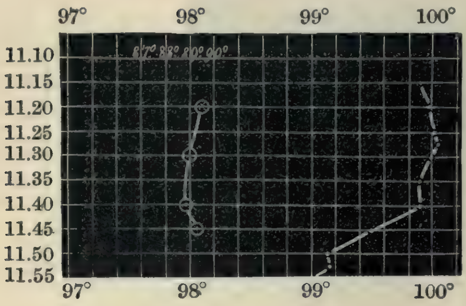
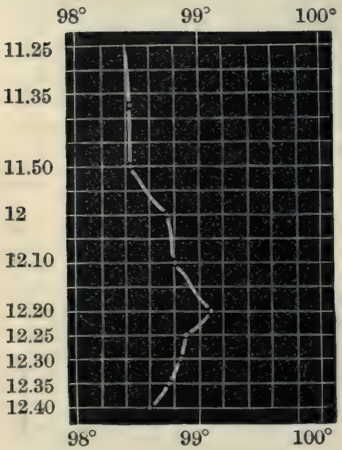
No. VII.—*From* 11.10 P.M. *till* 11.55 P.M.



Standing in a room (temp. of air 53° F.) from 11 until 11.25. Fully clad until 11.9, when stripped, and nude at 11.10. Continued nude until 12. At 11.25 seated, and remained so until 12, on a bed. At 11.40 put feet in water from 110°—114°, above ankles, and remained thus rest of time, maintaining the heat of the water. Chilly when feet in bath, not before. At 11.52½ contracted limb muscles tonically, and maintained them so until 11·55.

⊙ Indicates temperature of pectoral region, two inches above nipple, taken with spiral thermometer, for five minutes.

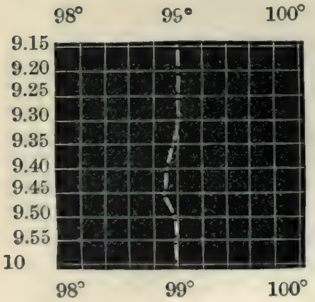
No. VIII.—*From* 11.25 P.M. *till* 12.40 *night.*



Standing in a room (temp. of air 58° F.) from 11 until 12, and sitting during the rest of the time on a bed. Fully clad until 11.50. Nude from 11.52, and remained so. Feet a little cold at 12.20, and put them into hot water (108°<114°) at 12.21, gradually increasing the heat of the water. Kept feet in water, above ankles, until 12.40.

On adding more hot water and putting feet in it chills followed.

No. IX.—*From* 9.15 A.M. *till* 10 A.M.

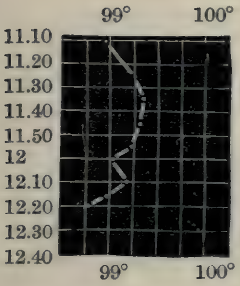


Sitting all the while in a room (temp. of air 52° F.), not far from an ordinary fire.

Felt cold all over during the time. Reading. At 9.30 turned to the fire and put feet on the fender, having been previously quite at the side of the fireplace. As feet got warm, hands, which were previously warm, became cold.

Clad in winter clothes.

No. X.—*From* 11.10 A.M. *till* 12.40 P.M.



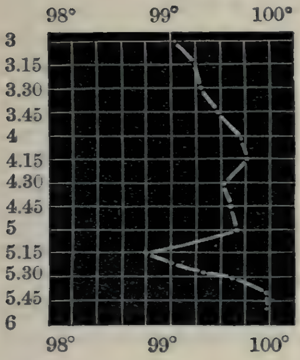
Temperature of air 62° F. A cloudy, breezy day. At 11 walked about 200 yards on to a beach, and sat down on the shingle at 11.5, where there was a slight side breeze. Hands and feet a little cold.

Sun covered by clouds until 11.35, after which it began to shine; immediately after which began to feel warm, and continued to get warmer until 12.7, when at 12.7 a cloud covered sun until 12.11. During time sun covered, several chills came over body.

Walking in sun from 12.16 onward.

Clad in thin merino next skin and summer clothes.

No. XI.—*From* 3 P.M. *till* 6 P.M.



Temperature of air 66° F., slowly diminishing to 64° F. Sitting on a beach from 3 until 5, after a dinner at 2.15–2.45. A slight face breeze. In the shade. Warm until 4.15, when feet began to get a little cold, and by 5 so cold that obliged to move about. At 5 began to walk slowly, and had to go up several steps. At 5.20 began to walk briskly. Began to perspire at 5.25. Continued walking, perspiring until 6.

Clad as in last.

To explain these Tables:—

The actual temperature of the body at any given moment must be the resultant of (1) the amount of heat generated in the body, and (2) the amount lost by conduction and radiation.

(1.) The *source* of heat in the body is not considered in this paper; and no more will be now said of it, except that there is every reason to believe that it is not in the skin itself, and that, for the short periods through which each observation was made, it is approximately uniform.

(2.) The *loss* of heat from the body is modified by changes in the skin and by changes in the surrounding media; and these two are mutually dependent.

It has long been known that cold contracts and heat dilates the small arteries of the skin, respectively raising and lowering the arterial tension, and thus modifying the amount of blood in the cutaneous capillaries.

But modifications in the supply of blood to the skin must alter the amount of heat diffused by the body to surrounding substances; and so we should expect that by increasing the arterial tension, thus lessening the cutaneous circulation, the blood would become hotter from there being less facility for the diffusion of its heat, and that by Page 425. lowering the tension, thus increasing the cutaneous circulation, the blood would become colder throughout the body, from increased facility for conduction and radiation.

That such is the case is proved by Tables I, II, III, IV, V, and VI, where, by stripping the warm body of clothing, in a cold air, when the tension was low (as in Tables IV, V, shown by the sphygmograph-trace), the temperature and tension rose, at the same time that the surface became colder.

In Tables I, II, III, IV, V, and VI, by covering the nude body with badly conducting clothing, when the tension was high, the surface-heat soon accumulated sufficiently to cause a sudden reduction of arterial tension, commonly called a glow, and a rapid fall in the temperatures, from the larger amount of blood exposed at the surface of the body to the influence of colder media.

Changes in the arterial tension are easily recognised by the subject of experiment, from the sensations they produce; a feeling of warmth followed by a shiver, or a shiver itself, generally shows that the tension is lowered, while the opposite effect follows a rise in the tension; and this can be generally confirmed by the sphygmograph-trace. A bounding weak pulse shows a low, and a small thready one a high tension.

We know, from the observations of Davy and others, that by reducing the tension in one part of the body the tension of other parts is lowered; thus by placing one hand in hot water, a thermometer in the other rises. In Tables VII and VIII, it is shown that by putting the feet in hot water (at 110° to 115°) the lowering of the tension was so great that the amount of heat lost into the air considerably exceeded that gained to the body from the water, so that the temperature of the body began to fall directly, and decreased considerably; and it was noticed that on adding more hot water chills were produced, which was the same as the effect of first putting the feet in the water.

By covering a small part of the body with a bad conductor, the tension of the whole body soon falls, from the accumulation of heat in the covered parts causing a lowering in the tension generally, and a consequent greater carrying away of heat. In this way the fall after sitting down on a bad conductor when nude can be explained (Table VII).

A glow is felt in the skin directly upon short muscular movement, as stooping, and the temperature falls at the same time, as in Table IV, between 11.45 and 12.20, and in Table XI, between 5.0 and 5.15. In the latter case the muscular movement was carried to such an extent that the loss was made up for by the increase of heat from the muscular movement.

Simply heating the feet lowers the tension and temperature together, as in Table IX and in Table X. The passage of a cloud before the sun seems to have acted by reducing the loss of heat, as the temperature rose at the time.

Further confirmation of the facts stated as to the modification of arterial tension may be found in Marey's work, *De la Circulation du Sang*, published in Paris in 1863. In that book the author ascribes the uniformity of the heat in the internal parts to the same cause as the author of the present paper ascribes the variations. Page 426.

The fact observed by Dr. W. Ogle in the St. George's Hospital Reports for 1866, and by Drs. Ringer and Stewart in a paper read before the Royal Society this year, that the temperature falls at night, and is lowest at from 12 to 1 A.M., and begins to rise after that time, is simply explained on the theory given above; for it depends on the custom of Englishmen going to bed at about that hour, and thus giving a large amount of heat to the cold bedclothes, which at first is expended in warming the sheets, &c., while later on in the night the bedclothes are warm, and therefore the body has only to make up for the heat diffused.

Other natural phenomena can be similarly explained. Thus, on a cold day, the effect of sitting with one side of the body in the direct rays of a fire is to cause the other side to feel much colder than if there was no fire at all, because the fire lowers the tension over the whole body, and supplies heat to the full cutaneous vessels of one side, while the other side, being equally supplied with blood in the skin, does not receive heat, but has to distribute it rapidly to the cold clothes, &c.

3. ON THE RELATIVE DURATION OF THE COMPONENT PARTS OF THE RADIAL SPHYGMOGRAPH TRACE IN HEALTH.*

(PLATE I.)

Page 351. THE graphic method of representing the various phenomena occurring in the body during life, which has been so much developed by MM. Marey and Chauveau of Paris, has placed within our reach great facilities for obtaining an accurate knowledge of the relations, in point of time, of mutually dependent physiological events, and the sphygmograph has become, among others, an instrument familiar to most interested in science.

By means of this instrument a detailed and truthful record can be easily obtained of the modifications in the diameter of any superficial artery, and, as usually constructed, it is intended to be applied to the radial at the wrist.

The traces to be referred to were taken with one of Marey's instruments, as made by Breguet. The recording paper ran its whole length, 4⅜ inches, in seven seconds, and thus, by counting the number of pulse-beats in each trace, and multiplying the number thus obtained by 8·57143, the rate of the pulse at the time the trace was taken was easily found.

The lever-pen was of thin steel, sharply pointed, and it recorded by scratching on highly-polished paper previously smoked.

It is now generally agreed that in each pulsation of the radial sphygmograph trace, the main rise is the effect of the contracting ventricle sending blood into, and thus filling, the arterial system.

This rise is followed by a continuous fall when the pulse is quick, but when slow, its continuity is interrupted by a slight undulation, convex upwards.

The major fall is followed by a secondary rise, not so considerable as the main one, but more marked than any other, and this secondary rise is evidently due to the closure of the aortic valves preventing further flow of blood heartwards.

The two points therefore, the commencement of the primary and of the secondary rise, may be considered to mark the beginning of the systolé of the heart, and the closure of the aortic valve respectively, as far as they influence the artery at the wrist; and the interval between these two events may be called the *first* part of the arterial sphygmo-

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* "Proceedings of the Royal Society," XVIII. pp. 351–4, Pl. II. Read May 19, 1870.

Page 352. graph trace, while the interval between the beginning of the secondary rise and that of the succeeding primary one constitutes the second part of the same trace.

In 1865, Prof. Donders* published the results of experiments to determine the relative duration of the first and second part of the cardiac revolution with different rapidities of movements of the heart, taking as his data the commencement of the first and second sounds respectively, and he came to the conclusion that, though the second part varied with the rapidity, the first part was almost constant in all cases.

On commencing work with the sphygmograph, the author came to the same conclusion with regard to the trace at the wrist, but, on improving his methods of observation, he has arrived at a different result.

The best means of insuring an accurate measurement of any sphygmograph trace is to project all the points desired to be compared on to one straight line, and this is done by fixing the trace on to a piece of board, which has another pointed lever attached to it, with relations similar to those of the lever and recording apparatus in the original instrument. By this means lines can be scratched on the trace similar to those which would be produced by the instrument itself if the watch-work were not moving, and a result, as shown in Plate I. fig. 1. can be easily produced.

The reason why this means has to be employed is, because the lever in the sphygmograph moves in part of a circle, not directly up and down.

The ratio between the length of the first part of each pulse-beat in a trace and that of the whole beat was measured with a small pair of compasses, and from these the average was obtained, which thus eliminated, in a great degree, the variations produced by the respiratory movements, and also some of the clock-work imperfections.

For example, in fig. 1, the ratios in the several beats are:—

1 : 1·8
: 1·725
: 1·725
: 1·775
: 1·725
: 1·7
: 1·725
: 1·775
: 1·8

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* "On the Rhythm of the Sounds of the Heart." By F. C. Donders. Translated in the "Dublin Quarterly Journal of Medical Science," Feb. 1868, from the "Nederlandisch Archief voor Genees- en Natuurkunde," Utrecht, 1865.

1 : 1·775
: 1·675
: 1·75
: 1·75
: 1·725

with an average of 1 : 1·7443.

Page 353. Again, in fig. 2, the ratios are:—

1 : 3·8
: 3·775
: 3·8
: 3·825

with an average of 1 : 3·8.

Calling the rate of the pulse x, and the number of times the *first* part is contained in the whole beat y, xy equals the number of times that the *first* part is contained in a minute, and $\frac{1}{xy}$ equals the part of a minute occupied by the *first* part of each pulse-beat.

From several observations, it was found that xy increases with x, not directly as it, but as its cube root, consequently the following equation finds xy in terms of x,

$$xy = k \sqrt[3]{x},$$

k being a constant, equal to 47 (about).

For instance in fig. 1, $x = 137$, $y = 1·7443$;
and in fig. 2, $x = 44$, $y = 3·8$;
and $137 \times 1·7443 = 238·9691$,
$44 \times 3·8 = 167·2$;
and $238·9691 : 167·2 :: 1·43 : 1$,
and $\sqrt[3]{137} : \sqrt[3]{44} ::$
$= 5·155 : 3·54 :: 1·456 : 1$,

which shows that in these individual cases xy varies, within the limits of experimental error, as the cube root of x.

If this statement of the ratio of the *first* part of the trace to the whole beat is a correct one, a knowledge of the rapidity of the pulse alone is sufficient to enable the length of the *first* part to be found by multiplying the cube root of the rapidity by the constant quantity 47.

Thus, supposing the pulse beats 64 times in a minute, the cube root of 64 being 4, $4 \times 47 = 188$, and the length of the first part of the beat ought to be $\frac{1}{188}$ of a minute. In one case with $x = 64$, xy was found to be 185·75, and in another with $x = 63·5$, $xy = 181·77$, both numbers which agree closely with the requirements of the equation.

With $x = 140$, and therefore $\sqrt[3]{x} = 5·2$,

$$5·2 \times 47 = 244·4;$$

and therefore the first part $= \frac{1}{244} - \frac{1}{245}$ of a minute; in a pulse of that rapidity xy was found $= 242{\cdot}9$.

To save the trouble of extracting the cube root for any rapidity, these facts have been thrown into a co-ordinate form in the accompanying table, and the observations on which the formula is based are represented by dots on their proper co-ordinates, the calculated curve, with $k = 47$, being represented by a continuous line.

Since the above equation was worked out, a great many other observations have been made, several of which are recorded on the Page 354. table, and in health no cases have been found which depart from the curve more than those indicated on it.

The observations made on the author are represented by simple black dots, those made on others are encircled by a ring; great size of a dot indicates that more than one independent observation has produced exactly similar results.

In none of the cases have measurements been made after violent exercise. Differences in the height and age of the subjects experimented on have not been found to produce any appreciable effect.

The trace from infants has not been examined.

From the equation $xy = \sqrt[3]{x} \,.\, k$ the length of the *second* part of the pulse trace may be represented in terms of x, as $\frac{k - \sqrt[3]{x^2}}{x \,.\, k}$; and as from the nature of y it cannot be less than unity (no pulse having been seen with two contractions or more between two successive closures of the aortic valve), the limit of cardiac rapidity may be deduced to be 322 in a minute ($k = 47$); but it is scarcely probable that pulses of such a rate could remain so sufficiently long to be counted.

In many cases of disease implicating the circulatory system, the equation given above indicates that the duration of the *first* part of the heart's action is not normal; thus, in a boy suffering from typhoid fever, on the second day after the pyrexia had ceased, and when the temperature was below the normal, xy was found $= 225{\cdot}25$, where $x = 60$, which differs from the equation

$$\sqrt[3]{67} \times 47 = 190{\cdot}82,$$

which shows that the length of the *first* part is considerably too short in the former. In the same case, three days later, the patient rapidly improving, with $x = 56{\cdot}5$,

$$xy = 188,$$

which is much nearer the calculated normal result, $180{\cdot}5$, than on the former occasion, the trace keeping pace with the other physical changes.

It is probable that many other imperfections in the circulatory system can be similarly indicated, and it has been shown above with what facility a diagnosis may be arrived at.

Page 17.

4. ON CARDIOGRAPH TRACINGS FROM THE HUMAN CHEST-WALL.*

(Pl. II.)

On applying the hand over the left pectoral region the movements of the heart can be felt with facility, especially at the end of expiration. In the following paper an attempt is made to classify and partly explain these movements, as they are reproduced by the sphygmograph.

The earliest and perhaps the only published observations on these curves are by Dr. Marey of Paris,† who gives one trace from the human subject and others from the horse, which latter have the advantage of being associated with synchronous traces from the interior of the ventricle and of the auricle. No previous observations can be found as to the relative duration of the different elements of and the other peculiarities in the human heart apex traces at different rapidities of pulse.

While the subject is sitting or standing the sphygmograph can be made to give a very perfect record of the heart's movements, as they are transmitted to the intercostal tissues, by holding the instrument horizontally with the watchwork to the right hand, the plane of the recording paper, and consequently of the whole instrument, being parallel to the floor, and the lever-pad at or near the point of maximum pulsation, between the fifth and sixth ribs. While lying, the instrument must be held upright, as when wrist traces are taken.

The movements of respiration cause so much irregularity in these traces, that it is advisable to stop breathing while they are being taken; and this should be done at or near the end of a normal expiration; it is then found that little or no effect is produced on the heart's action, during the short time, about seven seconds, that the instrument is applied.

It will also be found that quick pulses are more easily taken than slow ones, because the heart can only be rendered slow by means Page 18. that make the skin cold and inelastic, or by positions that make the application of the apparatus more difficult.

In all cases the spring carrying the pad should be screwed down so as to give its greatest pressure.

In the account of the traces thus obtained, the rapid beats will be

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* "Journal of Anatomy and Physiology," V. pp. 17–27. November, 1870.

† "Physiologie Médicale de la Circulation du Sang." Paris, 1863. Pp. 68 and 121, and elsewhere.

first described; after these the slow ones, by which means an idea can be best formed of the relation between curves at first sight so different as those produced when the heart's action is over 100 and those when it is below 50 in a minute (compare Figs. I and VI).

There is a great similarity in traces from pulses above 105 to those over 140 in a minute; and the description of one will include them all. Figure I is from a heart beating 125, and it represents all the characteristic features. The movements of the lever are very extensive and sudden, so as to give the impression that they depend more on its momentum than on the heart's action; but that such is not the case is shown by applying the instrument a little way from the point of greatest pulsation, when (as in Fig. II) all the same elements appear, though much less ample and otherwise modified.

The main ascent commences abruptly immediately after a slight rise and fall (*a*, Figs. I, II), and is always broken about midway (*b*) by a small fall; it is followed by a most considerable and rapid descent, which carries the lever in an unbroken line, down to a point almost as low as that from which it started. Subsequently to this comes a less sudden rise (*f*), which reaches about as high as the break in the main ascent; its summit is not nearly so sharp as the previous one, and from it a fall, frequently a little irregular, commences slowly, becoming more rapid, though it is interrupted by a slight rise (*g*), after which it continues to sink until it reaches the lowest point of the trace, from which it makes a sudden slight ascent (*k*), which soon becomes more gradual, continuing until the rise (*a*) from which the description commenced.

Neglecting for the present small differences in the relative durations of these components, the pulse of 140 differs from that of 110 a minute in the movements being more extensive and consequently the angles more sharp, the intermediate rates being intermediate in character.

In the pulse of about 90 a minute (Fig. III) another small rise and fall appears (*e*) in addition to those previously described, which is very constant, and becomes more considerable when the heart's action is slower. Page 19.

Here also, as shown in Fig. IV in a trace taken directly after Fig. III between the sixth and seventh ribs, there is sometimes seen a reduplication of the first part of the main rise (*b*, *c*, Fig. IV), which is disguised in Fig. III probably by the momentum of the lever. Another point in which it differs from the quicker pulses is in the formation of a second undulation (*b*) in the main descent before it reaches its lowest point. The main ascent also is not so extensive.

When about 70 beats are made in a minute, the main rise can frequently be shown to be doubly broken (*b*, *c*, Fig. V); but these often get merged into one curved line. The subsequent fall (*d*) is here seen to have become much diminished, and the next rise and fall (*e*) of greater duration.

In the slow pulses (Figs. VI, IX) the fall after the small rise preceding the main ascent (*a*) is inconsiderable, or nil, which makes that rise appear as part of the main one, which is not the case.

The rise *c* has now become more marked, while *d* has diminished so much that it is no longer the highest point of the trace, that now being at the end of the rise preceding the main descent (*f*), which is frequently found to be double.

It is to be noticed that as the pulse gets slower, the generally ascending line between *k* and *a* gets longer; also that at all rates there is a great similarity in shape in the fall and rise between the points *h* and *k*, which is quite characteristic of that part of the curve.

A precise knowledge of the causes of these various changes in the direction of the human apex trace will always be somewhat deficient, from the impossibility of vivisectional verification, and from the fact that the relation of the organs concerned is different in man to what it is in animals, from which, otherwise, arguments from homology might have been more extensively employed.

Page 20. By means of synchronous traces from the exterior and interior of the heart of the horse Marey explains his apex trace, which in the main resembles that from the human subject. He shows that the rise, here called *a*, results from the contraction of the auricles, which makes it clear that that event occurs much nearer to the commencing ventricular contraction, represented by the origin of the main ascent, than is supposed by many. He also shows that the semilunar valves close at the break, single in his trace, in the main descent. The irregularities in the systolic interval he considers due to vibration of the blood caused by the tightening of the auriculo-ventricular valves, but his results were recorded after having been communicated to india-rubber tubes filled with air, and the undulations probably originating in them.

It is necessary in attempting to explain these traces, especially when comparing different rapidities of pulse, always to bear in mind Marey's most important law, that "the arterial tension (blood potential) varies inversely as the rate of the pulse." This law, though disputed by some, must closely approximate to the truth, because by it so many facts with regard to the circulation of the blood are perfectly explained, that cannot be in the least accounted for elsewise; and it will shortly appear how much it assists in interpreting the curves under consideration.

After the auricles have contracted at *a*, the commencing ventricular action originates the main rise, which continues uninterrupted until the closure of the mitral and tricuspid valves at *b*. From this point, until the opening of the aortic and pulmonary valves, the heart's force is expended in raising the potential of its contained blood to that of the large arteries, and it is a well-known fact that during that time the form of the ventricles becomes somewhat globular, their diameter increasing and thus causing them to recede in their conical pericardial cavity, producing the fall *b* in the quick pulses.

Immediately the semilunar valves get opened, the ventricles distend the proximal parts of the large arteries, and it is evident, from what has been said above with regard to the relation of blood potential and rapidity, that the quicker the pulse the more relaxed is the aorta at the moment before the semilunar valves open; consequently, the more rapid the pulse the greater is the disturbance of equilibrium when they do so; and as the aorta gets stretched and lengthened by **Page 21.** the sudden repletion, so it sends the heart forward at that moment, causing the rise *d*, which must therefore be greater as the pulse is quicker, which is the case. In very slow pulses the blood potential being high, the repletion of the already greatly distended arteries does little in further filling them, but acts by sending the whole mass of blood forward; consequently the rise *d* is inconsiderable. The rise *c*, if not resulting from the shock of closure of the auriculo-ventricular valves, must remain unexplained.

The repletion of the proximal arteries is very rapid; and the accompanying rise is overcome in quick pulses by the speedy retreat of the apex, resulting from the emptying of the heart, causing the fall *d*, at the end of which the ventricles cease contracting.

In slow pulses the heart's systolé is prolonged, causing slight irregularities in the upward tending trace, which are fairly constant (*e*, which is frequently double).

There is evidently an appreciable interval between the end of the ventricular systolé and the closure of the semilunar valves, during which the retrograde blood-current is arriving at sufficient velocity to enable them to act; but if Marey's law of the relation of blood potential and rapidity of heart's action is correct, we are justified in going much further, and saying that *the quicker the pulse, the more slowly do the aortic valves close;* for the greater the blood potential, the sooner does the heartward current become sufficiently rapid to close the valves, whose hydrodynamical relations are not otherwise modified by the rate.

From these considerations, combined with the fact, in quick pulses, that just before the rise *f* originates the trace loses its jerky character, it is most probable that the ventricles cease contracting just before the commencing rise *f* (at the end of the fall *d* in Figs. I, II), and that the whole of the time occupied by the rise and fall *f* is employed in generating the retrograde current to close the valve, the change in direction of the curve being produced, first by the relaxation of the heart causing it to advance, and then by the partial collapse of the aorta causing it again to retire. This rise and fall is also clearly shown in Fig. II, *f*.

Page 22. It can be seen in Fig. IV that in the pulse of 90 the undulation *f* is not so long as in the quicker ones, and in the slow curves it is shorter still, but the want of sharpness and the blending of the neighbouring rises prevent any accuracy being attainable in the latter cases.

The immediate effect of the closure of the semilunar valves, at the end of the fall *f*, is to cause a check to the descent of the lever (*g*), as the aorta is no longer emptying itself heartwards; but this is very soon counteracted by the consequent repletion of the coronary arteries,* which, as can be easily shown on the post-mortem heart, increases the diameter of the ventricles and makes them recede, drawing the apex back, further than during any other part of the revolution. During the rest of diastolé, other minor forces come into play which are not easy to trace.

Figures VII, VIII, IX are given to show that under different conditions the various rises and falls may be made to assume different degrees of importance. In Fig. VIII, where the greater part of the weight of the heart rests against the chest-wall, it is particularly to be noticed that the fall after *g*, before which the semilunar valves close, commences from the very top of the trace, showing that the main force by which the heart is made to recede, which from the great length of the down stroke must be considerable, does not commence until after the closure of the aortic valve, which supports the theory of the cause of the active ventricular diastolé noticed above.

A superficial examination of cardiograph tracings is sufficient to convince the observer that when the heart beats slowly the *first* part of the revolution, namely, from the commencing systolé until the closure of the semilunar valves, bears a smaller ratio to the whole than in quick pulses. This led the author to make a series of measurements of these ratios, on the assumption that the ventricles commence to contract at the origin of the main rise, and that the semilunar valves close at the end of the fall *f*.

Page 23. To ensure accuracy, the trace was placed on a flat piece of wood, to which was attached a ledge, along which it could be made to slide.

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* That the active diastolé of the ventricles results from the congestion of the coronary vessels was discovered by Brücke; and I regret that my ignorance of his observations, published in the "Sitzungsberichte der Wiener Akad. der Wiss.," Nov., 1854, XIV. p. 345, prevented my referring to them, in a paper on the same subject, in this Journal for May, 1869. (*Suprà*, p. 3.)

A lever with a steel point was also in connection with the instrument, in such a way that when the tracing rested on the ledge the steel point produced scratches on the paper similar to those produced by the sphygmograph pen.

By this means, the parts of the curve under consideration can be all projected on to one straight line, and their relative lengths measured with facility. Fig. X is a trace so prepared for measuring, and this arrangement is necessary on account of the sphygmograph lever moving in part of a circle instead of quite vertically. Further, to diminish inaccuracies in the watchwork movement, all the pulsations on a trace were measured, and their average taken as the result.

It was soon found that, with a given rapidity of pulse, the ratio of the *first* part of the heart's revolution to the whole did not vary appreciably when traces were taken in any given position, but that when standing or sitting the *first* part was longer than when lying.

Further, on comparing traces of different rapidities, it was found that the length of the *first* part varied very definitely, inversely as the rate; not so quickly, but as its square root: and the number of measurements that have been made seems to justify the law, that *in health, the length of the first part of the heart's beat varies, for a given position of the subject, inversely as the square root of the rapidity.*

This result differs from that of Donders,* who found that the length of the *first* part did not vary with different rates of heart's action; but his means were much less efficient, he having to depend on the registration by the hand of the first and second cardiac sounds.

All the facts on which the above law is supported are given in the accompanying table, in which they are thrown into the co-ordinate form, one co-ordinate, x, representing the rate of pulse, and the other, y, expressing the number of times the *first* part of the revolution is contained in the whole. The observations made while lying are represented by a cross (×), when semi-recumbent these are encircled (⊗). The encircled dots (⊙) indicate that the position was sitting, and the standing ones are erect encircled crosses (⊕).

Page 24.

The simple dots are either from sitting or standing observations, but it is not certain which, as note was not taken at the time.

For example, the measurement of two heart traces, one at 41 a minute while lying, and another at 141 when semi-recumbent, gave in the former case the ratio of the first part to the whole revolution 1 : 3·4125, in the latter, 1 : 1·832; the length of the *first* part is found by multiplying the rate into the number of times the *first* part is

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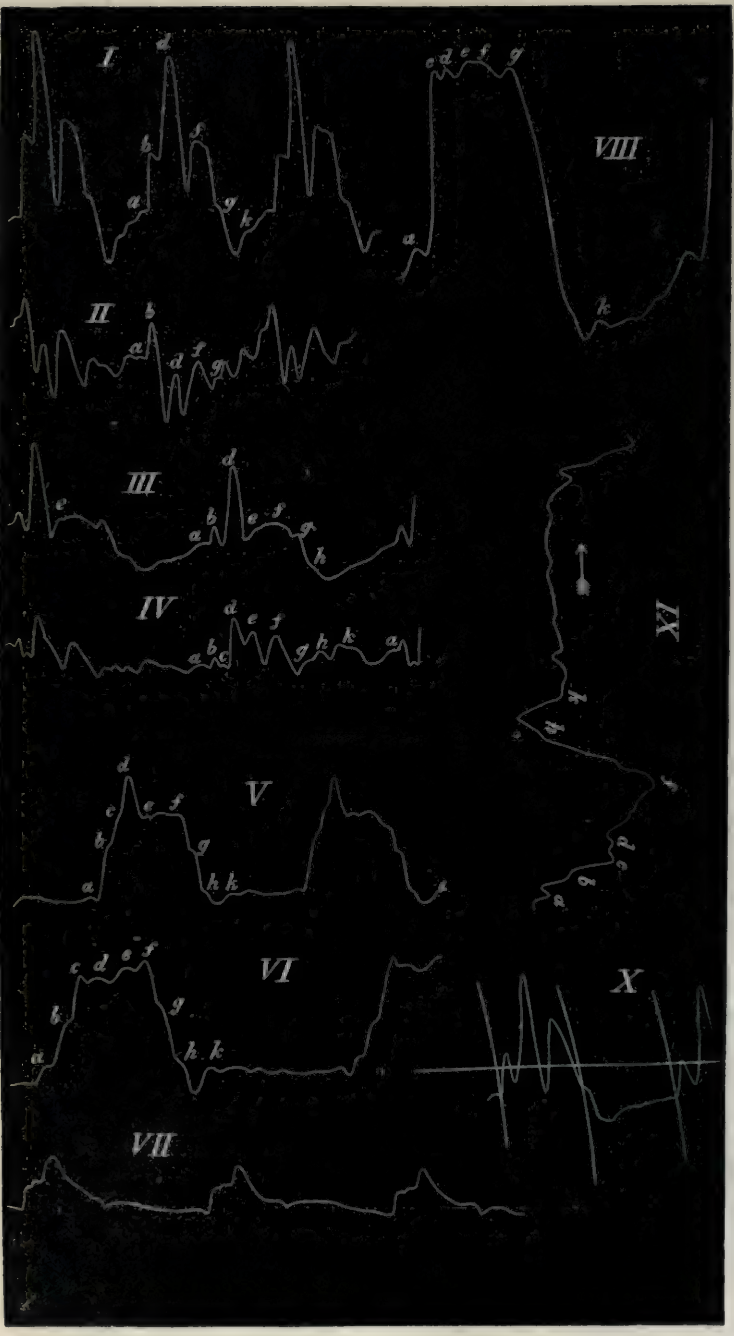
* "On the Rhythm of the Sounds of the Heart." By F. C. Donders. 1865. Translated into the "Dublin Quarterly Journal of Medical Science," Feb., 1868.

Page 26.


I
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contained in the whole, or the x by the y, when $\frac{1}{xy}$ is the required result.

Thus $41 \times 3{\cdot}4125 = 139{\cdot}9125$, say 140;
$141 \times 1{\cdot}832 = 258{\cdot}312$;
and $\sqrt{41} = 6{\cdot}4$, about; $\sqrt{141} = 11{\cdot}88$, about;
and $6{\cdot}4 : 11{\cdot}88 :: 140 : 259{\cdot}9$, about;
which is very near the required numbers.

If xy varies as the square root of x this can be stated thus $xy = k\sqrt{x}$; k being a constant for any given position. Taking one of the above cases, x equalling 41, $xy = 140$; consequently $k = 22$ nearly, which includes, within the limits of experimental error, all the measurements that have been made of traces taken while lying. When sitting or standing the results are not quite so uniform, as may be seen in the table, on which the equation curves have been drawn with $k = 22$, and also $= 20$: the latter, the lower one, passes through or approaches most of the sitting and standing observations.

To find the duration of the ventricular systolé is very important, but not at all easy in many cases. In all rapid pulses, measuring from the commencement of the main ascent to the point from which the rise *f* originates, and which can scarcely be anything but the termination of the systolé, it has been found that that interval is contained 3·4 times in each revolution. In Fig. IV the trace of 87·5 a minute (rare from being very detailed), it is found that between the same points the ratio to the whole is 1 : 3·3965, which is very near the former **Page 25.**
result. In slower pulses it is not easy to find an origin for the rise *f*, but if, as must be the case when the pulse is at 40 (its limit of slowness), the arterial tension is at its maximum, the rate of closure of the aortic valve must be at its maximum also, and the whole first part almost entirely occupied by the true systolé. When such is the case the equation $xy = k\sqrt{x}$ with $k = 22$ is satisfied by y being equal to 3·46 (about), which is curiously near the relation found in quick pulses, and tends strongly to show, though these are all the grounds for it, that the length of the systolé of the heart is always a definite part ($\frac{10}{34}$th) of the whole pulsation, whatever its rate.

The traces from which the preceding observations have been made were all taken on myself, and the repetition of them by others at different rates of pulse would be a means of verifying or a cause for rejecting the results arrived at. The chief sources of error in finding the ratios given above lie in the watchwork, which, if not going at an exactly similar rate each time it runs, gives the rapidity of the heart incorrectly. Also, on starting, its speed augments for a short time and then decreases, both which cause variations from the true results.

By taking a trace after having remained some time in the hot room of a Turkish bath very rapid pulses can be recorded up to and above 150 a minute in health, without the least inconvenience. Very slow pulses can be produced by lying nude some time in a cold air, or by drinking iced water, especially when nude.

Page 27.

DESCRIPTION OF THE FIGURES.

They were all taken one-half the size here represented. Except Fig. IX, they read from left to right.

Fig. I. Apex trace of a heart beating 125 times a minute.

Fig. II. Trace of a heart beating 125 a minute, half an inch internal to the apex beat.

Fig. III. Apex trace of a heart beating 88 a minute.

Fig. IV. Trace between 6th and 7th ribs, below the apex, of a heart beating 88 a minute.

Fig. V. Apex trace of a heart beating 76 a minute.

Fig. VI. Apex trace of a heart beating 50 a minute.

Fig. VII. Apex trace of a pulse of 90 a minute, taken with a lever two inches long, attached to the sphygmograph pad by a thread.

Fig. VIII. Apex trace of a pulse at 60 a minute, taken when the body was inclined forward.

Fig. IX. Apex trace of a pulse at 42 a minute. It reads from right to left.

Fig. X. Apex trace of a pulse at 103 a minute, prepared for measuring.

5. ON THE CONSTRUCTION AND USE OF A SIMPLE CARDIO-SPHYGMOGRAPH.*

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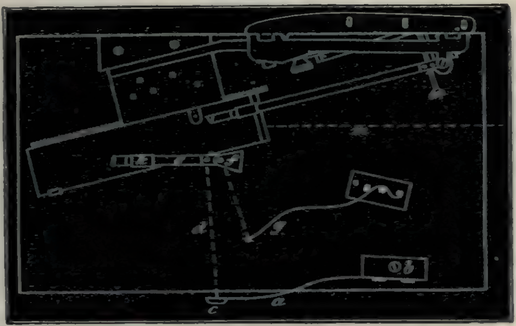
It is evident that a precise knowledge of the intervals between the main elements of the cardiograph and the sphygmograph trace must be of value in studying the hydrodynamics of the circulation of the blood; and a description will be here given of an instrument by which several results of interest have been obtained on this subject.

This cardio-sphygmograph consists of a piece of board, 10 inches long by 5½ inches broad, and is about half an inch thick, along one side of which one of Marey's sphygmographs can be fixed, as shown in the accompanying figure. On the opposite to this is a spring (*a*), similar to that employed in the sphygmograph, which is attached to a movable support (*b*), so that its strength may be modified. A small ivory pad (*c*) is fixed to the lower surface of the free end of the spring, and this is in communication with the recording lever of the cardiograph apparatus by means of a silk thread (*d*). In this instrument the cardiograph lever (*e*) is very light, a little over two inches long, and connected to the board by means of a frame (*f*), which is just free of the movable part of the sphygmograph, when that is in position. The lever, which is one of the third system, is connected on either side, close to its fixed end, to two silk threads, one of which (*d*) is attached to the cardiograph spring, and the other to a small spring (*g*), which Page 266.
moves it when it is less acted on by the stronger one. The apparatus is so arranged that the lever works perfectly when it is so placed as to be above the recording paper of the sphygmograph, when the latter is in position. The tip of the lever carries a steel pen (*k*).

Fig. I.



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* "Journal of Anatomy and Physiology," V. pp. 265–70. May, 1871.

The apparatus therefore consists of a cardiograph and of a sphygmograph, and these are so fixed that they both record on the same paper; and the object to be attained is to get them both to record at the same time, the one the movements of the heart's apex, the other the dilatations of the artery at the wrist.

To obtain this result the sphygmograph is first fixed, as usual, on the *left* arm, and the recording paper is adjusted to its place on the watchwork. With the cardiograph in the right hand, the left arm is then moved until the attached instrument rests on the board in the position shown in the figure, and when there, it is maintained in its place by certain pegs and holes in the board, which respectively come in contact with the main parts and receive the projections of the instrument.

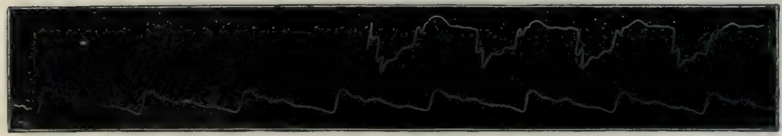
The arm and attached instruments are then moved until the pad of the cardiograph spring is brought in contact with the spot, generally between the 5th and 6th ribs, at which the heart's pulsations are most marked; the position of the pad in relation to the board having been previously so fixed as to enable this to be done with facility, the whole being maintained in the horizontal position.

The contact of the cardiograph pad with the chest-wall causes the lever to recede from the chest, and it is allowed to do so until its pen arrives above the recording paper; the whole apparatus being steadied by the right hand. When the levers of the two instruments are both found to be moving freely, the watchwork of the sphygmograph is set in action by a string (*m*) held by the right hand, and at the other end connected with the stop-block of the train of wheels. The two levers recording on the smoked paper give a combined trace of which Fig. II is an example.

As with simple cardiograph traces it is advisable and almost necessary to hold the breath while the trace is being taken, and further, to simplify the working of the instrument, the chest should be empty at the time.

Fig. II.

Page 267.



It is evident from the above description that the two levers write in opposite directions, and consequently this figure must be turned the other way up that the cardiograph trace may be properly seen, and then it must be read from right to left, not from left to right, as the sphygmograph trace.

The commencement of the two traces is indicated by the curved lines to the left of each trace as they are looked at without moving the page, and these curved lines are produced by letting the levers move without the watchwork, whilst the instrument is being fixed in position. Synchronous points in the two traces must evidently be at equal distances from the starting points in the traces, and therefore the one can be projected on the other by compasses or by superposition.

In all cases it is necessary, both in the cardiograph and in the sphygmograph trace, to project all the main points, such as the origin of the main rise, and the deepest point in the secondary fall, on to one line in the trace; for, as the levers move in part of a circle, any point at the summit of the trace, if projected straight downwards, would not be correctly related to the lower parts of the trace. This correction is best made by a most simple arrangement; a flat piece of board has a straight slip of wood fixed close to one edge; against this the tracing rests, being supported on the board. Two nails are fixed on the board, so that they bear the same relations to its supported trace as that did to the axes of the levers which marked on it in the cardio-sphygmograph. The marking apparatus consists of two pieces of string, each fixed at one end to the nails, and at the other carrying needles; these pieces of string must be of the same length as the levers to which they correspond, the points of the needles must pierce them, and the other ends of the needles must be attached to the nails by a thread to prevent them from moving irregularly.

The cardio-sphygmograph can be best applied when the person using it is sitting, as it can then be made to rest on the arm of a chair, and in practice it is better not to have the main part of the instrument press against the chest-wall, as if it does the heart's movement imparts itself to the whole apparatus, and so complicates the trace. Page 268.

In considering the results arrived at by the use of this instrument, it will be necessary to define a few of the terms that have to be employed in explaining them.

(1.) The first cardiac interval is that which occurs between the commencing systolé and the closure of the aortic valve at the heart.

(2.) The first arterial interval is that which occurs between the indications of the commencing systolé and the closure of the aortic valve in an artery. The radial artery at the wrist is the only one that is here considered.

As the commencement of the arterial rise is somewhat later than the commencing systolé at the heart, and as the difference between the first cardiac interval and the first arterial interval is not great, these two events coincide in part of their duration, and give rise to minor divisions, which may be thus named and defined.

(3.) The first cardio-arterial interval is that which occurs between the commencing systolé at the heart and its indication in an artery (the radial).

(4.) The conjugate cardio-arterial interval is that which occurs between the commencing systolic rise in an artery and the closure of the aortic valve at the heart.

(5.) The second cardio-arterial interval is that which occurs between the closure of the aortic valve at the heart and its indication in an artery.*

On comparing the lengths of the first cardio-arterial interval with different rates of pulse, it is found that as the pulse is slower, so this interval is longer, and that its length does not increase as rapidly as Page 269. the pulse beat, but as its square root. Consequently if the number of times that the first cardio-arterial interval is contained in its component pulsation is represented by z and the rapidity of the pulse by x, then $kz = k.\sqrt{x}$, and measurements show that the constant quantity k equals 39 (or perhaps 39·25) for the sitting posture. A knowledge of this equation, therefore, gives a means of calculating the length of the first cardio-arterial interval when the rapidity of the pulse is known; and as the first cardiac interval also varies as the square root of the pulse beat,† it is evident that from its definition the first cardio-arterial interval must be a constant part of the first cardiac interval, whatever the rate, and this has been found to be the case by independent measurement. Another necessary result from these equations is, that the conjugate cardio-arterial interval varies inversely as the square root of the heart's rapidity.

The length of the second cardio-arterial interval can also be found by subtracting the length of the conjugate cardio-arterial interval from that of the first arterial interval, which varies inversely as the cube root of the pulse rate,‡ and by this means it has been found to vary very little with different rapidities of pulse, being a little longer in the slower pulses.

In the sphymograph traces of slow pulses the major descent of the first arterial interval is broken by a notch, and it is found that the

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* In the above definitions it has been assumed that the sphygmograph trace gives indications of the closure of the aortic valves; and in the measurements to be referred to below, the secondary rise, which puts so abrupt a termination to the major fall in each pulsation, is considered to be caused by the closure of these valves, as generally assumed; though Dr. Sanderson has arrived at a different conclusion ("Medical Times and Gazette," March 25, 1871), from evidence which seems to be anything but convincing.

† "Journal of Anatomy and Physiology," Nov., 1870. "On Cardiograph Traces from the human chest-wall." (*Suprà*, p. 18.)

‡ "Proceedings of the Royal Society," No. 120, 1870. "On the relative duration of the component parts of the radial sphygmograph trace in health." (*Suprà*, p. 14.)

deepest point of this notch is always exactly synchronous with the point of closure of the aortic valve. This leads to the almost necessary conclusion, that the subsequent slight rise or change in direction of the trace is the result of the simultaneous movement of the whole column of blood produced by the shock of the closure of the aortic valve; the secondary rise at the commencement of the second arterial interval being the more slowly transmitted pressure wave, which started at the same time This explanation being correct, it is evident that the results obtained, by measuring the number of times that the interval between the origin of the main arterial rise and the bottom of the notch in the major fall is contained in the first arterial interval, ought to give the same results as those obtained by dividing the calculated length of the conjugate cardio-arterial interval into the first arterial interval. Such has been found to be the case very closely, but a sphygmograph trace must be a very good one to show the notch in the first arterial interval sharply defined, and the subsequent rise commencing abruptly. **Page 270.**

In all the cases above discussed it has been assumed that the subject from whom the traces were taken was sitting at the time, and as the length of the first cardiac interval changes for the same rate of pulse with change of position, it is evident that the equation given above (namely, $xz = 39\sqrt{x}$) must be changed also; and the change probably consists in increasing the value of the constant for the standing posture, as then the first cardiac interval is shorter, but still varies inversely as the square root of the heart's rate.

The explanation given above of the cause of the notch in the first arterial interval, might lead to the expectation that the commencing cardiac systolé indicates itself at the wrist in the same way; but there is no such marked change of direction in sphygmograph traces, though a slight rise is generally seen just before the main ascent originates, especially in pulse of about 70 in a minute; and it is not improbable that the second rise in the extremely dicrotic pulse of adynamic pyrexia is caused by a combination of the slow pressure wave resulting from the closure of the aortic valve, and the sudden onward motion given to the whole mass of blood in the vessels at the moment of opening of the aortic valve at the commencement of the next systolé.

The facts on which the above equations have been based are published in the "Proceedings of the Royal Society," XIX. No. 126, p. 318.*

Mr. Hawksley, of Blenheim Street, is constructing a cardio-sphygmograph from the model described above, with a few minor improvements, which can easily be applied in the study of pathological conditions.

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* *Infrà*, p. 32.

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6. ON THE MUTUAL RELATIONS OF THE APEX CARDIOGRAPH AND RADIAL SPHYGMOGRAPH TRACE.*

A DESIRE to acquire an accurate knowledge of the relation born by the commencing contraction of the heart to the origin of the primary rise in the pulse at the wrist, led the author to construct an instrument which has enabled him to determine, with considerable accuracy, the mutual relation of these two points, and to demonstrate one or two unexpected results, not altogether without interest.

[Here follows an account of the cardio-sphygmograph described in the preceding paper.—ED.]

Page 320. All the observations were made on the same subject, aged 24, in good health. They were all made in the sitting posture, as the apparatus could then be held more firmly, or rested on the arm of a chair.

To facilitate description, the following terms and symbols will be employed with regard to pulse-traces.

1. The rapidity of the pulse is symbolically represented by x.

2. The first cardiac interval is that which occurs between the commencement of the systolic rise and the point of closure of the aortic valve, in cardiograph traces. The number of times that this interval is contained in its component beat is represented by y; and the law as to its length, published elsewhere,† will be assumed. It may be stated thus:—

$$xy = 20\sqrt{x}.$$

3. The first arterial interval is that which occurs between the commencement of the primary rise and the termination of the major fall in arterial sphygmograph traces. The number of times that this interval is contained in its component beat is represented by y'; and the law as to its length at the radial artery, which is alone considered in this communication, published in the "Proceedings of the Royal Society" (No. 120, 1870),‡ will be assumed; it may be thus stated:—

$$xy' = 47\sqrt[3]{x}.$$

4. The first cardio-arterial interval is that which occurs between the commencement of the systolic rise in the cardiograph trace and the origin of the main rise in the sphygmograph trace. The number of times that this interval is contained in its component beat is represented by z.

5. The conjugate cardio-arterial interval is that portion of the first

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* "Proceedings of the Royal Society," XIX. pp. 318–24. Read Feb. 23, 1871.

† "Journal of Anatomy and Physiology," Cambridge, V. Nov. 1870. (*Suprà*, p. 18.)

‡ *Suprà*, p. 14.

cardiac interval which is synchronous with a portion of the first arterial interval. It is therefore the interval between the commencing sphygmograph rise and the point of closure of the aortic valve as represented in the cardiograph trace.

6. The second cardio-arterial interval is that which occurs between the point of closure of the aortic valve and its indication at the artery under consideration.

In commencing to work with the cardio-sphygmograph, measurements were made to find the duration of the first cardio-arterial interval, as it required but a few experiments to prove that the heart commences to contract before the pulse is indicated at the wrist.

By means of compasses, or by superposing one trace on the other, the commencing cardiograph rise was projected on the sphygmograph trace; and the interval between this event and the origin of the radial rise was then measured into its component beat in each pulsation of the trace, from which the average of the observation was obtained. The results are given in Table I, Column II; and in Column III some of these are expressed in parts of a minute, whereby a better idea can be obtained as to their significance.

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TABLE I.

I. x.	II. z.	III. $\frac{1}{xz}$.	IV. $\frac{1}{39\sqrt{x}}$.
58	5·2	·003316	·0033649
64	5·083		
70	4·74		
71	4·52		
74	4·50625	·00299	·00298
79	4·3127		
80	4·4437		
81·5	4·1125		
85	4·355		
86	4·2	·002768	·002802
97	4·17		
102	3·885	·002524	·002538
132	3·41	·002222	·002229
154	3·		
170	2·95	·00197	·001957

From these results it is seen that the first cardio-arterial interval is longer in slow than in quick pulses, and that it does not increase as quickly as the pulse diminishes in rapidity; but that the statement that it varies inversely as the square root of the rapidity is correct, or very nearly so, is rendered evident by comparing Columns III and IV, in the latter of which the duration of the first cardio-arterial interval is calculated from the formula $xz = 39\sqrt{x}$. The chief source of error in these observations is the slight uncertainty in the rate of movement of the watchwork of the instrument, on which the calculation of the rapidity of the pulse depended.

On comparing this equation, namely $xz = 39\sqrt{x}$, with the one above referred to as to the relations of the first cardiac interval, namely, $xy = 20\sqrt{x}$, it is evident that the length of the first cardio-arterial interval is ·5128, or just over half that of the first cardiac interval, whatever the rate of the pulse.

This being the case, a more precise method is acquired of verifying the results arrived at; for by finding the number of times that the first cardio-arterial interval is contained in the first cardiac interval, a constant quantity ought to be the result, which is independent of the
Page 322. rapidity of the pulse. Table II contains these measurements; and it may be seen that, though there is a small range of variation, the numbers are all very near to the theoretical requirement, which is 1·95; and their average is 1·983.

TABLE II.

Rapidity of pulse.	Number of times that the first cardio-arterial interval is contained in the first cardiac interval.	Rapidity of pulse.	Number of times that the first cardio-arterial interval is contained in the first cardiac interval.
58	1·95	81·5	1·95
64	2·	83	2·1
69	1·9	84	2·1
70	1·9125	85	1·995
71	1·975	85·5	1·95
72	2·058	86	2·
74	1·975	88·5	2·05
76	1·98	91	2·15
78	1·9	92	1·85
79	1·925	94	1·95
79·5	1·9	97	2·15
80	1·95	154	1·975

It is generally known that in the sphygmograph traces of most slow pulses there is a notch in the first arterial interval, immediately preceding the major fall; and one of the most marked results of the use of the cardio-sphygmograph is the determination of the fact that the point of closure of the aortic valve at the heart is always exactly synchronous with the lowest part of this notch, or the point of abrupt change of direction in the major fall of the sphygmograph trace. This leads to the almost necessary conclusion that the subsequent slight rise or change in direction of the trace is the result of the simultaneous movement of the whole column of blood produced by the suddenness of the shock of closure of the aortic valve, the secondary rise in the same trace being the more slowly transmitted pressure wave resulting from the same cause.

The slower the pulse the more distinct is this notch; and by comparing different rapidities, a gradual diminution in its conspicuousness is apparent, it rising higher and higher above the point of termination of the major fall as the pulse is quicker and quicker. When the heart's rate is about 75 in a minute, the notch is halfway down the major descent, and is partially blended with it; when over 100 a minute, as the aortic valve closes when the ascent is at its maximum, the notch is so blended with the pressure wave as not to indicate itself separately.

In slow pulses, the systolic main rise being quite over when the aortic valve closes, the shock wave indicates itself by an abrupt but not considerable rise, breaking the very gradual major descent.

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This explanation being correct, another means is obtained of checking the results arrived at by the combined instrument; and Table III, Column II, contains a few measurements of the number of times that the conjugate arterial interval is contained in the first arterial interval, as found by measuring the ratio of the interval between the commencing arterial rise and the bottom of the notch in the major fall to the whole first arterial interval. Column III gives the theoretical results necessitated by the equations given above.

TABLE III.

Rapidity of pulse.	Number of times the conjugate cardio-arterial interval is contained in the first arterial interval,	
	as found from measurement of radial trace.	as calculated (approximately).
37	1·595	1·6
45	1·635	1·625
58	1·69	
59	1·7083	1·72
60	1·74	1·734
68	1·797	1·78

It may be mentioned that the reason why so few of these instances are given, is, that there is considerable difficulty in measuring these small intervals into one another with precision; but by practice a very fair estimate can be made of their value, and in all cases they seem to agree with theoretical requirement. The close accordance of the results obtained by this method in very slow pulses, and the calculated results arrived at from facts relating only to quicker ones, tends strongly to establish the correctness of the law given with regard to them.

In Table IV the lengths, in parts of a minute, of the different intervals referred to in this communication, are given as calculated from the equations on which they have been shown to depend. With regard to the second cardio-arterial interval, a reference to Column VII will show that it varies very slightly within the range of the heart's action, not being $\frac{1}{8}$ longer in a pulse of 36 than in a pulse of 169 in a minute.

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TABLE IV.

I. Rapidity of pulse.	II. Length of pulse-beat, in parts of a minute.	III. Length of first cardiac interval, in parts of a minute.	IV. Length of first arterial interval, in parts of a minute.	V. Length of first cardio-arterial interval, in parts of a minute.	VI. Length of conjugate cardio-arterial interval. in parts of a minute.	VII. Length of second cardio-arterial interval, in parts of a minute.
36	$\cdot 02\dot{7}$	·0083033	·006428	·0042735	·0040298	·00239821
49	·020408	·00714286	·005813	·003663	·00347986	·00233342
64	·015625	·00625	·005319	·003205	·0030449	·00227425
81	·0123457	$\cdot 00\dot{5}$	·00491356	·0028474	·0027081	·00220546
100	·01	·005	·0046234	·0025641	·0024359	·00218745
121	·0082645	$\cdot 00\dot{4}\dot{5}$	·004299	·002331	·00221445	·0020847
144	$\cdot 0069\dot{4}$	$\cdot 0041\dot{6}$	·0040486	·0021365	·0020301	·0020185
169	·005917	·003846	·0038485	·0019704	·0018756	·0019729

In conclusion, the following are the results that have been arrived at by the use of the above cardio-sphygmograph:—

1. The first cardio-arterial interval varies inversely as the square root of the pulse-rate.

2. The conjugate cardio-arterial interval varies inversely as the square root of the pulse-rate.

3. The second cardio-arterial interval varies very little with different pulse-rates, but is slightly longer in slower pulses.

4. The depth of the notch in the first arterial interval of the sphygmograph trace occurs at the moment of closure of the aortic valve.

5. There is no definite indication in the sphygmograph trace of the moment at which the cardiac systolé commences.

7. ON THE RELATION OF THE TEMPERATURE OF THE AIR TO THAT OF THE BODY.* Page 126.

THE nature of the evidence affecting theories in biological science is generally so far from direct, that it is only by the systematic working out of many of the necessary deductions that any idea can be formed as to their value. The experiments detailed in this communication were suggested by the theory to be referred to immediately, and their close agreement with its requirements tends strongly to substantiate its accuracy.

In a paper published elsewhere† I have detailed several observations which tend to show that many of the minor fluctuations in the temperature of the human body result from alterations in the amount of blood exposed at its surface to the influence of external absorbing and conducting media. Others have repeated these experiments‡, and obtained the same results.

For example; on stripping the healthy body in an air of about 50° F., a rise of the internal temperature (judged by that of the floor of the mouth) commences immediately, and in about half an hour amounts to as much as three-fourths of a degree. According to the above-mentioned theory this phenomenon is explained thus; the contact of the cold air against the surface of the skin, previously maintained at a much higher temperature by the clothes covering it, produces so considerable a contraction of the cutaneous muscular vessels, and the blood is driven so far inwards, that the conducting power of the thus modified skin is rendered considerably less than that of the clothes and blood-filled skin combined, in the previous condition; consequently the body temperature rises until a higher equilibrium is attained.

Such being the case, and the contraction of the cutaneous vessels being evidently caused by the cold, it is more than probable that the amount of this contraction should depend on the degree of cold applied, that is, on the temperature of the external air in which the observation is being conducted; and the extent of this action would Page 127. manifest itself by its effect on the body temperature, less cutaneous contraction causing less diminished conduction and consequently less rise of temperature on stripping.

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* "Journal of Anatomy and Physiology," VI. pp. 126–30. Nov. 1871.

† "Proceedings of the Royal Society," No. 112, 1869, p. 419, *et seq.* (*Suprd*, p. 6.)

‡ J. F. Goodhart, "Guy's Hospital Reports," 1869.

Similar reasoning would lead us to anticipate a temperature of air sufficiently high to produce exactly as much cutaneous contraction as will make up for the loss of the clothing, and consequently no change in the body temperature on stripping.

The correctness of these deductions may be judged from the following observations, which were all made under similar conditions, on myself, while standing.

I.		
Time.	Temperature.	Temperature of Air.
11.15	98·95	47° F.
11.20		
11.25	98·975	
11.30	98·975	
11.35		
11.40	99·3	
11.45	99·35	
11.50	99·575	
11.55	99·625	
12 NIGHT	99·7	
12.5	99·675	

Stripped at 11.30. Rise 0·7° F.

II.		
Time.	Temperature.	Temperature of Air.
11.15	98·8	52° F.
11.20		
11.25	98·8	
11.30	98·8	
11.35		
11.40	99·	
11.45		
11.50	99·35	
11.55		
12 NIGHT	99·375	

Stripped at 11.30. Rise 0·575° F.

III.		
Time.	Temperature.	Temperature of Air.
10.45	98·1	59° F.
10.50	98·	
10.55	97·925	
11 P.M.	98·	
11.5	98·19	
11.10	98·35	
11.15	98·4	
11.20	98·425	

Stripped at 10.55. Rise 0·5° F.

IV.		
Time.	Temperature.	Temperature of Air.
11 P.M.		67° F.
11.5	99·	
11.10	99·	
11.15	99·	
11.20	99·	
11.25	99·05	
11.30	99·19	
11.35	99·21	
11.40	99·19	

Stripped at 11.15. Rise 0·2° F.

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V.			VI.		
Time.	Temperature.	Temperature of Air.	Time.	Temperature.	Temperature of Air.
10.15	99·15	71° F.	10.15	98·8	71° F.
10.20	99·15		10.20	98·875	
10.25	99·15		10.25	98·95	
10.30	99·125		10.30	98·95	
10.35	99·025		10.35	99·	
10.40	99·125		10.40	99·	
10.45	99·175		10.45	99·	
10.50	99·175				
10.55	99·175				
11 P.M.	99·175				

Stripped at 10.30. Rise at 0·05° F. Stripped at 10.25. Rise 0·05° F.

VII.			VIII.		
Time.	Temperature.	Temperature of Air.	Time.	Temperature.	Temperature of Air.
10.30	99·21	72° F.	10.15	98·8	73° F.
10.35	99·205		10.20	98·825	
10.40	99·2		10.25		
10.45	99·3		10.30	98·9	
10.50	99·3		10.35	99·	
10.55	99·15		10.40		
11 P.M.	99·35		10.45	99·1	
11.5	99·3		10.50	99·1	
11.10	99·325		10.55	99·1	
11.15	99·4		11 P.M.	99·1	
11.20	99·425				

Stripped at 10.50. Rise 0·125° F. Stripped at 10.36. Rise 0·1° F.

It is readily seen that the hotter the air, the less is the stripping rise, and that when an external temperature of 70° F. is reached, there is no rise at all. Several of the higher temperature observations are here given and but few of the lower, because in the paper above referred to ("Proceedings of the Royal Society," No. 116, 1869)* there are six or seven of the latter recorded with the temperature noted in all.

From these facts it may be clearly seen that *in air below the temperature of* 70° F., *the stripping rise varies inversely as the temperature.* Page 129.
Experiments as low as to 45° F., have been made, but no limit has

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* *Suprà*, p. 6.

been reached in that direction yet. Above 70° F. of the air, the results are modified by the sweating that *always* accompanies so high a temperature if the body is clothed, and quite a different class of phenomena appear, which have not been much studied.

In V and VII there was a slight fall of temperature at the moment of stripping; this was probably connected with the perceptible moisture on the surface which evaporates almost immediately the clothes are removed.

With regard to the nature of the clothing removed. It always had considerable non-conducting power, being composed in all cases of at least two layers of woollen material; though, as the observations in the warmer air were made in summer, and those in the colder, during corresponding seasons, the dress worn varied with the time of year, being thinner in the former and thicker in the latter. On the whole the amount of clothing worn does not seem to affect the results as long as there is sufficient to keep the body warm under ordinary circumstances; and in the English climate to do this, one woollen covering seems always essential.

Some results obtained by Dr. V. Weyrich* with regard to the hygrometric condition of the skin at different temperatures of the atmosphere, obtained by means of an hygrometer specially adapted for the purpose, bear so fully on the subject under consideration that they will be here given.

1st. When the body is clothed, the amount of moisture excreted by the skin does not vary appreciably when the observations are conducted in an air below 70° F.

2nd. When above 70° F. the amount of moisture excreted by the skin rapidly increases with a rise in the temperature of the atmosphere.

It is thus seen that by means of an entirely different method of observation, Weyrich finds that in an air of 70° F. sweating commences; and by a combination of his results with those arrived at from the facts given above, the following conclusions may be drawn:— Page 130.

With regard to the human body, when covered with badly conducting clothing, 70° F. is a *critical* temperature of the atmosphere. The removal of the clothing at that temperature produces sufficient contraction of the cutaneous muscular arteries to counteract the cooling effects of its loss, and consequently the internal temperature does not change; whilst on stripping at lower temperatures, the vascular contraction induced more than makes up for the covering lost, and is

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* "Die Unmerkliche Wasserverdunstung der Menschlichen Haut," Leipzig, 1862. Abstract in "British and Foreign Medical Chirurgical Review," Oct., 1863.

consequently followed by a rise of internal body temperature; which, like the vascular contraction, is greater as the cold is more considerable. Above 70° F. the amount of perspiration varies with the degree of heat and so far compensates, by evaporation, for the differences of temperature as to maintain the body at a nearly uniform temperature.

The temperature of air at which sweating begins in the nude body is not known. It is at about 86° F. when standing at rest.

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8. ON PULSE FREQUENCY, AND THE FORCES WHICH VARY IT.*

The circulation of the blood is a uniform circulation, the pulsation being neglected, and a uniform circulation is one in which the quantity of fluid flowing through all segments of the circulating system is the same; otherwise there would be a tendency for the fluid to accumulate at certain points, which is contrary to the premises.

To arrive at precise conclusions respecting the circulation there are two points which must be considered:—1st., The laws which regulate the flow of fluids through capillary tubes. 2nd., The variations in the capacity of the circulating system under different pressures. These will be considered separately. Poiseuille found that the flow of fluids through capillary tubes varies directly as the pressure and as the fourth power of the diameter of the tubes. The author has verified the former of these results on the vessels of the animal system by a different method. Respecting the capacity of the arteries and ventricles under different blood-pressures, it is evident that the capacity of the former must depend on the pressure only, for they are simple elastic tubes, and must be more capacious under high than under low pressures; reasons are given below for a more precise statement of this relation. To maintain a uniform circulation with a pulsating motor, like the heart, it is evident from the above considerations that variations in the resistance at the small arteries must produce variations in pulse-rate; and that unless the capacity of the arteries and heart vary directly as the pressure, variations in blood pressure must be also attended with change in pulse frequency. That the capacity of the ventricles is dependent on the arterial blood pressure can be proved by the varied amount of opening up of the ventricular cavities which follows different fluid pressures in the coronary arteries.

Next, the different forces which vary the pulse-rate must be considered. It can be shown that any change in the resistance to the flow of blood through the capillaries varies the pulse-rate, increased resistance rendering the pulse slower, and the reverse. As instances of these effects may be given, the pulse-slowing effects of stripping in a cold air, of a cold bath, and of compression of large arteries; the

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* "Nature," VI. pp. 446, 7. Sept. 26, 1872. Paper read before the British Association at the Brighton Meeting in Section D, Department of Anatomy and Physiology. *See* "Report of British Association," 1872, p. 151.

pulse-quickening effects of a hot bath, whether air or water. Numerous experiments by the author prove that the effect of copious blood-letting is not to modify the pulse-rate at all, thus showing that the law given by Marey respecting pulse frequency is not correctly based. The above points, namely, the law of Poiseuille, the dependence of the capacity of the arteries and ventricles on the pressure of the blood, the dependence of the pulse-rate on the peripheral resistance and its non-dependence on the blood pressure, can all be correlated by only one theory, namely, that the heart always re-commences to beat when the tension or pressure in the arteries has fallen at invariable proportions, which also assumes that the capacity of the heart and arteries varies directly as the pressure. The facts that the arteries are generally empty after death, and that the cavity of the heart is sometimes found to be obliterated on *rigor mortis*, show that absence of pressure and capacity go together.

This theory explains the known peculiarities in pulse-rate attending change in position, by showing that while standing all the pressure of the body weight is borne by non-compressible rigid tissues, and so the circulation is normal, but while lying, the soft parts are compressed and resistance introduced into the circulation, reducing the rapidity of tension-fall, and therefore the frequency of the pulse; an intermediate condition attends the sitting posture. The pulse quickens during inspiration, and becomes slower during expiration; for during the former act the reducing pressure in the chest lowers the aortic blood pressure, and makes the tension-fall more rapid, while in expiration the reverse occurs.

This theory also is the only one which throws light on the cardiograph law published by the author (see "Journal of Anatomy and Physiology," 1870–71), which may be thus stated:—For any given pulse-rate the first part of the heart's revolution has a constant length, but it varies as the square root of the length of the complete pulsation. The pulse-rate not depending on the blood pressure, and the length of the first cardiac interval not varying when the rate is constant, its length also does not depend on the blood pressure. The first cardiac interval may be divided into the systolé and the interval between that and the closure of the aortic valve (the diaspasis); these combined not varying as the blood pressure, it is almost certain that separately they do not do so either; so it may be said that neither the length of the systolé nor of the diaspasis depends on the blood pressure. But the fall of tension between the pulse-beats being but small, and the diaspasis length not depending on the blood pressure, there is no reason why it should vary in length with different pulse-rates; and assuming this in connection with the measured diaspasis length in a particular case (·00183 of a minute), it can be deducted from the above cardiograph law, that the systolic length varies as the square root of the diastolic. From these facts the relation of the nutrition of the heart to the time of heart nutrition (diastolé) and to the blood pressure may be deduced; for the systolic length not varying with the blood pressure when the pulse-rate is constant, it is evident that the cardiac nutrition must vary directly as the blood pressure in the aorta; and the systolé varying as the square root of the diastolic time, shows that the nutrition of the heart varies as the square of the time of nutrition (diastolé), for with a quadruple resis- Page 447. tance to the peripheral circulation, the heart would be four times the time in emptying itself, but it is only double that time, which demonstrates the statement.

A complete logical explanation of the action of the pneumogastric can be given on this theory, by assuming that its function consists in diminishing the calibre of the small arteries of the coronary system, and always keeping them somewhat contracted.

9. ON THE LAW WHICH REGULATES THE FREQUENCY OF THE PULSE.* Page 1.

THE paucity of mechanical theories to explain the frequency of the pulse, probably arises from the very general assumption, that in all cases when the rapidity of the heart's beat is caused to vary, the action of nerves with special powers of retarding or quickening it is brought into play; and the relation of heart power to work to be performed, has not been introduced into the problem.

The theory of energy has of late spread so far and wide the necessity for finding in all cases where work is done a sufficient source for the production of that work, in one form or other, that a vague statement to the effect that heart frequency depends solely on nerve action, is far from sufficient for the requirements of physiologists. It is now necessary to show that with different amounts of work to be performed in the circulation, different supplies of nutrient substance must be presented to the motor organ, just as in the steam-engine the amount of fuel must be varied according to the work required from the machine.

When the microscope revealed the existence of a well-marked muscular coat to the smaller systemic arteries, it became evident that the different diameters of those vessels consequent on the degrees of contraction of their walls, varied the amount of force necessary to propel the blood through them; and these variations have been con- Page 2. siderably studied of late. Dr. Marey of Paris, the introducer of the sphygmograph, has, in his most scientific treatise "On the Circulation of the Blood,"† strongly drawn attention to this subject, and he has worked out a theory respecting the law regulating the frequency of the pulse, which is based mainly on the variations in arterial resistance.

This theory of Marey's it will be necessary to recapitulate here, and to examine the facts on which it rests. The following is the law in the two forms in which he gives it.

1. "The heart beats so much the more frequently, as it experiences less difficulty in emptying itself."

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* This paper was originally printed and published separately (London: H. K. Lewis, 136, Gower Street, 1872), but was afterwards republished in the "Journal of Anatomy and Physiology," VII. pp. 219-32, and VIII. pp. 54-61, with one or two corrections which have been here inserted.—ED.

† "Physiologie Medicale de la Circulation du Sang." Paris, 1863.

2. "The frequency of the pulse varies inversely as the arterial tension."

As reasons for the accuracy of this law are given—

1st. The analogy of other intermittent muscular movements, as the following:—A man can walk a certain distance quicker, the less he is loaded. Or this—The hand can be moved alternately backwards and forwards more quickly in air than in the more resisting fluid, water.

2nd. The pressure can be made to change by variations in the amount of blood in circulation, and by modifications in the degree of arterial or capillary resistance, both of which vary the pulse-rate in the manner required by the theory.

Page 3. To prove the effects of different amounts of blood in circulation, the experiments of Hales are quoted, in which he found that loss of blood increased the frequency of the pulse.

To prove the effects of varied arterial or capillary resistance, many satisfactory and original results are referred to; among them, the effect of compressing the abdominal aorta, or the femorals, which retards the pulse; the effects of cold baths, according to Drs. Bence Jones and Dickinson, when the pulse was greatly reduced in frequency; the quickened pulse following successive additions of warm clothing over the body is also proved.

From these latter results it is clear that Marey assumes that by varying the capillary resistance the blood pressure is also varied at the same time, but this assumption is not necessarily true in a circulation that is maintained by a pulsating motor organ whose rate is variable, as can be easily shown by an analogy from electricity, which is a useful one in many ways to students of the circulation, and is quite worth being worked out by each. It is this:—Suppose a battery connected, through a break-and-make key, to a long uniform insulated line or telegraph cable, insulated at the other end, and connected with a static galvanometer.

First connect the two parts by the key and thereby charge the line, and then break connection; upon this the charge will fall in tension slowly, and this fall may be observed on the galvanometer; when the tension has fallen one half, reconnect and break again. It is evident that if this process be repeated, a definite current is maintained Page 4. between the cable and the surrounding bodies to which it leaks. If the line be now halved in length, whereby the resistance is doubled, and again insulated at the free end, it is evident that by again breaking and making contact as before, when the tension is halved, the maximum tension will not be changed. So with the circulation, if the resistance in the arterial peripheral vessel is varied and the length of the pulsation depends on the time of fall in tension only, the pressure does not vary, if the vascular capacity is constant.

It is thus seen that the blood pressure need not depend on the arterial resistance, but if the pressure does not vary, the pulse-rate must do so.

A desire to arrive at the genuine value of this theory of Marey's, led me to make experiments similar to his own, as to the accuracy of his fundamental facts. My observations were divided into two series, to find,—

1st. Whether the pulse-rate was related to the capillary resistance.

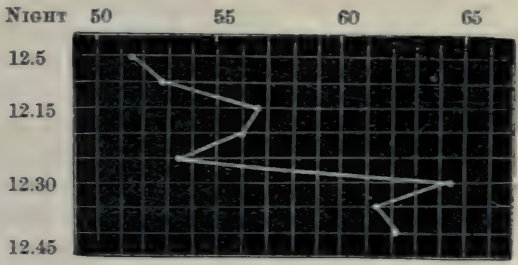
2nd. Whether the pulse-rate depended on the pressure of the blood in the arteries.

These points will be considered separately.

1st. *The relation of the pulse-rate to the arterial resistance.*

The effect of exposing the surface of the body to the influence of different temperatures, whereby, as it has been my endeavour to prove elsewhere,[*] variations in the calibre of the cutaneous vessels are produced, was carefully examined and the following tables embody my results, the curves being those of changes in pulse-rate.

Experiment I. Temperature of the air 51·5° F. Nude at 11.57 P.M. Page 5.
Lay down on floor, carpeted, on right side, at 11.58 P.M., with head on foot-stool. Did not feel cold. Got up and put on night shirt and jumped into bed at 12.20; a skin glow came on at 12.29. Same position maintained in bed as when on carpet.



Experiment II. Temperature of air 50° F. Nude at 11.40 A.M. and lay down on right side. Experiment conducted exactly as the last.

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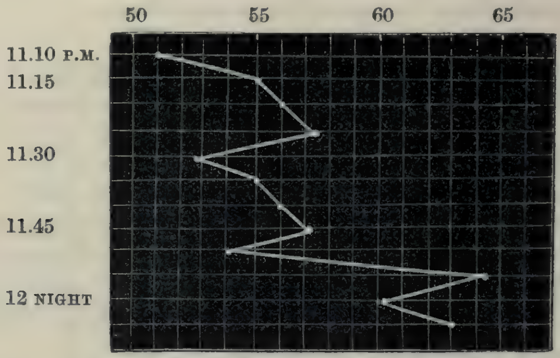
[*] "Proceedings of the Royal Society," 1869, p. 419. (*Suprà*, p. 6.)

Got up at 12 night, and in bed in less than a minute. A glow came on at 12.6.

Experiment III. Temperature of air 52·5° F. To show that the change in pulse-rate did not depend on the effort of getting into bed.



Experiment conducted exactly as the first. Nude, lying on the right Page 6. side, at 11.7 P.M. Got up at 11.26 P.M., put on night shirt, took it off again and lay down again on floor. Got up again at 11.45′5″ and went into bed, in night shirt. A glow came on at 11.54′5″ P.M.

From these observations it is apparent that the effect of simply altering the condition of the cutaneous vessels, by varying their relations to external agencies, varies the pulse-rate in a definite manner; and thermometric results show that on warming the skin, as by covering it with bad conductors, the vessels are increased in calibre and the arterial resistance reduced. These experiments therefore show that reducing the resistance quickens the pulse.

Marey's own observations, specially as they are recorded mostly by the graphic method, are of themselves sufficiently convincing on this point. He compressed the abdominal aorta of a horse, per rectum, and found the pulse thereby rendered much slower. The same result followed compression of the human femoral arteries.

Page 7. The quickened pulse produced by the Turkish bath (in one case reaching the extreme rapidity of 172 in a minute on myself), is well known; as is the slow one following a cold bath, as shown by Drs. Bence Jones and Dickinson.

From these many facts, all tending in one direction only, it may be stated that the rapidity of the pulse varies inversely as the resistance to the flow of blood from the arteries.

2nd. *The relation of the pulse-rate to the amount of blood in circulation, or to the blood pressure in the arteries.*

The following experiments were made :—

Experiment IV. An old donkey which had been standing for more than half-an-hour in the room in which the experiment was conducted, had at 7.30 A.M. a pulse of 34 a minute. At 7.40 half an ounce of chloral hydrate was given it in 2 oz. of water.

At	Pulse a minute.	
7.50′	46	Standing unsteadily as if intoxicated.
7.52′		It fell down asleep.
7.55′	43	
7.59′	40	
8.8′	48	A tap having been put in the jugular vein, but no bleeding having occurred.
8.12′	52	Bleeding slowly from jugular.
8.15′	67	Minute after minute, the animal having lost altogether about one pint or a little more of blood.
,,	64	
,,	62	
,,	60	
8.19′	59	Bleeding freely.
8.20′	52	Bleeding ceased.
8.21′	49	,, ,,
8.22′	48	,, ,,
8.22′ 30″		Bleeding resumed.
8.23′ 30″	49	Bleeding. Resp. 11·5.
8.24′ 15″		Bleeding ceased after loss of another pint and half. Page 8.
8.24′ 30″	43	Bleeding ceased.
8.25′ 15″	42	No bleeding. Resp. 11·5.
8.26′	42	,,
8.28′ 15″	42	Bleeding freely.
8.30′ 30″	42	,, ,, Resp. 13.
8.34′ 30″	37	,, ,,
8.36′	38	,, ,,
8.40′	37	,, ,,
8.42′	35	,, ,, Resp. 14.
8.45′	36	,, ,, Resp. 16.

and from this time until 9.10, by which time more than half a pailful of blood had been lost and the carotid pulsations were very feeble, the pulse remained at 35·6 to 35 in a minute, with the respirations varying from 12 to 13 in the same time, and the loss of blood being continuous throughout.

The animal did not move once through the whole experiment.

Experiment V. A terrier dog had 30 grains of chloral given it in two doses, 15 grains first and another 15 grains about an hour afterwards. This did not render it quite comatose, so it sniffed chloroform until insensible, when a hæmadynamometer was connected with one of its carotids, and a pressure of 6·6 inches was immediately registered, which was steadily maintained, undulating with the respiration.

		Resp. in a minute.	Pulse in a minute.	Pressure.
		40	186·5	6·45 inches.
	In 3 minutes..	42	192	6·3 „
	„ 2 „	40	188	6·4 „
Page 9.	„ 2 „	—	184	6·4 „
	„ 2 „	49	182	6·6 „
	„ 1 „	52	164	6·85 „
	„ 1 „	—	159	7· „
	„ 1 „	—	150	7· „
	„ 1·5 „	70	138	6·9 „
	„ 4 „	—	142	6·7 „
	„ 5 „	—	149	6·8 „
	„ 6 „	—	156	5·8 „
	„ 7 „	—	168	6·4 „
	„ 6 „	—	102	1·7 „
	„ 10 „	—	129	2·1 „
	„ 5 „	—	138	1·9 „
	„ 2 „	—	141	2·1 „
	„ 3 „	64	142	2·1 „
	„ 5 „	—	138	1·9 „

In this experiment the bleeding occurred from the carotid, and took place between the pulse countings, which were traced on a revolving drum. The great fall in pressure indicates the excessive bleeding in one case. In others a much less quantity of blood was lost on each occasion.

There was no bleeding after the fall in pressure to 1·7 inches, and from that time the pressure and pulse became less and less till the animal died.

Experiment VI. A rabbit was made comatose by 15 grains of chloral, and was bled to death, the whole operation taking half an hour. An hæmadynamometer was connected with the carotid, and the blood was lost from the jugular of the same side, in drops continuously. The pressure, at first at about 6 inches, fell at the end of the experiment, to less than 1 inch, when death occurred. The following are the pulse-rates taken at equal intervals during the half hour:—

		In 10 seconds.	In 10 seconds.
Page 10.		42·5	42·75
		41·9	43·
		44·	42·
		43·	42·
		42·75	42·5
		41·	41·5
		43·	42·
	Bleeding began..	46·	42·4
		44·5	41·
		45·5	41·75
		44·75	42·

In 10 seconds.	In 10 seconds.
43·25	42·
44·	41·
45·	41·
43·5	42·
43·9	40·6
43·	42·
42·	42·
43·	39·

Experiment VII. A rabbit under the influence of 15 grains of chloral—

When pressure 4·8 inches.	Pulse 136 in a minute.
„ 4·3 „	„ 133 „
„ 2·8 „	„ 127 „
„ 1·7 „	„ 132 „
„ 2·8 „	„ 133 „
„ 2·4 „	„ 158 „
„ 1·9 „	„ 144 „
„ 1·1 „	„ 133 „
„ ·75 „	„ 136 „
„ ·9 „	„ 127 „

death from loss of blood.

From these experiments it is evident that the pulse does not increase in frequency with loss of blood, as it did not do so in any one of them.

In Experiment IV the pulse-rate rose on making the incision in Page 11. the skin necessary to expose the jugular vein, and continued to do so shortly after bleeding commenced, but soon diminished; and after reaching 36 a minute, remained perfectly constant, notwithstanding a continuous and considerable loss of blood from the vein until the animal was almost exsanguinated.

With the rabbits the difficulty in keeping them completely under the influence of the hypnotic, with the tendency to struggle, makes the results less uniform; but in all the cases there was a fall in pulse-rate, not a rise, accompanying the reduction in blood pressure. This fall, which was not very great, may result from the cooling of the surface, consequent on the lessened circulation.

From these observations it may be concluded that variations in the amount of blood in circulation do not vary the rapidity of the pulse, and consequently, that the pulse-rate is not dependent on the blood pressure as Marey supposed.

The next question was—What law as to the frequency of the heart's beats would satisfy these two above-proved facts, namely, the dependence of the pulse length on the arterial resistance and its non-dependence on arterial blood pressure?

The method adopted by Mr. Fleeming Jenkin for detecting the insulation of long cables at different times occurred to me as being subject to exactly similar laws, the time of fall of cable charge from tension to half tension, which he employs, varying directly as the leakage, and as that only.

Page 12. Can it be that the heart always recommences to beat when the tension falls a certain invariable proportion, and then only? This theory it was my next object to analyse, and the different elements into which it resolves itself were, and will be now, considered separately.

First, as to the full meaning of the term—a uniform circulation. A uniform circulation is one in which the quantity of fluid flowing through all cross sections of the circulating system is the same; for if the flow through one part were less than through another, there would be a tendency for the fluid to accumulate in front of the obstruction, which is incompatible with the premises.

As a consequence of this, the heart must always recommence to beat directly as much blood has left the capillaries as was sent out from it in the previous pulsation, and therefore the length of the pause or diastole must depend on the relative capacities of the heart and of the arterial system, and on the rapidity of the flow of blood through the capillaries.

At this point the work of Poiseuille respecting the flow of fluids through capillary tubes is invaluable. He found* that, other things being the same, the flow of fluids through capillary tubes varies directly as the pressure. These results were verified by a Committee of the Academy of Sciences; and by an entirely different method I have been enabled to do the same on the vessels of the animal system.

Page 13. My method was the following in a particular case:—The kidneys of a deer, with the aorta and renal vessels intact, were removed from its body and placed for some time in water at 100° F.; the aorta was ligatured just below the origin of the renal arteries, and a uniform glass tube was tied into it just above them. Water at 100° F. was poured into the tube and it distended the organs; the tube was maintained full by a continuous supply, which was suddenly stopped and the time of fall of the column from tension to half tension at different initial pressures observed, and it was always found that it took exactly the same time to fall from 40 inches to 20 inches as from 20 inches to 10 inches, thus verifying the law.

This law being thus true, it is evident that if the capacity of the arterial system, including the left ventricle, varies directly as the

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* "Recherches expérimentales sur le mouvement des liquides dans les tubes de très-petits diamètres." "Rapport de l'Académie des Sciences. Comptes Rendus." Tome IV. 1842.

pressure, then the heart must always recommence to beat when the arterial tension has fallen a certain proportion; for with double pressure and consequently double amount of blood, the time of flow through the capillaries is constant, as the flow varies directly as the pressure; and with double resistance and unvaried pressure the time of flow is double also, for the heart pumps again when as much has gone from the capillaries as it has sent into the arteries and the relative capacities of the heart and arteries do not vary according to the assumption.

But does the capacity of the arterial system vary as the pressure?

This is a point which it is very difficult to prove. With regard to the heart, the following facts bear on it:—By connecting a syringe with the coronary arteries, or by tying it into the aorta and pumping Page 14. backwards, it can be shown that increasing the pressure in the coronary arteries increases the capacity of the ventricles. Also in many post-mortem examinations the heart is found with the ventricular cavities fully obliterated, and as they are not then in action, the capacity of the heart and the pressure in it are at a minimum together. This is all the direct evidence that it is in my power to bring on this point.

With regard to the arterial system and its capacity, the absence of blood in the arteries after death has been known from time immemorial, and if their capacity varied directly with the pressure, it is evident that that must be the case, both capacity and pressure being at a minimum.

A direct method of determining this point having occurred to me, the following description will illustrate it. In a rabbit one of the carotids was put in communication with a kymographion; and during the time the recording drum was revolving, the chest was suddenly opened and the ventricles cut across transversely. The pressure fell rapidly to zero, and it is clear that the fall must have arisen from the escape of the blood through the peripheral vessels, as the aortic valves would close immediately. The curve of descent would take a definite form, which is easily expressed in mathematical language, if the capacity diminished as the pressure. Unfortunately the time required to open the chest, and other difficulties connected with the operation, prevented my results from being of much value, and Dr. Michael Foster suggested to me that the same object would be attained if the Page 15. heart were made to stop by the action of the interrupted current on the pneumogastric nerve. Mr. Martin of Christ's College, Cambridge, kindly sent me some traces thus taken, and one of the two which are suitable for measurement, entirely conforms with the law that the capacity of the vessels varies directly as the blood pressure, assuming Poiseuille's law to be correct. The other curve does not exactly fulfil the requirements, but varies very little from them. When further opportunity occurs, I hope to repeat these experiments on a larger scale.

It can also be shown in other ways that the arteries do not obey the laws of ordinary elastic tubes. They are covered by a dense, scarcely elastic, fibrous coat which limits their distension, and they are surrounded by organs and muscles which are pressing on them in all directions. So it may be said at least that they do not vary in capacity as simple elastic tubes, and that the difference is towards their varying directly as the pressure.

However, the indirect evidence proves that the capacity of the arterial system, the ventricle included, varies directly as the pressure: for the facts above considered as to the frequency of the pulse depending on the resistance, and *not at all* on the pressure, can only be explained on this assumption.

If the direct evidence as to the capacity of the vessels had been contradictory, it is true that it would have been necessary to assume some error in the method of conducting the pulse experiments; but as above shown, it is quite in the right direction and only lacks partial direct verification.

Page 16. So much in the verification of theories connected with Physiology must depend on the way in which collateral facts are explained by them that it will be advisable now to consider some of them, and these considerations will be divided into two sections,—1st. The explanation of the known variations in pulse-rate in health; and 2ndly, The explanation of the cardiograph laws.

1st. *Variations in Pulse-rate in Health.*—With reference to these points, as on this theory change in pulse-rate can only depend on change in arterial resistance, it is evident that Marey's law will, upon his supposition as to the relation between blood pressure and arterial resistance, explain the phenomena equally well.

The following are some of the best known:—

The Effects of Respiration on the Pulse-rate.—Physiologists, though not completely agreed as to the effects of respiration on the pressure of the blood in the arteries, all acknowledge that during inspiration the pulse quickens, and during expiration it gets slower, whether the pressure rises or falls. The theory under consideration clearly shows that this must be so, for during inspiration the expansion of the chest must reduce the pressure in the intra-thoracic aorta, and consequently its contained blood must fall in tension more rapidly than if the chest were motionless, and the more rapid tension fall causes increase in pulse-rate. In expiration the opposite occurs, diminution in chest capacity reduces the size of the aorta and consequently delays the time of fall of tension, and therefore slows the pulse.

If other remote effects of respiration tend to modify the pressure in the vessels, it is evident that they would co-exist with the above and influence it but slightly, explaining the existence of the experimental discrepancies. Page 17.

The Effect of Position of the Body on the Pulse-rate.—The experiments of Dr. Guy led him to explain the differences in pulse-rate following change of position as depending on the amount of muscular effort necessary to maintain the positions assumed, and his explanation, assuming that muscular effort of itself can change pulse-rate, is very complete. It is curious that the theory under consideration gives an interpretation of the same facts, though very different from that of Dr. Guy.

The following are the most essential facts:—The pulse is quickest while standing erect, slowest while lying, intermediate while sitting, slow while standing leaning, and while supported entirely, as by being bound to a wheel in any position.

The following is the explanation:—While standing, the only soft parts of the body which support the weight of the body are the soles of the feet, and the weight is transmitted to them through non-vascular and rigid tissues, cartilage and bone. Consequently the blood flows freely through almost all the vascular system unobstructed. But while lying, most of the weight is supported by highly vascular tissues, as the shoulders, arms, thighs, and legs, and consequently much of the circulatory system is greatly reduced in capacity from the compression it experiences, and considerable resistance to the flow of blood is introduced into the system, the fall of tension is retarded, and the pulse therefore rendered slower. Page 18.

In sitting, an intermediate condition is the result and an intermediate rate of pulse is produced.

Leaning while standing, and entire support on a wheel, both by introducing resistance from compression of soft parts, tend to make the pulse slow.

Thus, according to Dr. Guy's assumption, the slow is the normal pulse, and the quick the induced; upon the fall of tension theory the reverse is the case. The occurrence of bed-sores and the paleness of a compressed part prove that pressure disturbs the uniformity of the circulation.

The rapid pulse after a meal, during digestion, depends on the relaxation of the vessels of the alimentary canal while its functions are being performed.

In a paper on cardiograph tracings* from the human chest wall,

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* Since writing the paper referred to, a further comparison of tracings has shown me that in the slow pulses taken while lying, I mistook the primary systolic

published in the 5th vol. of the "Journal of Anatomy and Physiology,"* I have endeavoured to substantiate a law respecting the elements of the heart's beat, which may be thus enunciated :—

Page 19. The heart's beat consists of two parts, which for any given pulse-rate do not vary in their ratio to one another; but the length of the first part varies inversely as the square root of the rapidity of the pulse.

A second series of measurements of the cardio-arterial intervals, published in the "Proceedings of the Royal Society,"† have further verified the law just stated, and in the rest of this paper it will be assumed as proved. No theory respecting the circulation throws light on its significance; but the one which it has been my endeavour to demonstrate above gives a very satisfactory explanation of it, which will now be considered in detail.

First, the heart's beat consists of two parts, which for any given pulse-rate do not vary in their ratio to one another. It having been proved previously that the pulse-rate does not depend on the blood pressure, and, as shown now, the length of the first part of the heart's beat not varying when the pulse length is constant, it is evident that the length of the first part of the pulse-beat does not depend on the blood pressure in any way.

Again, the first part of the pulse-beat is compound, for it is the interval between the commencement of the cardiac or ventricular systole and the closure of the semilunar valves; therefore it may be divided into the systole and the valve-closure interval.

Physiologists have laid very little stress on this valve-closure interval, it generally being considered as instantaneous. But in the study of cardiograph tracings it is to be remembered that the dis-
Page 20. tances between events occurring within one-fiftieth of a second of one another can be appreciated without much difficulty, and there is every *a priori* reason for believing that this interval has a longer duration than that. In my paper on the cardiograph trace, reasons have been given for the belief that in quick pulses the commencement and the end of this valve-closure interval are indicated by separate and distinct changes of direction in the curve, and its length as obtained by measuring from these points agrees entirely with that required from arguments to be mentioned further on. It may be called the *diaspasis*,

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rise for the auricular, and was so led to the conclusion that the length of the cardiac intervals depended in some measure on the position of the body. This is incorrect, as subsequent measurements show me, and the length of the first part does not vary with the position of the body; the proper equation for finding the cardiac first part under all circumstances being $xy = 20\sqrt{x}$.

* *Suprà*, p. 18.

† *Suprà*, p. 32.

that is, the period during which the heart is being opened out by the regurgitation of blood from the arteries.

The length of the combined systole and diaspasis not depending at all on the pressure, and it being constant for any pulse-rate, it is infinitely probable that the systole and diaspasis separately are independent of the pressure, and this is extremely interesting, as it gives a further insight into the mechanism of the heart. For, in order that the duration of the diaspasis should not vary with different blood pressures, it is evident that with higher pressures there must be greater obstruction to the heartward flow of blood, otherwise the valves would then close more quickly. And this is exactly what would be expected from the combination of Mr. Bryan's observations concerning the shape of the heart, and Brücke's theory of the active diastole of the ventricles.* According to the latter author the cardiac muscular tissue has no inherent power of opening out the ventricles, but remains inactive after systole, during diaspasis in fact, until the regurgitation from the aorta has closed the aortic valves and so uncovered the orifices of the coronary arteries, immediately upon which the resulting sudden turgescence of the heart's walls makes them open up. Mr. Bryan has shown that during systole the whole heart alters its position as a result of its change in shape during contraction, and recovers it during diastole; therefore the greater the force of contraction the more will it alter its shape, and the more difficult will it be for it to resume the original one, which has to be done partly by the regurgitating arterial blood; but the greater the blood pressure, the greater will be the facility for overcoming this greater work, which two, as must be the case, vary together. This argument explains how the diaspasis need not vary in length with different blood pressures. Page 21.

Next, with regard to the systole. As the first part of the heart's beat varies as the square root of the length of the beat, and as the diaspasis, a part of that first part, does not vary with the blood pressure, upon which alone it can depend, it is necessary that the other component of that interval must vary more than as the square root of the pulse length. And to find how much more quickly, it is necessary to obtain the actual length of diaspasis. Careful measurements of a cardiograph trace, beating 102 in a minute, give the ratio of the systole to the whole beat as 1 to 3·1915, and that of the first part to the whole beat as 1 to 2·0, which leaves the ratio of the diaspasis to the beat as ·187 to 1, or the diaspasis length as ·00183 of a minute. A similar length of diaspasis is found from quicker pulses. Page 22.

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* Mr. Bryan's paper is in the "Lancet," Feb. 8th, 1834.

Brücke's theory appeared in "Sitzungsberichte der Wiener Akad. der Wiss.," 1854, Vol. XIV. p. 345. A paper on the same subject by myself will be found in the "Journal of Anatomy and Physiology," May, 1869. (*Suprà*, p. 3.)

The great interest attaching to these figures is that, when with the diaspasis equal to ·00183 of a minute, the ratio of the systole to the diastole is enquired into, it is found that there is a very simple relation between them, and that after subtracting this diaspasis of constant length, there remains the systolic varying as the square root of the diastolic period, and with no other diastolic length is so simple a ratio obtainable, which is all-important, because it will be seen that the systole must depend directly on the previous diastole.

Next, considering the systole itself; the fact above demonstrated, that its length does not depend on the blood pressure, is extremely important, and can only be explained by assuming that when the pressure rises, the circulation through the coronary vessels increases to a sufficient extent to enable the heart to get through the extra work it has to perform without altering the duration of its action, or, in more precise terms, the nutrition of the walls of the heart must vary directly as the blood pressure in the aorta.

But the systolic length varies as the square root of the diastolic, in other words, the longer the time of nutrition of the heart, the longer the systole. This at first sight seems an anomaly, but the Page 23. theory that the pulse-rate depends on the fall in tension only, presents a most complete explanation, and so throws great light on cardiac action in general.

Consider the heart as a pump working against a certain pressure, and filling an elastic reservoir with a certain resistance to the outflow of its contents. Varying the pressure has been shown to have no effect on the lengths of the different parts of the pulsation for the reasons given above; and it has next to be considered how it is that varying the resistance changes the lengths of the elements of the revolution. This pump, directly its muscular fibres begin to contract, exerts its full pressure, for there is nothing to prevent it doing so. But during the previous diastole it was supplied by blood at a certain definite pressure and for a definite time, both of which factors limit the force of the systole. Consequently, the ventricles produce directly their full systolic pressure, and maintain that pressure until they are empty. But it is evident that the time necessary for emptying them of a definite amount of blood under these conditions must depend on the rapidity of the flow from the capillaries, for when the flow is halved the systolic time must be doubled, if no other force come into play; in other words the length of cardiac systole is a function of the arterial resistance; and the pulse-rate has also been shown to be a function of the same, upon the fall of tension theory.

It has been proved that the systole varies as the square root of the diastole, not directly with it, as might be supposed. This clearly shows that the time of diastole influences the length of the systole

and shortens it, in other words, strengthens the heart, according to Page 24.
the law that may be stated thus: the nutrition of the heart varies as the square root of the time during which the coronary circulation is maintained.

It will strike some as peculiar that no mention has yet been made of the influence of the nervous system on the heart. But it appears to me that the facts which have been brought forward have not called for any special reference to it. May not the law it has been my endeavour to prove, be but an expression of that action in the healthy body? For it must depend on a somewhat complicated mechanism, as is shown by the fact that it is almost impossible to contrive a self-acting engine which would pulsate in accordance with its requirements.

As is well known, the effect on the kymographion trace of slightly stimulating the pneumogastric nerves is greatly to amplify the oscillations, and at the same time to lower the mean pressure; while cutting the pneumogastrics produces the reverse effects. The larger oscillations of the hæmadynamometer column in the former case show that the proportionate tension fall and the time of pulsation are both greatly increased, and from previous considerations it is evident that these are necessarily associated when, as now, no influence is being exerted on the peripheral vessels.*

Further, these amplified oscillations must be attended with an Page 25.
abnormal enlargement of the ventricular cavities during diastole, for the time intervening between the beats being increased, the amount of blood which flows through all segments of the circulation between any two pulsations must be also more considerable. Having arrived so far, it is extremely interesting to observe how an augmentation in the degree of cardiac dilatation during diastole, as a cause, will include and correlate all the peculiarities which are observed when the depressor nerve is thus operated on; and it is not unreasonable, therefore, to suppose that this is the direct effect of its action. As the quantity of blood contained in the heart at the end of diastole has been shown to depend on the circulation through the coronary vessels, it is evident that the explanation of any variations in the capacity of the ventricles must be referred to changes in the cardiac walls themselves. Just as the degree of rigidity of an india-rubber tube through which a current of water is flowing, can be made to vary by changing the diameter of the orifice from which the fluid is allowed to escape, so the turgescence of the ventricular walls, or what is the same thing,

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* In rabbits the normal fall of tension as judged by the hæmadynamometer trace is about $\frac{1}{20}$th of the whole, while when the pneumogastric is stimulated it may increase to $\frac{1}{10}$th or more.

the amount of active diastole of the heart, can be altered, by varying the diameter of the small arteries of the coronary system, their contraction producing a greater, and their dilatation by facilitating the flow of blood through the capillaries a less, degree of diastolic enlargement of the ventricular cavities.

Page 26. From the above argument, therefore, the amplified range of pressure and time depending on change in heart capacity, and the change in capacity being caused by modification in the calibre of the smaller coronary arteries, it is almost a logical necessity that the function of the pneumogastric nerve is to regulate the degree of tonicity of those vessels, and Dr. Brown Séquard, from entirely different facts, has also published it as his belief that the pneumogastrics contain fibres which contract the small coronary vessels.*

It will be noticed that throughout this paper it has been assumed that the systole never recommences until the ventricular cavities are completely filled, that is, until a pressure equilibrium has been arrived at in the interior of the heart. Perhaps it is the absence of pressure which admits of the heart recontracting, but this is a doubtful point, and until more is known as to the mechanism of muscular action in general, it is probable that the question as to the reason why the heart recommences to beat at a particular moment will remain unsettled. Sir J. Paget,† when he pointed out the relation of rhythmic nutrition to rhythmic action of nerves and muscles, laid the foundation for a scientific treatment of the subject, and the law which it has been my endeavour to substantiate, is only a precise method of expressing that relation.

Page 27. The following summary of the main features in the circulation, as they appear to me, may assist in explaining some of the previous arguments.

The circulation of the blood is maintained by the repeated contraction of the heart. Each cardiac revolution is divided into three parts, the systole, the diaspasis, and the diastole. The following laws hold with regard to the length of these intervals.

I. The systole together with the diaspasis, or in other words, the first cardiac interval, varies as the square root of the whole revolution.

II. The systole varies as the square root of the diastole.

III. The diaspasis varies very slightly with different pulse-rates.

The amount of work that the heart has to perform in maintaining the circulation depends on two sets of changes which may occur in

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* *See* "Principles of Human Physiology." By Dr. Carpenter, 1869, p. 219. Foot-note.

† "Croonian Lecture." Royal Society, 1857.

the system; 1. Variations in the blood pressure. 2. Variations in the resistance to the outflow of that fluid from the arteries.

As the capacity of the arteries, including the ventricles, varies directly as the blood pressure, and as the flow of blood from the capillaries does the same, the frequency of the heart's beats is dependent on the resistance to the capillary outflow, and not at all on the blood pressure; in other words, the heart always recommences to beat when the blood pressure in the systemic arteries has fallen a certain invariable proportion.

Variations in blood pressure result from: 1. Absorption into, and excretion from, the vascular system of fluids. 2. Changes in the capacity of the arterial system, which occur on the contraction or relaxation of the muscular arteries. 3. Changes in the amount of Page 28. available blood, which result from the hæmastatic dilatation of some of the yielding vessels on altering the position of the body. As changes in the first of these cannot be very sudden, and those in the latter are never very considerable, the mean blood pressure in health varies but little during short intervals.

Variations in peripheral resistance result from: 1. Different degrees of tonicity or patency of the muscular arteries. 2. Different resistances in the venous system. The former may occur independently in one or other system of vessels, as the cutaneous or the alimentary; also mechanically from pressure on a part of the body. The latter are insignificant in health.

The heart depends for its power of doing work on chemical properties in the blood it pumps into the systemic vessels, and as the blood reaches it direct from those vessels, the cardiac intramural circulation varies with the changes in the former; and the length of the systole varying only as the square root of the time of diastole, the degree of cardiac nutrition varies directly as the systemic blood pressure, and as the square root of the diastolic time. The coronary arteries supplying the whole heart, the work done by the right ventricle is governed by that done in the left; thus the supply of blood in the left auricle is always rendered sufficient for the requirements of the systemic circulation; though, as there is no reason for believing that the resistance in the pulmonary vessels varies with that of the systemic, there must be some peculiarities in the former circu- Page 29. lation (which may explain the variations in the ratio of the number of pulse-beats to respirations, in some cases).

The auricular contraction is a very small force, and its function is most probably to close the tricuspid and mitral valves.

The heart commencing its systole as a whole, it is highly probable that the impulse for action is given by a force which affects both ventricles; such is found in the coronary circulation and the active diastole produced by means of it.

In conclusion I have to present my best thanks to Dr. Michael Foster, Professor Sanderson, and Professor Pritchard of the Royal Veterinary College, for the opportunities they have afforded me in trying the experiments above detailed; without their assistance it would have been impossible for me to have put the law of the relation of blood pressure to pulse frequency on any satisfactory basis.

June 10*th*, 1872.

10. ON SPHYGMOGRAPHY.* Page 399.

PART I.

IT is to the happy conception of Marey's, in which he obtained correct amplification of sudden small movements by employing the elastic force of a spring rather than the statical pressure of weights, that we owe the form of Sphymography, now well known to most students of physiology; and the introduction of this fresh method of research has given a stimulus to the progress of precise thought respecting the circulation of the blood and the action of the heart, which must necessarily prove of extreme value in the investigation of pathological conditions, now quite beyond our grasp.

Marey's original instrument, as constructed by Breguet, is so well known, and so many excellent descriptions are accessible,† that it is not necessary to go into detail regarding it. In most respects it is the best form that has been introduced, and much credit is due to M. Breguet for the excellence of the mechanical construction. This maker has lately introduced a second instrument, which has the advantage of removing the chief defects of the original one, and of introducing very little intrinsic error.

The chief objection to the old, or knife-edge construction, as it may be called, from the fact that the recording lever is connected with the pulse pad by means of a sharp steel edge, depends on the necessary sliding of that knife-edge on the steel surface below the recording lever, by which means the distance between the axis of rotation of the lever and the point of contact of the knife-edge must vary with every movement of the former; the accompanying diagram shows how this is the case for two different heights of the lever.

In consequence of this imperfection, two traces taken, one near the top, and the other lower down on the recording paper, present characteristics which are in many respects different, and whose differences arise solely from the sliding above mentioned. The lever in the upper trace falls less rapidly than in the lower, as the knife-edge has to slide over a much larger surface in the former than in the latter, where it scarcely moves at all. As a result of this, the length of the first part of the higher trace is apparently greater than it ought to be. Page 400.

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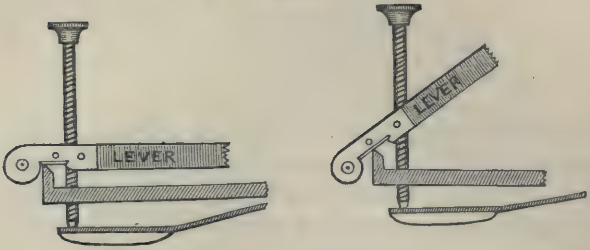
* Part I, "Journal of Anatomy and Physiology," VI. pp. 399–404. May, 1872. Part II, l.c. VII. pp. 98–105. Nov. 1872.

† Marey, "Physiologie médicale de la Circulation du Sang," Paris, 1863; B. F. Foster, M.D., "On the use of the Sphygmograph in the Investigation of Disease," 1866; J. Burdon Sanderson, M.D., F.R.S., "Handbook of the Sphygmograph," 1867; and others.

Fig. 1.



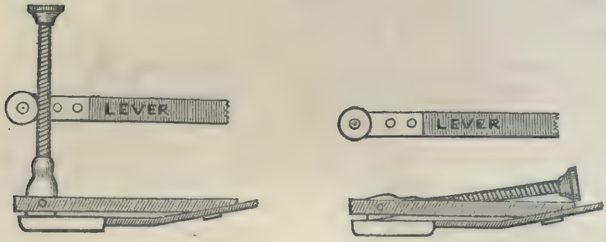
Another objection is, that there is no firm connection between the pulse-spring and the recording lever, so that when the latter is suddenly raised, as by the systolic impulse, the contacts of the lever, intermediate brasswork, and pulse-spring, are not maintained, and a "percussion-rise" is seen in the trace. This error is partly obviated by a small spring, which presses on the recording lever, and tends to keep it in contact with the other moving parts, though this is omitted by some, much to the detriment of the instrument.

Though in the taking of the trace itself, this absence of connection between the lever and pulse-spring is disadvantageous, yet in the applying and removing of the instrument it is of extreme value, for it allows of any amount of pressure being put on the latter, without producing any strain or injurious effect on the former. In practice this quality is invaluable, and it is almost impossible to obtain it in any construction other than the one under consideration.

Breguet's new sphygmograph is very simple and ingenious in principle, and in practice works admirably. As to the older instrument, the recording lever is fixed to the body of the apparatus by an axis or arbor, but the novelty consists in the manner in which this is brought into connection with the pulse-spring.

Page 401. The lever is of the third kind, as in the other instrument, but it has no steel surface below it for a knife-edge to play on, and it is, when not in use, entirely disconnected from the pulse-spring.

Fig. 2.



Near the middle of the arbor there is a small circular ring of brass, surrounding it, which has a diameter of about one-sixth of an inch. On its outer surface this ring is grooved and an endless screw is cut in this groove.

There is no brasswork attached to the pulse-spring corresponding to that in the older instrument. In its stead a long flat slip of brass, fixed about two-thirds the length of that spring from its attached end, extends onwards over the ivory pad. Just above this pad a steel screw about an inch long, with a milled-head at one end, is fixed at the other to the unattached extremity of the piece of brass just mentioned, by a hinge, and is so arranged that by means of the pulse-spring it is retained either at right angles to it, or lying along it, on the same principle that an ordinary knife-blade can be fixed half open or closed.

This long screw, when at right angles or nearly so, to the spring, comes in contact with the endless screw cut in the brass ring surrounding the arbor, and as they are of corresponding size, they bite and are retained in contact by the pulse-spring pressing on the fixed end of the screw, which is squared off in such a manner that it shall continue to press slightly backwards when in contact with the ring. It is evident from this construction that any up or down movement communicated to the pulse-pad, produces a corresponding rise or fall in the recording lever. When not in action the long screw can be thrown out of gear, down on the spring, as seen in Fig. 2, and it has also a movement which allows of its being turned round, which can be employed as a fine adjustment in regulating the height of the lever point. Page 402.

In this instrument the distance between the axis of rotation of the arbor and the part of the long screw which is in contact with the ring surrounding it, cannot vary, whatever the distance of the pulse-pad, and therefore no error is introduced in that direction. Also the difficulty in disconnecting the spring from the axis, after the trace has been taken, is very slight; though it requires some little practice to do this, before removing the instrument from the wrist, as it always should be.

This, the rackwork sphygmograph, will probably supersede the knife-edge one by degrees, for the tracings are more uniform, and in other respects quite as good as those obtained by the earlier instrument. For cardiograms it is not so advantageous.

With regard to the best means of binding the sphygmograph on the arm, the original method adopted by Marey, of lacing it with a silk ribbon to the side-lappets, is as efficient as any. The wrist should be always bent a little backwards, and care should be taken that the pad presses on the lower end of the radial artery, not on the superficialis volæ, as is apt to occur if it is fixed too far forwards. The pad introduced by Mr. Berkeley Hill enables the correct position of the hand to be maintained with facility, but it is scarcely necessary, as a little practice removes all difficulty. It is worthy of notice that better traces can be obtained after the instrument has been applied a few minutes than immediately; for the pad, by its pressure on the skin, drives blood from the small vessels covering the artery, and so lessens the distance between it and the pulse-spring.

To record the movements of the lever, it is best to employ highly glazed paper which has been smoked thinly by the flame of a composite candle; and to effect this properly, the paper must be folded on the metal plate, which is connected with the running gear of the sphygmograph, and moved quickly up and down in the flame. By Page 403. this means its edges are not charred, and a more uniform film is produced. The pen must have a fine sharp point. A spirit varnish, such as is used for photographic plates, fixes the tracings, if a little is poured over them gently, and the paper is subsequently warmed.

An entirely novel form of sphygmograph has been constructed by M. Longuet,* which, from a figure in Dr. Loraine's work, appears to possess all the requirements of an accurate instrument, except in the recording portion, where the pen, instead of writing laterally, as it might easily be made to do, rests on the paper horizontally, and has to change its relation to the body of the instrument whenever the pulse-pad moves in the least. In principle its construction is in a great measure similar to that of the cardiograph in my combined cardio-sphygmograph, which was described in this Journal in May, 1871.† It has a dynamometer attached, which measures the pressure and its changes throughout the beat.

One of the points in which Marey improved upon Vierordt's original sphygmograph was, that he made his lever write laterally instead of at its tip, by which means he obviated all difficulties connected with an exact up and down movement of the recording pen. But this gives rise to another slight error, which can and must be corrected in comparing the length of the elements of the pulse-beat. The lever, when the clockwork is stationary, traces a curved line and not a straight one, the curve being part of a circle, of which the lever is the radius, and its arbor the centre. Therefore, when the watchwork is in action, the horizontal relation of points at different heights on the recording paper is not truly represented by straight lines, drawn perpendicular to the length of the paper, but by lines projected from these points in curves parallel to that produced by the lever on the paper when it is stationary. These lines can be easily formed after the tracing has been removed from the apparatus, by scratching on it with a needle that is tied to a nail, or a piece of board with two pieces of cotton of the

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* "Bulletin de l'Acad. de Médecine," XXXIII. p. 962, 1868.

† *Suprà*, p. 27.

length of the recording lever, one to its eye, and the other near its point, if the tracing be fixed with its lower edge in the same straight line as the nail; for then the paper and nail bear the same relation to one another that the former did to the arbor of the lever when it was being recorded. Page 404.

Dr. Sanderson,* Mr. Mahomed,† and others have introduced different ingenious methods for regulating and measuring the pressure applied on the artery, which they have described in full in their books and papers on the subject; but the desired results can be only approximate, as from variations in the elasticity of the skin in different individuals and in the same individual under different atmospheric conditions, complications are introduced which cannot be eliminated.

The sphygmograph is a bad hæmadynamometer at its best, and as such its employment will probably diminish. A glance at the work of Dr. Loraine‡ will show that numberless variations in the character of a tracing can be introduced by very small changes in the position, &c., of the subject experimented on. But there is one part of the trace which is not affected in any way by these complications, and that is the relation borne by the *length* of the different portions of each beat to one another. Whether the arm is raised or lowered, whether the pressure is great or small, the interval between the systolic rise and the commencement of the diastolic rise does not vary in the least. These intervals cannot be correctly estimated, except by the aid of the sphygmograph; and as the value of any method of investigation is greatest in that direction in which it is least influenced by surrounding circumstances, it is, as it will be my endeavour to prove when considering the tracings themselves, for the measurement of these intervals that we must look for the future value of the sphygmograph.

PART II.

IN endeavouring to form a correct estimate of the significance of the various details of the sphygmograph trace, it will be necessary to enter somewhat minutely into the consideration of each of the several mutually related forces which, by their combined action, produce the resulting curve. As some of these forces are but little understood, it is clear that any attempt to explain the pulse movements by arguments deduced from tracings obtained from a "schema" of the circulation, can only be of value, as far as they relate to forces acting on Page 98.

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* *Loc. cit.*

† "Medical Times and Gazette," 1872.

‡ "Etudes de Médecine Clinique. Le Pouls." Paris, 1870.

the "schema" which are strictly comparable with similar forces at work in the human body. This consideration has prevented my basing any deductions on facts derived otherwise than from the animal body itself.

To commence with, it will be necessary to describe the tracings obtained by means of the "Hæmadromograph" of Chauveau. Dr. Lortet, of Lyons, has given an excellent figure and description of this instrument,* which, from its simplicity and efficiency, is a perfect masterpiece of mechanical design. By means of two levers it indicates on a revolving drum both the modification in the diameter of an artery during a pulse-beat, and also the changes in the velocity of the blood-current at the same spot, simultaneously. The former of these results is obtained by the use of an ordinary sphygmoscope, an instrument which measures indirectly the modifications in the area of an artery; and the latter by a long lever which, at its attached end, after passing through a slit in the side of the tube, projects a short distance into the vessel, which allows of its being moved backwards and forwards by the blood-current.

The accompanying trace (Fig. 1), taken with this instrument from the carotid of the horse, is copied from Dr. Marey's work.†

Page 99.

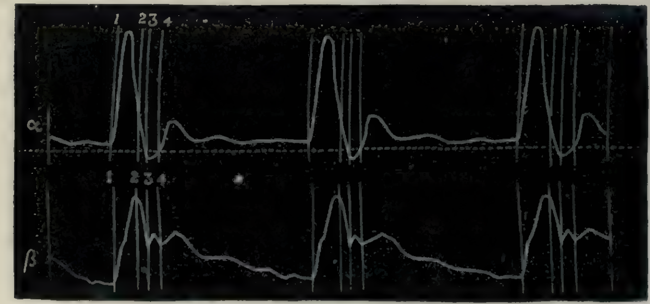

Fig. 1. Hæmadromograph trace from the carotid of the horse.

a. The current trace, in which the horizontal dotted line is the zero, indicating no current in either direction.

β. The sphygmoscope trace.

In both, the vertical line 1 cuts the curve at the commencement of systole, the line 3 at the moment of closure of the aortic valve, and the line 4 when the centrifugal current recommences.

The figure reads from left to right.

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* "Recherches sur la Vitesse du Cours du Sang dans les Artères du Cheval." Par M. L. Lortet, M.D. "Annales des Sciences Nat.," Tome VII. Zoologie, 1867. An earlier but very similar instrument, by M. Chauveau, is described in Marey's "Physiologie Médicale de la Circulation du Sang," 1863, p. 156.

† *Loc. cit.*, p. 273.

The upper curve (α) is that of the blood-current; in it the horizontal dotted line indicates the zero, or line of no current in either direction; all above shows a centrifugal current, and all below a heartward stream. The velocity of the blood's movement is measured by the distance of the point which is under consideration from the zero line in the trace. The lower curve is that obtained by the sphygmoscope, and is in all respects strictly comparable with an ordinary sphygmograph tracing. The slightly curved vertical lines which intersect both tracings are drawn by the levers when the watchwork is at rest, and the points where similarly situated lines intersect the pulse traces are exactly simultaneous, to indicate which they are drawn. With regard to these figures, Marey makes the following observations:—"I. The commencement of the pulsation coincides with the production of a rapid centrifugal current. II. The summit of the pulsation is not reached before the centrifugal current has already ceased. III. At the instant of closure of the sigmoid valves, a retrograde current is flowing in the carotid, as indicated by the position of the curve, which at that moment is below zero. IV. After the closure of the sigmoid valves a fresh centrifugal current originates, which constitutes the secondary pulsation—(dicrotism)." Dr. Lortet explains the portion of the upper or current-trace which is below the zero line, by **Page 100.** supposing that the shock of closure of the sigmoid valves is sufficiently great to produce a stretching of the proximal end of the aorta and of the valves themselves, which results in a retrograde current for a short time in the large arteries after the valves have closed. Marey's explanation, as far as it goes, seems much more satisfactory, and it will be necessary to discuss it more fully. Before doing so the precise definition of some of the terms employed will not be out of place. The main rise in the sphygmograph trace may be termed the *primary* rise, and that which occurs just after the small rise and fall which is nearly simultaneous with the sinking of the current-trace below the zero, and which therefore commences with the secondary centrifugal current, may be termed the *secondary* rise; it is almost always very clearly indicated in sphygmograph tracings (c, α, Fig. 2). The interval between these two rises may be called the *sphygmosystole*, for it is the time during which the systole at the heart influences the pulse-beat; **Page 101.** it corresponds to the *first* part of the pulse-beat in my former communications, and it must be remembered that it is not synchronous with the cardiac systole, as I have endeavoured to show elsewhere.*

From a study of tracings obtained by the use of the cardio-sphygmograph I have demonstrated, in the paper just referred to, that in

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* "Proceedings of the Royal Society," 1871, p. 318, *et seq.* (*Suprà*, p. 32), and "Journal of Anatomy and Physiology," May, 1871. (*Suprà*, p. 27.)

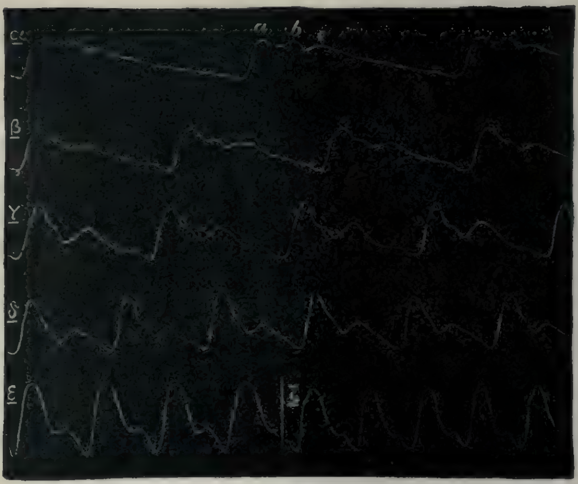

Fig. 2. Sphygmograph tracings, all taken from the same individual in health, under different conditions, to show the effect of difference in pulse-rate on the trace.

α. Pulse-rate 44 in a minute.
β. „ 63 „ „
γ. „ 72 „ „
δ. „ 103 „ „
ε. „ 137 „ „
ζ. „ 172 „ „

They are all drawn on one scale and read from left to right.

the sphygmograph trace of slow pulses the closure of the aortic valve occurs when the lever is at the lowest point of the notch that is nearly always present in the sphygmosystole, which is also clearly seen in the lower of the two tracings in Fig. 1, the curved line 3 cutting it exactly at the place which represents the moment when the valve shuts. Consequently, in the upper trace, the line 3 must also cut it at the same time, and this occurs when the retrograde current is at its maximum, as would be expected, the valve being closed by the regurgitating blood. But it may be asked, how is it that the backward current between the lines 3 and 4 in α, Fig. 1, is associated with a rise in the sphygmoscope trace? and to explain this clearly it will be necessary to refer to some of the elementary principles which operate in the transmission of currents through elastic tubes. First, it can be demonstrated that increase in the diameter of an artery may originate from two quite independent sets of causes, one being the simple result of the heart sending more blood into it in a given time than it can dispose of, the other being a shock-expansion, comparable with the waves of condensation and rarefaction in the air, which constitute sound. Most of the important elements of the pulse-trace are

referable to the former of these causes, as is proved by the general similarity between the two curves α and β, in Fig. 1. But when there are rises in the second, which are quite independent of changes in the first, they must evidently be the result of some sudden movement in the circulating system, originating a shock, which is not of a character to affect the current in any way. It is but reasonable to suppose that such should occur as a result of the closure of the semilunar valves, and the rise and fall between the vertical lines 3 and 4 in the lower Page 102.
trace (β) of Fig. 1, commencing immediately on their closure, and being unconnected with any current changes, can be nothing else than a shock-wave.

At first sight it would seem probable that when the semilunar valves had closed, the retrograde current in the aorta would immediately cease; but that such is not the case is clearly proved by the continuance below the zero line of the current curve for a short period after that event (between the lines 3 and 4 in the upper trace). It is by the combined operation of two causes in the same direction that this result is produced. First, the orifices of the coronary arteries being quite close to the semilunar valves, it is evidently necessary that the blood which enters them during diastole must be derived from the aorta, and so tends to produce in it a retrograde current. Secondly, the equilibrium of the arterial system is disturbed during the closure of the aortic valve, for immediately the systole has terminated, the only force tending to prevent the blood from regurgitating into the heart is the statical resistance of the ventricular walls, which at that moment are closely approximated, causing their cavities to be completely obliterated. This resistance is clearly much less considerable than that offered by the heart-walls during the systole, one being a statical and the other a dynamical condition; consequently the arterial blood rushes back, pushing asunder the ventricular walls, and in so doing developing a sufficiently rapid retrograde current to close the semilunar valves. The interval thus arising, namely, the time between the end of systole and the complete closure of the aortic valve, I have called the *diaspasis*, in a pamphlet on "On the Law which Regulates the Frequency of the Pulse,"* and there is considerable evidence to show that when the pulse-rate does not vary it is constant; also that it varies very slightly with different frequencies of heart-action, occupying in slow pulses about 0·002 and in quick ones 0·0018 of a minute.† The diaspasis is so short in duration that it has Page 103.

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* Published by H. K. Lewis, 139, Gower Street, London. (*Suprà*, p. 45.)

† In my pamphlet on "The Law which regulates the Frequency of the Pulse," from a mistake on my own part, a statement is made as to the length of the diaspasis, which is incorrect. Mathematical friends soon informed me of my error, as,

terminated before the loss of blood from the proximal aorta into the heart is made good by any retardation of the onward current, or a reverse stream in the more distant vessels originates; consequently this restoration of equilibrium has to be in great measure effected after the valves have closed, encroaching on the diastole to form the second cardio-arterial interval of the cardio-sphygmograph trace, which does not cease until all the complications attending the closure of the semilunar valves have come to an end, whereupon the again augmenting centrifugal current, or in very low-tensioned pulses, such as that figured in Fig. 1, the diminishing centripetal one, originates the secondary rise in the sphygmoscope trace.

In both the primary and secondary rises of the pulse-beat (Fig. 1), it is found on inspection that the summits of the pulsations (β) are delayed upon, or are not reached so soon as the centrifugal current maxima (α); and that such should be the case is essential, in a circulation maintained by an intermittent motor organ, which, like the Page 104.

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when precisely stated, the problem is a manifest contradiction. In p. 22 the diaspasis is discussed, and in the summary of the results arrived at, in p. 27, the following are given as the relations of the lengths of the various elements of the pulse-beat to one another.

1. The systole together with the diaspasis, or in other words, the first cardiac interval varies as the square root of the whole revolution.
2. The systole varies as the square root of the diastole.
3. The diaspasis is constant.

The incompatibility of these three statements it is not difficult to prove, for if the first and second are true, the third cannot be so, and, as a fact, the diaspasis is *not* constant. There is every reason to believe that for a given pulse-rate the diaspasis does not vary; and, on subtracting its length, as obtained by measurement in quick cardiograph tracings, from the first part of slow ones, I found that the remainder, the systolic interval, varied *very nearly* as the square root of the diastolic. On repeating the operation on the pulse of intermediate rapidity a similar result was obtained, and the error being extremely small, I attributed it to my not having extracted the necessary square roots to a sufficient number of decimal places, and thus felt justified in making the generalization given above. Since the mistake has been pointed out to me I have repeated the arithmetical computations more carefully, and find that what I had first supposed were errors on my part, are constant variations, which prove that, the other statement standing as above, the diaspasis is slightly longer in slow pulses, occupying approximately 0·002 of a minute in a pulse of 61, and 0·0018 of a minute in a pulse of 152 in a minute. This fact, therefore, leads to the conclusion that the rapidity of the fall of blood-tension has an influence on the length of the diaspasis, lengthening it slightly when the tension-fall is retarded, probably because the previous systole is then more powerful and gradual. It is to be noted that the second cardio-arterial interval of cardio-sphygmograph tracings is almost of the same length as the diaspasis, and varies in the same or in a very similar manner, which may be the cause of the somewhat undecided nature of the notch in the sphygmosystole of slow pulses. From these remarks it is necessary to substitute for statement 3, as given above, the following: 3. The diaspasis varies, being slightly longer in slow pulses.

heart, rests between its pulsations; for after the rush of blood into the arteries immediately the sigmoid valves open, during the rest of the systole the blood which leaves the heart is employed in retaining the higher pressure in the vessels, as will be explained more fully further on.

We are now in a position to consider the human sphygmograph tracing from the wrist, and on looking at Fig. 2 (α), which is from a slow pulse, it is evident that in all respects it closely resembles that taken with the sphygmoscope from the carotid of the horse, which has been discussed above, and there is every reason to believe that the details originate from similar causes. The primary rise (a) is followed by a gentle fall; this is soon broken by the shock-wave (b) consequent on the closure of the aortic valve, and is followed by the secondary rise (c), which commences when the centrifugal current is augmented by the recommencing onward current in the aorta. The sphygmodiastole is remarkably uniform and uninterrupted.

Between the tracings of slow and quick pulsings there is at first sight not much resemblance, but it is not difficult to obtain a series between them exhibiting every intermediate condition (Fig. 2, α, β, γ). The most important cause of the variations exhibited by pulses of different rapidities, is that the ratio between the length of the sphygmosystole and the sphygmodiastole is not constant. For instance, when the pulse is 114 a minute, the sphygmosystole occupies just one half the beat; but when it is 40 a minute, it only occupies one quarter of the whole revolution. It is evident that this must influence the general appearance of the trace, and as the length of the sphygmosystole never varies in health for any given pulse-rate,[*] a knowledge of the ratio of the length of sphygmosystole to that of the whole beat is sufficient datum for determining the pulse-rate. In the paper just referred to I have given several measurements of these ratios, and have shown that the length of the sphygmosystole maintains a very definite relation to the length of the beat, varying as its cube root, consequently when the length of the revolution increases in the series 1, 8, 27, 64, &c., the sphygmosystole only does so as 1, 2, 3, 4, &c., so that if we call the rapidity of the pulse x, and the number of times that the sphygmosystole is contained in the beat y', the length of the sphygmosystole can be found from the equation

Page 105.

$$xy' = 47 \sqrt[3]{x}.$$

Further, the cardio-sphygmograph[†] shows that the interval between the closure of the aortic valve and the commencement of the secondary

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[*] "Proceedings of the Royal Society," No. 120, 1870. (*Suprà*, p. 14.)

[†] "Journal of Anatomy and Physiology," May, 1871. (*Suprà*, p. 27.)

radial rise (the second cardio-arterial interval) varies but little with different pulse-rates, while that between the primary radial rise and the closure of the aortic valve (the conjugate cardio-arterial interval) does so much more rapidly, both being longer in slow pulses. This also greatly influences the appearance of the pulse-trace, for, as previously shown, the small rise and fall at the end of the sphygmosystole results from the shock of closure of the aortic valve, and as this occurs in slow pulses an appreciable time after the primary rise has reached its maximum, it is clearly seen as a separate element of the curve. But in quick pulses the second cardio-arterial interval is nearly as long as in the slow ones, while the conjugate cardio-arterial interval is much shorter, consequently the shock-rise and fall following the aortic valve closure is thrown back, as it may be termed, on the primary rise, and, being blended with it, is not separately distinguishable. This is the cause of the simplicity in the sphygmosystole of quick pulses.

11. ON THE SOURCE OF NERVE FORCE: A THEORY.* Page 251.

The universally acknowledged inefficiency of any theory at present before the scientific world to account for the origin of the force by which, through the intervention of the nervous system, organs at a distance from one another are placed in communication, makes me feel justified in publishing a theory which has been in my mind for some time, and which during that time accumulated information has not in any way shaken.

The following is my proposition:—The species of energy which exhibits itself in the form of "nerve force," is electricity of thermo-electric origin, resulting from the fact that the surface of the living animal body is always colder than its interior. In other words, the available energy resulting from the interior of the living animal body being at a higher temperature than that of the surrounding medium, is expended wholly, or in great measure, in generating the force called nerve force. In the discussion of this problem, the following are the considerations on which it is based.

1. The temperature of the interior of the living body is always greater than that of its surface, because all animal life is only a form of chemical degradation, and is therefore necessarily attended with evolution of heat; which, no other force intervening, will always keep the interior of the body hotter than the medium in which it lives. When the temperature of the air in higher animals exceeds or nearly approaches that of the body, which varies but little, special arrangements (perspiratory, &c.) come into play to diminish that of the surface.

2. There is an available source of energy in the body, which has been but little considered by physiologists, depending on the temperature of the surface being lower than that of the interior. The theory propounded gives employment for this force.

3. In the struggle for life, the individuals that economise the forces at their disposal are most likely to survive; it is therefore im- Page 252. probable that this not inconsiderable source of energy should have escaped employment in this struggle.

4. The actual construction of the nervous system is quite sufficient for the working of such a force as the one proposed. In addition to the already known properties of the nerves, including their good conducting power, it is only required that *a thermo-electric current be cap-*

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* "Journal of Anatomy and Physiology," VII. pp. 251–4. June, 1873.

able of being generated between soft tissues of different composition or structure, such as the extremities of the sentient nerves and the corium in which they are embedded.

Although Magnus was not able to produce any thermo-electric current between fluid metals, his experiments are not in any way conclusive against the possible existence of such currents between different tissues; the subject is in a position for actual demonstration, no doubt, and I much regret that as yet I have not had opportunities of attempting to prove or disprove it. Notwithstanding this, some of the circumstantial or collateral evidence is so strong, that, without any direct proofs, I feel justified in assuming its correctness. The following points strongly favour my theory.

1. Within certain limits, which are those to which the body is most generally exposed, the energy of the individual (which must be closely related to the supply of nerve force) is greater as the temperature of the air is less. On a cold day, in a cold air, there is more will and power to work physically than in hot weather, in a hot air, during which languor is a prominent feature. In a paper published in this Journal* I have proved that the circulation through the skin in man varies according to the temperature of the atmosphere, and that when 70° F. of the air is reached, perspiration commences. Consequently by this means a difference of about 30° F. is always maintained in health between the surface and the interior; and exposure to the highest temperatures of the Turkish bath, when continued for some time, does not disturb this condition. But a hot-water bath is followed by very different consequences; if the body and face be immersed in one of 100° F., and breathing be performed through a tube projecting from the mouth to the surface, as I have tried, faintness, or loss of nerve power, comes on very rapidly, and is it not because the Page 253. temperature of the surface is raised to that of the interior? At all events this explanation is as reasonable as any other. This faintness is soon recovered from on the reapplication of cold to the skin.

2. The effect of muscular exercise is to raise the temperature of the body, and so to increase the difference of temperature between it and the external air; and when great muscular exertion has to be sustained, as in rowing, most of the clothes have to be removed in order to allow of the rapid cooling of the surface, the necessity for which is keenly felt.

3. During intra-uterine life the active chemical changes going on in the body of the fœtus maintains its temperature at a slightly higher point than that of the mother; but immediately after birth the nerve force generated by the cooling of the surface brings the intercostal

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* *Suprà*, p. 37.

and other muscles into play, and the child is otherwise much more active than when *in utero*.

4. The source of the body heat being central, and the circulation of the blood tending to render that of all the parts uniform, it is evident, as a simple physical deduction, that the temperature of the portion of the body which corresponds to the heated end of the thermo-electric couple (which in the theory now under discussion can only be the brain), must be lower than that of the blood, because the heat supplied to, and developed in it (the brain), is partly employed in generating the electric current which is circulating. Dr. John Davy noticed that the temperature of the brain of the rabbit was peculiarly low, considerably below that of the abdominal viscera; his results have been considered improbable by some, but have never been refuted; they are strongly in favour of my theory, which, as shown above, explains them completely.

Upon my theory the mechanism of the nervous system may be thus summarised—

The afferent nerves are the conductors to the nerve centres of the electric current which is generated by the contact of their peripheral ends with the tissues of the cooled skin, which they supply. The brain is the largest of the centres towards which the nerve current is directed, the other ganglia forming the smaller. Through these centres the currents, as through an elaborate commutator, are split up or concentrated in a manner not understood as yet, to be directed **Page 254.** along the efferent nerves, which are always so situated as to be beyond the reach of external cooling influences. Where an organ acts in any way automatically, it generally has centres of its own, of a size varying in degree according to its automaticity, and these minor centres are only to a certain extent subject to the influence of the brain.

As in the working of the electric telegraph, no return or second special conductor is required to carry back the current to the point from which it started; for where an efferent nerve terminates in a muscle, it loses its insulating covering, and so is put into indirect communication with the peripheral sentient nerves through the intervention of the mass of body tissue generally, which, though its resistance is much greater, offers an incomparably larger mass to be traversed by the current.

Page 140. 12. ON SOME POINTS CONNECTED WITH THE CIRCULATION OF THE BLOOD, ARRIVED AT FROM A STUDY OF THE SPHYGMOGRAPH-TRACE.*

(Pl. III.)

Since my first communication to the Royal Society, "On the relative Duration of the Component Parts of the Radial Sphygmograph-Trace in Health" ("Proceedings of the Royal Society," XVIII. p. 351†), it has not been my good fortune to find any similar observations by other physiologists, either in favour of or in opposition to my statements. From that time my attention has been continually directed to similar phenomena; and the employment of similar methods has led to results which seem to have an important bearing on the problem of the action of the heart. It is evident that a thorough knowledge of the nature of the pulse in the arteries, when combined with that acquaintance with the anatomical mechanism of the heart and arteries that can be arrived at from *post mortem* examination, is sufficient basis for a fairly thorough study of the circulation of the blood. It has been my endeavour, by the employment of the sphygmograph as constructed by M. Marey, to obtain an amount of information from the curves which it produces sufficient to generalise on the nature of the cardiac action in some of its details which have not as yet attracted attention. The results will be stated in the form of propositions.

Prop. I. The length of the interval between the commencement of
Page 141. the ventricular systole at the heart and the closure of the aortic valve does not vary when the pulse-rate is constant, and varies as the square root of the length of the pulse-beat—being found from the equation $xy = 20\sqrt{x}$, where x = the pulse-rate, and y = the ratio borne by the above-named part to the whole beat.

This law, in a somewhat modified form, was enunciated by myself in a paper published in the "Journal of Anatomy and Physiology" (V. p. 17),‡ where the peculiarities of the curves taken in the lying posture misled me as to the point of commencement of the ventricular systole, and led me to state that posture had an effect on the duration of the systole. Such, however, is not the case; for, while lying, the weight of the heart is apparently sufficiently great to neutralise the

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* "Proceedings of the Royal Society," XXIII. 1875, pp. 140–51, Pl. 5. Read April 23, 1874. An abstract of this paper is published, *loc. cit.*, XXII. pp. 291–3.

† *Suprà*, p. 14.

‡ *Suprà*, p. 18.

effect on the trace of the auricular contraction, and to make the thus taken trace deficient in the rise which at other times results from that contraction. At all events if this assumption be made, it is found that the lengths of the different parts of the beat are not influenced by posture, and they agree exactly with the above-stated law.

The following are measurements made since the publication of the original paper, which tend fully to confirm the above statement:—

Pulse-rate.	Number of times the first part is contained in the whole beat.	Calculated ratio of first part to whole beat on formula $xy = 20\sqrt{x}$.
46	2·925	2·93
48	2·8, 2·88	2·885
49	2·85	2·86
52·5	2·71	2·765
56	2·63	2·675
57	2·75	2·66
58	2·65	2·625
60	2·63	2·59
64·5	2·556	2·49
69	2·45	2·4
74	2·28	2·325
79	2·23, 2·275	2·24
80	2·24375, 2·207	2·225
81·5	2·2, 2·185, 2·093	2·2
84	2·105	2·175
85	2·09	2·16
86	2·17, 2·053	2·155
88·5	2·245, 2·275	2·11
90·5	2·062	2·1
92	2·12	2·09
92	2·0875	2·08
94	2·14125	2·05

Prop. II. The length of the interval between the commencement of the primary and the dicrotic rises in the radial artery is constant for any given pulse-rate, and varies as the cube root of the length of the pulse-beat—being found from the equation $xy' = 47 \sqrt[3]{x}$, where $x =$ the pulse-rate and $y' =$ the ratio borne by the above-named part to the whole beat. Page 142.

This law was enunciated in the paper before referred to as read before this Society by myself, and published in its "Proceedings" (XVIII. p. 351).[*] Since that paper was read a fresh series of measurements have strongly confirmed its accuracy, and practice in manipulation has diminished my limits of experimental error so far that a difference of 5 per cent. from the calculated results is rarely found.

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[*] *Suprà*, p. 14.

The following table contains some of the more recent results and one or two more careful measurements of old traces :—

Pulse-rate.	Ratio borne by sphygmosystole to whole beat, as	
	Found by measurement.	Calculated from equation $xy'=47\sqrt[3]{x}$ (approximately).
38	4·175	4·18
43·5	3·825	3·8
44·5	3·7875	3·75
56	3·29	3·22
58	3·195	3·135
59	3·185	3·0
63	2·911	2·96
63·5	2·938	2·95
64	2·904	2·93
65	2·83, 2·821	2·9
67	2·825, 2·788	2·84
66·5	2·889	2·795
69	2·7	2·78
73	2·625	2·685
105	2·132	2·13
140	1·735	1·75

Prop. III. The length of the interval between the primary and the dicrotic rises follows the same law in the carotid and posterior tibial that it does in the radial artery.

That such is the case as far as the femoral and posterior tibial arteries are concerned is shown by Dr. Galabin in a paper "On the Secondary Waves in the Pulse," recently published (Journal of Anat. and Phys., 2nd series, No. xiii). It is not necessary, in proving this law, to undertake any large series of measurements; for if *all* those which are taken agree exactly with the calculated result obtained from the radial equation, the probability that it is correct is almost infinitely great. In a boy, ætat. 16, whose radial pulse was previously
Page 143. proved to follow the above law exactly, the following are the results obtained by measuring the carotid tracings :—

Pulse-rate.	Ratio borne by sphygmosystole to whole beat, as	
	Found by measurement.	Calculated from radial equation.
67	2·899	2·84
68	2·827, 2·6	2·8
72	2·7144	2·7
77	2·583	2·59
77	2·594	2·59

In another subject, ætat. 22, the following are the results:—

Pulse-rate.	Ratio borne by sphygmosystole to whole beat, as	
	Found by measurement.	Calculated from radial equation.
77	2·6625	2·595
78	2·575	2·575
85	2·443	2·44

With regard to the posterior tibial artery, most of the results were obtained by the employment of the double sphygmograph, to be described further on, in which the superposition of the simultaneous posterior tibial trace on that from the radial artery showed that the interval between the commencing primary and dicrotic rises is the same in both. The following are a few independent measurements from tracings from the artery behind the ankle:—

Pulse-rate.	Proportion borne by first part to whole beat in ankle trace.	Proportion borne by first part to whole beat in radial trace (approximately).
70	2·7	2·76
73	2·675	2·685
80	2·596	2·525
82	2·4575	2·5
82·5	2·517	2·495
88	2·378	2·378

Corollary.—The length of the interval between the primary and secondary rises being exactly the same in the carotid, radial, and posterior tibial arteries, which are three vessels at very different distances from the heart, it is evident that *the length of this interval is constant throughout the larger arteries, and must be of the same duration at the origin of the aorta that it is in the radial artery at the wrist.*

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The corollary to Prop. III leads to theoretical results of considerable importance; for as the duration of the different elements of each beat in the radial artery is the same as that in the commencing aorta, by superposing the sphygmograph-trace upon the cardiograph-trace at any given pulse-rate, a comparison can be made between the duration of the different physiological changes going on in the heart and those going on in the commencing aorta; in other words, the time during which the ventricular and arterial systoles are continuous can be ascertained with precision by an indirect method, which alone is possible in the human subject.

Taking the equations given in Prop. I and Prop. II, the length of the systolic portion of each beat in the cardiograph- and sphygmograph-traces may be calculated with facility for any value of x. From the equation above given, namely, $xy = 20\sqrt{x}$ and $xy' = 47\sqrt[3]{x}$, it is found that the length of the arterial systole is shorter than the cardiac, as would be expected, because the cardiograph-trace is an indication of the movements in the muscular walls of the heart, and not of the contained blood, and because a certain tension must be reached by the intraventricular blood at the commencement of the systole before it can push open the aortic valves.

The sphygmosystole being therefore shorter than the cardiac systole, it becomes a question, when an attempt is made to superpose them exactly, as to whether they correspond at the commencement or the end of the cardiosystole. This is easily answered; for independent observations show the points in both at which the semilunar valves of the aorta close. These points in the traces must evidently be simultaneous, which is therefore the same thing as saying that the interval between the greater cardiosystole and the shorter sphygmosystole is at the commencement of the cardiosystole. This interval, the existence of which is well indicated in Marey's cardio-aortic tracings from the horse, may be termed the *syspasis* (the time during which the ventricles are raising the pressure of their contained blood); and the following Table, obtained from the two equations just mentioned, gives its length at different pulse-rates:—

·0018753′ at $x = 36$ approximately.
·00132986′ ,, $x = 49$,,
·000931′ ,, $x = 64$,,
·00004199′ ,, $x = 81$,,
·0003766′ ,, $x = 100$,,
·00024645′ ,, $x = 121$,,
·000118′ ,, $x = 144$,,
·000000′ ,, $x = 170$,,

From this Table it is evident that the syspasis varies considerably with different rapidities of pulse, decreasing rapidly with increase in
Page 145. the pulse-rate and becoming *nil* when it is 170 a minute, which may be fairly conceived to be very near the limit of cardiac rapidity in man.

That this interval (the syspasis) should vary so considerably in length with different pulse-rates is not easy to explain at first sight; nevertheless a careful review of the different processes which are in operation in the heart at the time has suggested to me an explanation which seems reasonable. It depends on the fact that the extreme shortness of the diastole makes any variation in its length have a marked influence on the amount of blood which enters the capillaries of the walls of the heart, and consequently influences the amount of work which the muscular fibres of the ventricle have to perform in emptying their interstitial vessels before they can commence contracting on the blood in their contained cavity. Experiment shows that the rapidity of the pulse does not depend on the pressure of the blood in the arterial system;* consequently the length of the syspasis is not influenced by the arterial blood-pressure, which is the same thing as saying that the force of the cardiac contraction varies directly as the blood-pressure; for then the muscular power of the ventricular walls to overcome the intramural distension, varying with it, prevents its duration from being modified.

It has been my endeavour to show elsewhere† that the force of the heart's contraction is modified by the length of diastole, varying as its square root. Such being the case, it is evident that the length of the syspasis must vary with that of the diastole, though not to the extent that is found to occur. But the diastolic period being always so short, it is evident that the longer it is the more thoroughly does the heart-tissue get permeated with blood, in a way which can have little or no influence on its nutritive power, but a great effect in modifying the length of the syspasis in the direction which is found to occur.

Again, referring to the results of the cardio-sphygmograph observations published by me in the "Proceedings" of this Society (vol. xix, p. 318),‡ that paper contains a table of the length of the different cardio-arterial intervals; and if from the first cardio-arterial interval, as there defined, the length of the syspasis be subtracted at the corresponding rates, it will be found that the remainder of the interval is of exactly the same length as the second cardio-arterial interval, which, on the assumptions made, it could only be, as both the systole and the shock of the closure of the aortic valve are propagated along the arteries from the same point under similar circumstances. The following table gives the lengths of the first cardio-arterial interval from which that of the syspasis as above determined has been subtracted, and by their side the lengths of the second cardio-arterial interval, as copied from the table in the communication referred to; *their similarity cannot be the result of simple coincidence*, as they are derived from independent sets of measurements.

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* "Journal of Anatomy and Physiology," November, 1873. (*Suprà*, p. 51.)

† *Ibid.* vol. viii. (*Suprà*, p. 59.) ‡ (*Suprà*, p. 32).

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Pulse-rate.	First cardio-arterial interval with syspasis subtracted.	Second cardio-arterial interval.
36	·0023982′	·00239821′
49	·00233314′	·00233342′
64	·002274′	·00227425′
81	·00220541′	·00220546′
100	·0021875′	·00218745′
121	·00208455′	·0020847′
144	·0020185′	·0020185′
170	·0019704′	·0019729′

After the completion of the cardio-sphygmograph tracing above referred to, it was my endeavour to obtain satisfactory double sphygmograph tracings from arteries at different distances from the heart. Two or three unsuccessful attempts suggested the plan which has proved successful. It was soon evident that there is only one artery, other than the radial, which it is possible to manipulate with any degree of facility, especially when the experimenter is the subject of experiment. This artery is the posterior tibial at the ankle, where it runs in the interval between the internal malleolus and the tuberosity of the os calcis, just before it gives off the internal calcaneal branches. On myself, this artery is as superficial and as easily reached as the radial; in the sitting posture it is quite under command when the foot is crossed over the opposite knee; it is considerably further from the heart than the radial; and to obtain as great a difference as possible, the right wrist was on all occasions the one experimented on, the wrist and the ankle being, as far as can be estimated on the living body, 29 inches and 52½ inches respectively from the aortic valves.

Before going further it will be necessary to consider *the sphygmograph-trace from the posterior tibial artery at the ankle.* Wolff* has published the results of his observations on the *dorsalis pedis* artery; and as they correspond with those from the ankle-trace of the posterior tibial, they may be recapitulated. He remarks that the pulse at the foot has a general resemblance to that at the wrist, it differing in the primary ascent being less abrupt and the summit less acute. In the descent the secondary undulation is remarkably insignificant. The other minor undulations are less constant. My observations confirm the above with respect to the general similarity between the two pulses, the greater obliquity of the primary rise, and the less constant character of the minor undulations; the secondary rise has, however,

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* "Characteristik des Arterienpuls."

never struck me as peculiarly insignificant, though it has peculiarities, to be mentioned immediately.

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The ankle-trace of a pulse at about 70 a minute, as taken with an ordinary sphygmograph, differs from that at the wrist in more than one point. The primary rise, as previously mentioned, is less abrupt; the following fall is more considerable, and is not broken by the notch nearly constantly seen in wrist-traces of this rapidity. The secondary rise starts from a lower level and is well marked, reaching its climax considerably nearer the next primary rise than in the wrist-trace. There is, however, another feature in the early part of the secondary rise in the ankle-trace, which deserves special attention because of its general occurrence. As is well known, in wrist-traces the secondary rise commences promptly and is quite uniform in character, but in ankle-traces there is nearly always a short horizontal continuation of the curve immediately following the primary fall, the point of departure of the two lines being clearly indicated by an abrupt, though not considerable, change in direction. This horizontal portion of the trace is not of any considerable length, being in a pulse of 70 a minute about one-eighth of the whole beat; it is followed by a well-defined secondary rise, which is much longer and more gradual than the primary. Though described above as horizontal, this short interval between the two undulations is not so always, being frequently slightly oblique, sometimes in one direction, sometimes in the other. When its curve is downwards (that is, when it tends in the same direction as the primary fall), it may appear to be part of that event, which would then look as if broken; when its curve is upwards (that is, when it tends in the same direction as the secondary rise), it makes the trace appear more normal in comparison with that from the wrist.

Having now explained the ankle sphygmograph-trace, in considering the simultaneous wrist and ankle traces, it will be necessary to commence with the description of the instrument employed to obtain them. A drawing from it above is seen in Plate III, fig. 1, from the side in fig. 2, and a double sphygmogram is given in fig. 4.

The double sphygmograph is constructed from two of the ordinary sphygmographs of Marey, as first constructed by Breguet. One, that employed in taking the ankle-trace, retains all its original parts, except the side lappets for fixing it to the arm, and its recording-apparatus receives the double trace. A second lever is fixed in connexion with it by two uprights so placed as to allow the axis of the second lever to be parallel to and above the one belonging to the instrument, sufficient room being left to allow the latter to move unobstructed up to the top of the recording paper. This second lever, which is a *fac simile* of that used in the sphygmograph, is placed so that it will write on the same recording-paper as the first; but its position is reversed. The accompanying sketch (fig. 3) will show this point, it representing a side view of the ordinary knife-edge lever upside down—that is, with the surface (*s*) on which the knife-edge ought to slide uppermost. The object of this arrangement will be seen immediately.

The second sphygmograph has the watchwork removed, as well as Page 148. the brasswork which is fastened to the spring that presses on the pulse, to the end of which a small wire loop is soldered. In addition, a small piece of wood is screwed into the nearer of the two holes by which the watchwork was fixed, in such a way that it can be made to revolve with difficulty. The two instruments are fastened together by means of a screw and nut in the foot-sphygmograph, which bind a brass plate in that for the wrist. This screw is fixed on a plate of brass which is attached to the end of the instrument furthest from the watchwork in the manner shown in the figure. The brass plate in the other sphygmograph, which it binds, is fixed on the side of the body of the instrument close to the arbor of the lever. The exact position of these additional pieces of brasswork has to be determined by the direction that a silk cord takes when, fixed at one end to the arbor-end of the inverted lever mentioned above, it is threaded through the loop on the tip of the spring of the wrist-sphygmograph. This cord has to be parallel to the sides of the ankle-sphygmograph, when the two instruments are fastened together with the nut at right angles to one another.

On commencing to take a double trace the nut is unscrewed, and the two instruments are separated from one another. The wrist-sphygmograph is then bound, as usual, on the right arm. The silk cord attached to the arbor-end of the wrist-pulse lever (the upper one in the ankle-sphygmograph) is then threaded through the loop at the tip of the wrist-spring, and the binding-screw to fix the two instruments is passed into the hole in the plate of the wrist-sphygmograph made to receive it; after which, the nut being screwed fast down, the two sphygmographs form a single mass. The silk cord is then carried round the piece of wood at the watchwork end of the wrist-sphygmograph, and, after being slightly tightened, is fixed in a groove on its side. The whole is now ready for commencing the trace. To do this the ankle instrument (with that for the wrist attached to it and to the arm) is placed over the left foot, which has to rest on the right knee, parallel to the direction of the leg, with the watchwork towards the body. The recording-paper is placed in position; the silk thread is tightened by slightly turning the wooden peg to which it is fixed, and the wrist-lever is made to pulsate by it towards the upper part of the recording-paper. The ankle-sphygmograph, held by its watchwork end in the left hand, and attached at the other extremity to the right wrist, is then pressed down on the inside of the left foot (which rests on the right knee), in such a way that its pulse-pad compresses the posterior tibial artery where its pulsation is most manifest. The lever is made to record on the lower part of the smoked paper, below the one connected with the wrist. When both levers are found to be working freely, the recording-paper is set moving by liberating the watchwork-catch with the left thumb, which is close to it. The respiration must be checked during the time the recording-paper is moving, to prevent irregularities in the trace.

Results arrived at from the Study of the Simultaneous Wrist and Ankle Tracings.

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In employing the tracings obtained from the above compound instrument, two objects were kept in view—*first*, to find the interval between the commencement of the primary rises in the wrist and ankle curves; and *secondly*, to observe whether or no the superposition of the one trace upon the other verified or falsified the statement made in Prop. III, that the lengths of the different parts of each element of the curve were the same in the two arteries.

The following table contains the measurements of the lengths of the intervals between the commencement of the primary rise in the wrist and ankle tracings at different rapidities of pulse, from which it is clear that this interval varies very slightly within the range that can be obtained, and that the tendency is for it to be very slightly longer in the slower pulses.

Rapidity of pulse.	Length of interval between commencement of systolic rise at the wrist and at the ankle.						
62	·00115′	occurring	14·08	times	in	each	beat.
63	·00125′	„	12·7	„	„	„	
67	·001343′	„	11·11	„	„	„	
„	·0013278′	„	11·24	„	„	„	
70	·001222′	„	11·7	„	„	„	
71	·00136′	„	10·2	„	„	„	
„	·00124′	„	11·41	„	„	„	
„	·0013′	„	10·8	„	„	„	
72	·0012′	„	11·7	„	„	„	
„	·001206′	„	11·52	„	„	„	
79	·001145′	„	11·06	„	„	„	
80	·00126′	„	9·96	„	„	„	
81	·001233′	„	10·37	„	„	„	
82	·001123′	„	10·86	„	„	„	
„	·00122′	„	10	„	„	„	
95	·00122′	„	8·67	„	„	„	
98	·001085′	„	9·7	„	„	„	
99	·00116′	„	8·607	„	„	„	

which gives an average length of ·0012314 of a minute for all the rates.

It being possible to estimate with considerable accuracy the distance from the aortic valves of the spots on the arteries at which the instrument is usually applied, it becomes a point of interest to determine from the facts arrived at the rapidity with which the primary undulation travels from its origin (the heart) to the peripheral vessels. The radial artery at the wrist and the posterior tibial artery at the ankle are, as nearly as can be determined, 29 inches and 52½ inches respectively from the origin of the aorta in myself (on whom all the tracings have been taken), as previously mentioned; and as Page 150. the time of transit of the wave varies very little with different rapidities of pulse, a single example may be taken to illustrate the point in question. With the heart beating 100 times in a minute, the time taken by the primary wave in reaching the wrist (that is, the length of the first cardio-radial interval with the syspasis subtracted) has been shown in a previous table to be ·0021875 of a minute. Adding to this the interval between the radial and ankle primary rise at the same rapidity, which is very nearly ·00116 of a minute, ·0033475 of a minute is the time taken by the systolic wave in travelling from the heart to the ankle. But if this wave went the extra distance to the ankle (52·5 —29 =) 23·5 inches, at the same rate at which it reaches the wrist, the length of the first cardio-malleolar interval would be ·00459375 of a minute (29 : 52·5 : : 21875 : 459375); but it is only ·0033475 of a minute, which is considerably less; consequently *the wave augments in rapidity as its gets further from the heart*, a phenomenon beyond my power to explain.

By superimposing the wrist-trace from a simultaneous sphygmogram on that from the ankle, it is found that the components of each are of exactly similar duration, though the peculiar short interval following the dicrotic notch in the latter sometimes complicates the results. This exact similarity in length of the different elements of the two pulses is not, as will be found by those who attempt to measure them practically, self-evident from the tracings themselves; because the one being slightly later than the other, and the watchwork varying in rapidity, gradually increasing and then declining, the radial, which is the earlier, is slightly the shorter in the commencement of the trace and the longer towards its end. In the middle of the recording-paper the two coincide. It may therefore be said that the compound sphygmograph-trace is entirely in favour of the correctness of Prop. III.

In conclusion, the following is a summary of the results arrived at in this communication:—

I. The lengths of the different elements of the pulse-beat being

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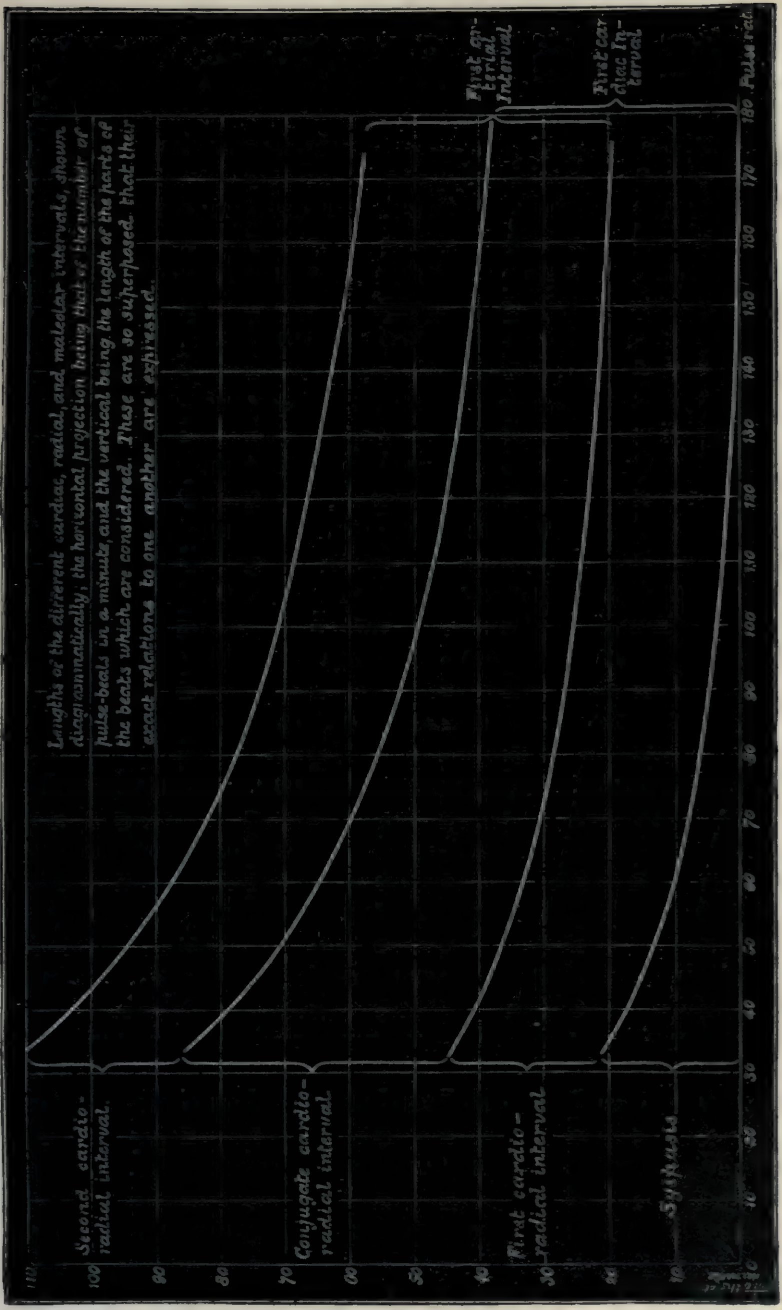
Lengths of the different cardiac, radial, and maleolar intervals, shown diagrammatically; the horizontal projection being that of the number of pulse-beats in a minute, and the vertical being the length of the parts of the beats which are considered. These are so superposed that their exact relations to one another are expressed.
Second cardio-radial interval.
Conjugate cardio-radial interval
First cardio-radial interval
Syphasis
First arterial Interval
First cardiac Interval
Pulse rate
110
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

the same in arteries at different distances from the heart, the radial sphygmograph-trace expresses their duration in the aorta.

II. The cardiosystole being longer than the sphygmosystole at all possible pulse-rates, the excess in the length of the former expresses the time required by the heart to reach, from a state of rest, a systolic pressure sufficient to open the semilunar valves. This interval, termed the *syspasis*, is constant for any given rapidity of cardiac action, and rapidly decreases as the pulse gets quicker, becoming *nil* at a rate of 170 a minute.

III. The interval between the commencement of the primary pulse-rise in the radial and that in the posterior tibial artery is less than would be estimated from the time taken by the same wave in travelling from the aortic valve to the radial artery.

The woodcut (p. 89) will assist in illustrating the mutual relations of the different component parts of the cardiac revolution, as its different elements are there shown in their actual relations one to the other.

PART II.

ANATOMICAL PAPERS.

13. ON THE TELSON OF THE MACRUROUS CRUSTACEA.* Page 271.

THE relations of the telson of the lobster and its allies are so variously regarded by zoologists of the present day, that no apology is needed in bringing forward any facts which tend to settle the point. By Milne-Edwards it is considered as a seventh abdominal segment; but I cannot find in his writings any reasons given for his belief. Van Beneden is also stated by Professor Rolleston to hold the same opinion. Professor Huxley considers the telson an azygos appendage, and not a true segment of the body; and Professor Rolleston agrees with him, stating that it only carries appendages in one or two cases, whereas it is a law common to all Crustacea, that every segment has its appendages.

An attempt will be here made to show that in a specimen of *Scyllarus arctus*, in the Zoological Museum of the University of Cambridge, there is sufficient evidence to prove that the telson is a true body segment, and that it is provided with true segmental appendages, though the nature of these is somewhat modified by cohesion and adhesion.

In this specimen the *sixth* abdominal segment is in the main similar to that in the lobster, but its dorsal surface is grooved instead of plain. The infero-lateral terminations of its dorsal shield are slightly recurved and not sharply pointed, those of the first abdominal segment being decidedly so, but the acumination becomes less marked in each succeeding one. The swimmerets are greatly developed, the propodite not exhibiting any decided spinous protuberances. Both the exo- and the endo-podite, which are expanded horizontally, are composed of two, a proximal calcified and a distal fin-like portion; the anterior margin of the former in each of these segments being prolonged outwards in the form of a spine. The distal fins are composed of a translucent membranous substance supported on a radiating framework.

At the attached extremities of the anterior and posterior margins of these fins, there are small elongated calcified masses, which seem to be the points at which their delicate structures come in contact with Page 272. one another and the neighbouring parts.

Ventrally there is a transverse calcified bar, concave forward,

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* "Journal of Anatomy and Physiology," V. pp. 270–3. May, 1871.

slender, and composed of a central and two lateral elements, which are fixed to the sides of the dorsal shield.

The *seventh* segment, or telson, consists of a distal fin and a proximal calcified portion. The fin is azygos, semi-elliptical, and supported on rays, like the exo- and endo-podites of the sixth segment. It also resembles them in having two lateral elongated calcified masses at its margins. There is no median separation.

The calcified portion consists dorsally of a small semicircular centrum or dorsal shield, which is close under the dorsal plate of the preceding segment, and is separated from the lateral masses by a marked groove, not by an articulation.

These lateral masses are each distinctly separable into three parts: 1st, a thin longitudinal one, which approaches the sixth dorsal plate, and ends posteriorly in a sharp spine.

Internally it comes in contact with the next, the 2nd part, which latter joins the azygos centrum at its antero-internal margin, and at its distal end gives attachment to the 3rd part. Beyond the centrum there is a considerable interval between the two lateral masses dorsally.

The 3rd part consists only of a free spine, directed backwards and articulated to the 2nd. It rests on the azygos fin.

Ventrally this segment presents only a short transverse bar, in front of the anus, composed, as in the preceding one, of a central and two lateral portions.

On the supposition that this seventh segment is a true one, the small dorsal centrum corresponds with the much larger one in the other segments, while the swimmerets are represented by the lateral masses described above; the 2nd part of which corresponds with the propodite, and the 1st and 3rd with the exo- and endo-podite respectively, each bearing spines, and connected with the propodite and with the fin.

The short transverse ventral bar corresponds to the narrow centrum, and is composed of the portions, as in the preceding segment. I have no means of telling whether it is laterally connected with the dorsal shield.

Page 273. The position of the anus behind this seventh transverse bar is strongly in favour of the alimentary canal being segmentally terminal, although this condition is disguised by the coalescence of the lateral appendages above, which consequently makes the anus ventral.

If the above explanation is accepted with regard to this particular species, it is highly probable that it is true in those allied to it, and would then refer to the lobster and cray-fish. Professor Rolleston says of the latter,* that the proximal segment of the telson is not

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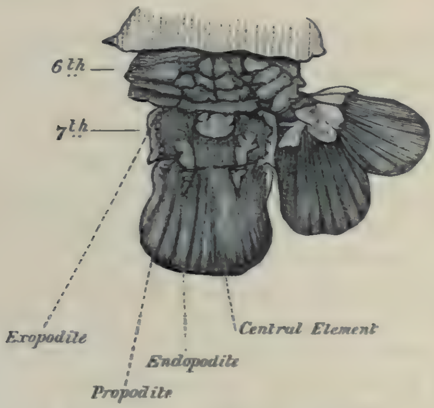
* "Forms of Animal Life," 1870, p. 95.

calcified continuously across its ventral surface, as the other segments are; but this appearance would arise from the small size of its real centrum, which, as in *Scyllarus*, would be quite anterior, and the coalescence in the middle line of the proximal portions of the endopodites of the segment. In the telson of the lobster, by looking at its dorsal surface obliquely, a system of undulations is observed, which corresponds, though in a much more disguised form, with the condition in *Scyllarus*, the two extreme lateral pieces with the accompanying spines being easily seen, and the small elevated centrum at the anterior part.

In conclusion, an attempt has been made to show (1), That in some Macrurous Crustacea, and therefore probably in all, the telson is a true body segment with lateral appendages, which are modified by cohesion and adhesion. (2) That the body of the segment terminates posteriorly in front of the anus, and that the cohesion of the endopodites superiorly causes the anus to be ventral.



Telson, &c., of *Scyllarus arctus.*

14. NOTES ON AN OSTRICH LATELY LIVING IN THE SOCIETY'S COLLECTION. (Written in conjunction with FRANK DARWIN, B.A.)*

Page 356. A MALE Ostrich (*Struthio camelus*) has been in the Society's Gardens since April, 1869, and was quite healthy until last October, when its appetite began to fail, and it did not take kindly to its food from that time until its death on the 6th ult. In September last the keeper noticed on several occasions that after running about as it was Page 357. accustomed to do in play, it turned giddy and apparently tripped, but never quite fell. For the last four months it had lost flesh gradually. Whenever any fresh food was offered it, it would take a little and then refuse any more, and would do thus, however many new things were presented to it.

It had suffered from diarrhœa more or less ever since October, the excrement having a yellowish-green colour.

Latterly it had been nearly continually in the sitting position, and would stand very unwillingly. It also frequently rubbed its head and eyes with its foot, as if something was irritating it there.

In the post-mortem examination very little structural disease was found; and the cause of death is more probably connected with the contents of the stomach rather than with any other agency.

There was more than half a gallon of stones in the stomach: most of them were about the size of cob-nuts or peas; and they fully dilated the organ and pulled it down abnormally. Mixed up with these stones were numerous copper coins and pieces of coins in a much worn state. There were two pennies and fifteen halfpence; and very few showed the least trace of the stamp they had previously borne, and those only by an oblique light, the difference in density of the metal, produced by the stamping, having caused them to wear unevenly. Most of them were slightly curved, being meniscoid in form. They were all highly polished, and not in the least corroded. Many were in pairs, with a layer of softish green matter, about $\frac{1}{20}$ of an inch thick, interposed. The chips of coins were very numerous, and of all sizes below that of the coins themselves. No silver was found, and nothing else except a glove-button and a nut, the latter being at the bottom of the æsophagus.

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* "Proceedings of the Zoological Society," 1872, pp. 356–63. Read, March 5, 1872.

All the contents of the stomach were of a green colour; and two small boluses of hay which it contained were tinged deeply with green.

Four more coins, deeply corroded and greenish-black, were found in one of the intestinal cæca, together with a few stones. There were also a few stones in the other cæcum; and the mucous membrane of both cæca was congested and unhealthy in appearance, which was not the case in the stomach to any extent.

There were no symptoms of jaundice, which frequently accompanies copper poisoning. The liver appeared healthy, except that scattered about were a few dense white lumps about the size of peas, mostly near the surface: it weighed 3 lb. 9 oz. No gall-bladder was present.

The spleen was very small, and altogether weighed just under 2 oz. There was very little healthy tissue preserved, it mostly consisting of spheroidal dense masses of matter which were about the size of chestnuts, and by protruding beyond the general surface produced an appearance of knobs. These masses, on cutting through the capsule, separated entirely, and were then seen to be rough and altogether very like urinary calculi; they were of a fawn-colour. The organ was situated nearly in the middle line, just above the kidneys.

The heart weighed 1 lb. 7 oz., and gave origin to two carotid arteries, one from each main branch, which ran to the head, a distance of about 3 feet 6 inches, side by side, in front of the cervical vertebræ, in the groove formed by the anteriorly projecting processes of those bones; and they never showed any tendency to unite or cross one another. They were thickly covered by the anterior cervical muscles, and sent off symmetrical branches.* Page 358.

Superficially on each side of the neck ran a vein with the pneumogastric nerve; but that on the left side was not bigger than a crow-quill, while that on the right had a diameter at the lower part of the neck of two-thirds of an inch. This condition is constant in many birds.

This right (practically the only) jugular vein, after coursing about half or a little more up the neck, sent two branches to the head, the second running in the middle line, just behind the trachea and in front of the œsophagus, the first being a direct continuation of the main trunk.

The intestinal canal was 34 feet long; and the two cæca, each

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* The presence of the two carotids in this bird, while there is only one in *Rhea*, would require that they should be far separated in Nitzsch's classification of birds according to the number of these vessels—the Ostrich being in his first class, with a carotid from each main aortic branch, and the *Rhea* in the fourth class, with only the left developed. See Nitzsch's "Pterylography" (English edition), App. p. 171.

2 feet long and arranged like a spirally twisted cone, were situated 11 feet from the pylorus, which is very different from their situation in most birds, as has been noticed by Owen.

The diaphragm was well marked. It formed a partition which divided the thoracic cavity into two parts, one posterior and small containing the lungs, and the other anterior and large containing the heart and liver. It was a fibrous membrane, concave forwards, with a muscular attachment at either side to the ribs and intercostal tissues, which it joined in about the middle of their course. This muscular part was formed of transverse fibres in the middle and upper part of the chest, while the lower ones slanted slightly upwards as they coursed towards the median line. They were about 2 inches long, and formed a thin layer. The pleural cavity was closed above and below by the fibrous diaphragm becoming blended with the first and last ribs.

The anterior thoracic cavity, which contained the pericardium-coated heart in its upper part, entirely independent of the pleural cavity, was divided into two by a dense fibrous membrane which sprang from two vertebral crura, much as the human diaphragm, and extended above the line to join the sternum, along the border which articulated with the ribs, leaving the heart entirely in front of it; its concavity was directed downwards and forwards; and it was separated from the diaphragm proper by very large air-cells. The œsophagus also ran in the interval; but the aorta was included in the pleural cavity, being clearly seen through the membrane of the diaphragm, along the median line, before its removal.

The liver was completely separated from the abdominal cavity by a fibrous membrane, so that when the included viscera had been removed it was not at all brought into view. The mesentery was very dense and strong, the vessels, especially the veins, being of large size.

Page 359. Some further points in the anatomy of this bird are not without interest.

There are three parietal abdominal muscles as usual, the muscular fibres of the external and internal being nearly parallel and transverse, while those of the intermediate one are longitudinal. They each send down a dense fascial attachment to the pubic bone; and a semilunar free margin between the ilium and the superior pubic crest appears closely allied to Poupart's ligament, the anterior crural vessels and nerves going underneath it to enter the leg. It may be here mentioned that the main vein of the thigh is the internal saphenous; but the main artery is the one that goes through the sciatic notch, therefore the sciatic. These come into relation with one another in the loop for the biceps tendon at the knee.

Exactly in the middle of the anterior border of the pubic portion of the innominate bone there is a small thin plate of osseous tissue which is connected with the pubis by strong fibrous bands, and which is continued anteriorly and superiorly by cartilage for some distance, when it becomes continuous with the tendons of the parietal abdominal muscles, being most connected with the external oblique.

Portions of the external surface of the left pubis and ischium of the Ostrich. The small osseous plate (*a*) attached to the pubis is represented partly surrounded by cartilage.

In dry skeletons a slight thickening of the anterior border of the pubic bone indicates the attachment of this ossification in most; but in one of the three skeletons in the British Museum this bone is anchylosed on one side, and Mr. Gerrard has specimens in which both are still attached. A diagram of the Ostrich's pelvis in Mr. Haughton's paper also shows this bone anchylosed, though no mention is made of it in his paper.

It would be extremely interesting to make out the homology of this small but perfectly independent ossification. Its relation to the muscles of the abdominal wall would favour the idea of its corresponding to the marsupial bone of the Kangaroo and its allies; and if that is the case, the whole of the anterior prolongation of the Ostrich's pubis would correspond to the small ridge of bone on either side of the superior margin of the symphysis pubis in the Mammalia. Page 360.

The *obturator internus* also arises from the superficial surface of this bone and its cartilage, as well as from the adjacent surface of the ischium and from the pubis, extending so far forward that the muscles of the opposite sides are only separated from one another by an inch or so at the symphysis pubis.

Mr. Macalister, in his description of the myology of this bird, has omitted a few of the muscles, some of which from the head will be described, together with those of the leg, which Mr. Frank Darwin has allowed me to introduce in this communication, from his notes and the dissection of that limb in this individual specimen.

Pterygoid.—From the inferior surface of the posterior part of the palate-bone, and from the process of bone which connects it with the main portion of it, this is fibrous—also from the whole of the inferior surface of the pterygoid bone, extending inwards almost to the basisphenoidal rostrum.

The fibres are all directed backwards, and are inserted in two ways:—the outer, and some of those from the palatine longitudinal process, into the anterior surface of the transverse ridge at the angle of the mandible, which posteriorly receives the insertion of the digastric muscle; the inner, and others from the palate-bone, into a fibrous band which runs from the side of the median Eustachian aperture and its cartilaginous continuation to the prominent ridge behind and internal to the condyloid articular surface for the mandible, thus forming an arch under which run the arteries and veins to the head.

This second portion of the muscle acts partly as an opener of the Eustachian aperture, partly as a retractor of the slightly movable pterygoid and palatine bones.

Quadrato-mandibular.—From the whole of the longitudinal ridge which forms the superior internal portion of the quadrate bone, and from the surface of the bone external to it. The fibres are directed outwards and downwards to be inserted into the inner surface of the mandible, in front of the articulation, not extending to the inferior margin, nor forwards further than the optic foramen.

Quadrato-cranial.—From the back of the orbit, below and behind the origin of the recti muscles and the exit of the nerve, from a surface bounded above by a semicircular line, and extending down in the space between the orbit and the quadrate bone. The fibres are directed outwards to the corresponding internal surface of the quadrate bone, a slight ridge separating the superior ones from those of the quadrato-mandibular.

Gastrocnemius consists of two enormous masses of muscle blending together at their origins round the proximal end of the tibia, and separating lower down into the gastrocnemius anticus, which laps Page 361. round the anterior half, and the gastrocnemius posticus, which surrounds the back part of the tibial section of the limb. Gastrocnemius anticus arises partly from the tibia, partly by blending with gastrocnemius posticus; the latter arises from the distal extremity of the femur, the tendon of the quadriceps extensor and patella, and from the tibia. At the tibio-tarsal joint the gastrocnemii form a sheath fitting into the trochlea of the tibia for the passage of the flexor tendons of the toes; this is effected by the tendons becoming very much thickened and semicartilaginous (especially gastrocnemius posticus), and uniting with each other at their edges, the anterior element of the sheath being formed by gastrocnemius anticus, the posterior by gastrocnemius posticus. Just above the joint, gastrocnemius anticus sends off a slip which passes down in a special sheath along the outer surface of the contiguous heads of tibia and tarso-metatarsal bone, and is inserted into the tendon of flexor perforatus. Gastrocnemius anticus is inserted into the posterior surface of the tarso-metatarsal bone just below the tibio-tarsal joint. Gastrocnemius posticus is inserted into the external and internal lips of the posterior border of the tarso-metatarsal bone, forming a sheath for the passage of the flexor tendons; it subsequently forms, with a "sesamoid" cartilage presently to be described, a pulley for the same tendons at the tarso-phalangeal joint, and ends by blending with the fascia covering the sole of the foot. Mr. Macalister* describes the gastrocnemius as ending in one tendon only, which he says forms a sheath for the deeper tendons on the back of the metatarsus.

The flexors of the toes are flexor magnus (perforatus), flexor perforans, flexor externi digiti, flexor interosseus, flexor profundus.

Flexor magnus arises (1) by a tendon from the upper part of the external surface of the outer condyle of the femur, the tendon winding over the knee, and then ending in the muscle; just before it does so, it receives the insertion of the rectus femoris (Cuvier and Meckel), (the pectineus of Owen); (2) from posterior surface of distal end of femur; (3) proximal end of tibia. The muscle ends in a broad tendon, which passes through the gastrocnemial sheath at the tibio-tarsal joint, and is here pierced by the tendon of flexor externi digiti. It passes down the tarso-metatarsal bone in the sheath formed by gastrocnemius posticus, receiving a tendinous slip, already described, from gastrocnemius anticus. At the tarso-phalangeal joint it passes through a sheath formed anteriorly by a "sesamoid" cartilage, posteriorly by the tendon of gastrocnemius posticus. This cartilage is ligamentously attached to the proximal end of the first phalanx of the internal digit, and to the synovial membrane of the tarso-phalangeal joint; it is deeply grooved posteriorly for the flexor tendons, and has two shallow grooves on its anterior surface, which fit on to the condyles of the tarso-metatarsal bone when the digits are ex-

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* Alexander Macalister, L.R.C.S.I., Demonstrator of Anatomy, Royal College of Surgeons, "On the Anatomy of the Ostrich (*Struthio camelus*)," "Proceedings of the Royal Irish Academy," IX. Part 1 (1865).

tended; there is a smaller "sesamoid" cartilage for the external digit. A small muscle arises from the larger cartilage and by a few Page 362. fibres from the smaller one, and is inserted into the anterior surface of the flexor profundus tendon. The flexor magnus is pierced, as it passes through the sesamoid sheath or pulley, by the tendons of flexor profundus and flexor perforans, and ends by dividing into two slips, which are inserted into the proximal end of the second phalanx of the internal digit.

Mr. Macalister gives as the origin of the flexor magnus the deep pit above the condyles of the femur, the tendon of the rectus femoris, the external lateral ligaments, and the back of the fibula. In the specimen which I dissected, the tendon of the rectus femoris was much smaller than the tendinous head of the flexor profundus, and was inserted into it, which is an arrangement differing very slightly from its usual insertion in birds, which is, I believe, into the fleshy part of flexor magnus (Owen, "Anat. Vert.," Vol. II, p. 107).

The Rev. S. Haughton* describes the rectus as becoming provided with a second muscular belly (p. 53), which does not all describe its condition in my specimen. He considers this "digastric rectus femoris muscle" to be "the key to the explanation of the complicated muscular apparatus of the Ostrich's leg" (p. 50). Speaking of it, he says, "it acts before the extensor muscles come into full play; it binds down the two patellæ, braces up the heel-joint, and gives the signal for the m. gastrocnemio-solæus and other associated muscles to contract, and thus produces what may be regarded as one of the most striking phenomena in nature, viz., that the delicate bones and ligaments of a bird's leg, acted on by muscles equal to those influencing a horse's hind leg, shall remain uninjured under the sudden action of forces the slightest error in the application of which would break to pieces the machinery on which they act." This arrangement of the rectus, which Mr. Haughton considers so important, is only a well-developed form of what is found in most birds, and which Professor Owen says is used in perching, by flexing the toes when the knee is bent (*loc. cit.*)

Mr. Macalister does not mention the muscle from the flexor profundus tendon to the sesamoid cartilage; but says that the flexor magnus sends a slip to it. The function of this muscle must be to keep the pulley-like sesamoid cartilage firmly in its place when the toes are extended preparatory to their flexion in the spring of the bird.

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* The Rev. S. Haughton, M.D., "Notes on Animal Mechanics.—No. 3. On the Muscular Mechanism of the Leg of the Ostrich," "Proceedings of the Royal Academy of Dublin," IX. Part 1 (1865).

Flexor digiti interni arises from the outside of the tubercle of the tibia, and from the tendon of the quadriceps extensor; the tendon passes through the gastrocnemial sheath and the sesamoid pulley. It pierces the flexor magnus, receiving a tendinous slip from it, and then spreads out and binds the tendon of the flexor profundus to the grooved under surface of the second phalanx of the internal digit, and is inserted by two slips into the proximal end of the third phalanx.

Flexor digiti externi arises from the posterior surface of the distal end of the femur, and from the tendinous head of flexor magnus. It passes through the gastrocnemial sheath, pierces the tendon of flexor magnus, passes through the lesser sesamoid sheaths, and is inserted into each of the three proximal phalanges of the external toe. Page 363.

Flexor profundus arises by two heads—one from the posterior surface of distal end of femur, the other from the posterior surface of the upper half of the tibia and part of the fibula. The tendon of the external muscle passes at the tibio-tarsal joint through a canal in the tendon of gastrocnemius anticus. The inner tendon does not enter the gastrocnemial sheath till below the joint; it passes down the inner surface of the contiguous ends of the tibia and the tarso-metatarsal bone, bound down to them by a special aponeurotic sheath, and joins the outer tendon near the tarso-phalangeal joint. The common tendon passes over the sesamoid pulley, piercing the flexor magnus tendon; it is here much thickened and hardened, and fits into the grooved and thickened tendon of flexor perforans. It is inserted into the fourth phalanx of the internal toe, sending off a short strong slip to the third phalanx, and an elastic slip to the second phalanx, as well as a small but long slip to flex the fifth phalanx of the external digit.

Mr. Macalister describes the tendon of the flexor profundus as being inserted only into the last phalanges of both digits; the insertion as it was in my specimen accords, I believe, with the usual condition of this tendon in birds.

The *flexor interosseus* is a delicate and weak muscle, which consists of numerous very short oblique fibres arising from the posterior surface of the tarso-metatarsal bone, and inserted into an aponeurosis stretching the whole length of the muscle; this aponeurosis ends in a tendon which is inserted into the outer surface of the first phalanx of the external digit. Its action appears to be to abduct and flex the toe.

A small muscle which Mr. Macalister does not describe, but merely mentions as probably representing the dorsal interosseus, arises from a small triangular space on the anterior surface of the distal end of the tarso-metatarsal bone, and is inserted into the capsular ligament of the tarso-phalangeal joint. There were some differences between the specimen which I dissected and that described by Mr. Macalister, in the precise origin of some of the muscles, which I have not thought to be worthy of note.

The *extensor communis digitorum* presents no peculiarities ; the very small *extensor unguis* mentioned by Mr. Macalister was present.

15. ON THE MECHANISM OF THE GIZZARD IN BIRDS.*

NOTWITHSTANDING the fact that the external form and general Page 525. structure of the gizzard is known to almost every one, very little seems to have been made out as to the means by which this organ is enabled to crush and render available for nutrition the hard grains taken as food.

By most writers the gizzard is supposed to act as a grinding-mill, moving from side to side, assisted in its work by sharp-pointed stones which its owner swallows for the purpose. This was evidently the opinion of Hunter, though he seemed scarcely satisfied on the point when he found that there was no perceptible lateral movement of the muscular masses during digestion.

Harvey gave a very good description of the action of the gizzard, as far as he knew it, in his description of the abdominal viscera of the common fowl ("On Generation," Exercise vii); and Hunter is the only physiologist who seems to have worked at the subject since that time.

The structure of the gizzard as a specialised organ is best seen in the Anserine birds; and that of the Goose will be now described.

Externally it is circular when looked at from in front, oval from the side, and fusiform from above or below. The œsophagus enters it as a large infundibuliform tube, with the broader end downwards at its highest point; and the duodenum is continued out of it behind Page 526. and above.

The organ may be shown to consist of two lateral masses of muscle, with an oblong cavity between them, which opens above and below into two sacs, with muscular walls of nearly uniform thickness.

The anterior superficial circular view presents the appearance of a central tendinous area, from which four lines radiate, nearly at right angles to one another, in an X-like manner. The upper and lower median areas between the corresponding limbs of the X are muscular and rounded at the margin, with the fibres directed to the central tendon. The lateral spaces are covered with glistening tendon, which at the edges shades into muscular fibres, not in this case curved, but straight and consequently squared off.

The superior and inferior median portions are parts of the walls of

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* "Proceedings of the Zoological Society," 1872, pp. 525–9. Read, April 16, 1872.

the corresponding cavities already mentioned; and the œsophagus enters the former at its inner angle, close to its junction with the right lateral mass; the duodenum being behind.

The lateral masses, with their tendinous coverings, are the muscular portions; and the cavity between them is just behind the central tendon.

The epithelial lining of the whole organ is very dense, and is continuous through the different cavities, terminating abruptly at the entrances to the œsophagus and the duodenum. Very shortly after the death of the bird it can be stripped off entire.* It is particularly dense where it covers the two lateral muscles, and generally forms a callous oval pad over each, which has to receive most of the force of the muscular walls as they act on the stones and food.

The central tendons, one in front and the other behind, are very strong; and so are the fibres which radiate outwards from them; they are almost entirely connected with the lateral muscles.

The lateral muscular masses have their fibres all tending forwards and backwards, each being inserted into both the front and back tendinous expansion, the central being nearly straight and the lateral ones being curved slightly outwards in the middle of their course.

The superior and inferior sacs are surrounded by muscular bands which bow over from front to back, being inserted into those parts of the margin of the central tendon to which they are opposite. By their contraction they reduce the size of the sacs and force any thing they contain between the lateral muscles, a considerable fold of the gizzard-lining, which acts as a kind of valve, preventing any stones entering the duodenum.

The action of the lateral muscles can be best understood by observing a horizontal section made through the middle of the gizzard.

The section is fusiform and exhibits a central oblong cavity, short from side to side, bounded before and behind by the central tendons, and laterally by the triangular muscular masses.

The accompanying figure and the above description show that in Page 527. the gizzard there is no mechanism which could in any way produce any lateral movement of the one mass of muscles on the other; and it is difficult to conceive any epithelium, however horny and dense, that could resist the tearing-strain which would necessarily be associated with such movement, in addition to which several gizzards that have passed through my hands have been so loaded with fat or adherent to the abdominal walls, that any lateral movement must have been impossible in them.

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* This coat is considered by recent German authorities to be a secretion from the deep glands, not an epithelium.

Fig. 1.

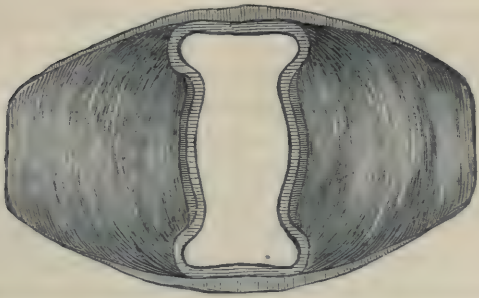

Fig. 2.

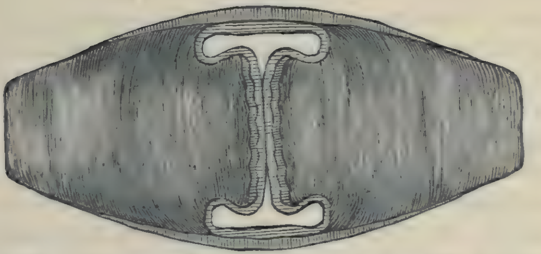

Fig. 1. Horizontal section of the gizzard in a state of relaxation.
Fig. 2. The same in a fully contracted state.

The following explanation of the action of the gizzard as a simple crushing-organ seems to me much more in accordance with the known principles of animal mechanics.

As is well known, muscular tissue, when it contracts, does not alter in volume, but gains in breadth what it loses in length during its action. Consequently when a large mass of short muscular fibres contracts it must alter its shape considerably, increasing greatly in breadth.

This fact being borne in mind, the action of the gizzard is easily explained.

The two enormous lateral muscles, with their fibres tending forwards and backwards, when relaxed, have a large cavity between them, into which the seeds and stones are thrust by the simultaneous contraction of the superior and inferior muscular bags. Directly these have become fully contracted, the lateral muscles act; and by approximating the anterior and posterior tendons they become greatly expanded laterally. But this expansion can take place in one direction only—namely, towards the gizzard-cavity; for the anterior and posterior tendons being situated obliquely with regard to one another, and the contraction taking place through the whole mass, Page 528.

expansion can only occur towards the base of the triangle. The motion in this direction is furthered by the arrangement of some of the muscular fibres, as can be seen on close inspection of the section of the relaxed gizzard; for the dense horny pads above referred to are cupped on their attached surfaces, and the fibres run from one margin of this cup to the other, in an arched manner, as seen in the section. Those fibres just above the cup are arched also in the same way, and the epithelial margins of the cup are more yielding than elsewhere. Consequently, when the contraction occurs, the fibres straightening reduce the antero-posterior diameter of the cup and make the pad more convex towards the intermediate cavity, and push each towards its fellow, this action, combined with that of the other more marginal fibres, producing a most powerful compression of the contents.

The great force exercised laterally by the contraction of a muscle can be well shown by tying a piece of tape round the middle of the arm proper, and then causing the biceps to contract forcibly, whereby the tape is broken.

As remarked by most writers on the subject, every intermediate condition of muscularity of stomach may be found in birds, from the simple non-tendinous one of the Raptores and others to the most muscular of the Anserine birds. The degree of muscularity depends on the nature of the food which the bird obtains, as shown by Hunter's experiment, in which he, by giving animal food to a duck (I believe),* caused a great diminution in the muscularity of its gizzard.

The state of the bird as to health also influences the development of the muscular fibres, the heart and gizzard being very similarly affected by impaired nutrition.

In the Gallinaceous and Passerine birds there is seldom a callous pad formed over the lateral muscles, the epithelium being generally plicated at right angles to the direction of the muscular fibres; and in them the organ seems to be a more simple squeezing-organ, though when rigor mortis occurs in a contracted gizzard it is seen that the muscular masses are convex on their opposed faces.

From these remarks and what has been previously observed on the subject, the following summary statement may be made:—

The gizzard is an organ which crushes, and so renders assimilable the harder portions of the food of birds. This food, having been previously macerated in the proventriculus or crop, is thrust between the lateral muscles (where it gets mixed with the small sharp stones
Page 529. it meets there) by the contraction of the superior and inferior gizzard-sacs—upon which these lateral muscles contract simultaneously; and

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* [The bird experimented on was, in reality, a sea-gull. *Cf.* Everard Home, "Lectures on Comparative Anatomy." I. p. 271. 1814. Ed.]

their arrangement is such that all the force of their contraction is converted into a compressing force at right angles to their direction. This force, by tending forcibly to obliterate their included cavity, comminutes the more yielding of their contents and squeezes from between them the resulting chyme, which finds no difficulty in entering the small orifice to the duodenum.*

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* Since writing the above, I find there is a peculiarity in the gizzard-pads in the swan and goose, which causes a slight up and down movement of the lateral muscular masses when in action. The lower end of one pad and the upper end of the other are much more strongly developed and are thicker than the rest; this causes them to present a surface of contact one with the other, which is somewhat oblique with regard to the axis of the lateral muscles. Consequently, when these muscles come into play, the oblique surfaces tending to come into contact, the material to be crushed intervening, they, being opposed inclined planes, slide slightly on one another, the one mass rising while the other descends. During the diastole of the gizzard it resumes its former relations, and a reverse sliding occurs.

16. NOTES ON THE ANATOMY OF THE HUIA BIRD (*HETERALOCHA GOULDI*).*

Page 643. A LIVING specimen of *Heteralocha gouldi* (*Neomorpha gouldi*, Gould, B. of Australia, IV. Pl. xix) was obtained by the Society on May 11th, 1870, as was announced by Mr. Sclater in the "Proceedings," 1870, p. 383. It died on the 28th of February, 1872, in a much emaciated condition, but without organic disease.

Page 644. The following notes relate to its anatomy, and may, I trust, assist in enabling its affinities to be more easily determined.

Pterylosis.—The arrangement of the feathers is completely passerine. The rhombic saddle of the spinal tract does not enclose any ephippial space, therein differing from the Crow's and resembling the typical Starling's. There are nineteen remiges, of which ten are on the hand; they increase in size up to the fifth. The rectrices are twelve in number. The oil-gland is nude.

Tongue.—Simple, horny, one-third the length of the beak. It forms a flat elongated triangle, slightly bifid at its apex, and a little prolonged backwards at its lateral borders, enclosing a curved line for the base, the concavity being backwards and carrying retroverted papillæ.

The mucous membrane of the palate extends forward as far as the middle of the tongue; that of the mandible goes a little further.

At the angles of the mouth, just below the eyes, are two yellow oval cutaneous expansions, fixed in front and free at their borders elsewhere; they appear as if they were prolongations outwards of the mucous membrane of the angles of the mouth, which had been reflected backwards—they being continuous in front, round the margins, with the mucous membrane.

Syrinx.—As in *Corvus* and most of the Old-World Passerines.

Intestines.—The gizzard is well developed. The intestines are 16 inches long, with the bile-ducts 2½ inches from the gizzard. The cæca are one inch from the cloaca and ¼ inch long, being cylindrical.

Arterial System.—There is one carotid artery, the left.

Foot.—The hind toe is slightly longer than the middle anterior toe. In arrangement the tarsal scutes are similar to those of *Corvus* and most Passerines. Their colour is blue-black.

Skull.—The palate (Fig. 2) is strictly ægithognathous; that is,

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* "Proceedings of the Zoological Society," 1872, pp. 643–7. Read, May 21, 1872.

the vomer is truncate in front abruptly, and cleft behind; the postero-external angles of the palatines are produced; the maxillo-palatines are slender, and approach towards but do not unite with one another,

Page 645.

Fig.1

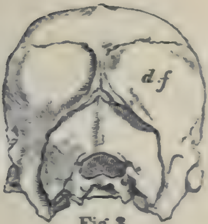

Fig.3

Fig.4

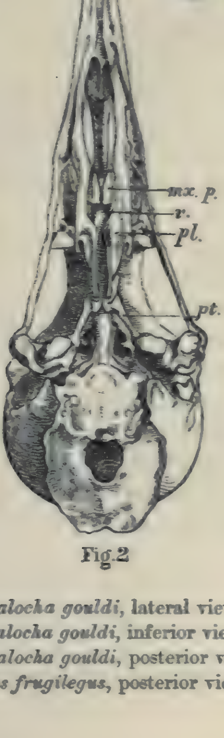

Fig.2

Fig. 1. Skull of *Heteralocha gouldi*, lateral view.
Fig. 2. Skull of *Heteralocha gouldi*, inferior view.
Fig. 3. Skull of *Heteralocha gouldi*, posterior view: *d.f*, digastric fossa.
Fig. 4. Skull of *Corvus frugilegus*, posterior view: *d.f*, digastric fossa.

nor with the vomer, which they partly embrace. There is no ossification in the nasal septum anterior to the vomer.

The whole cranial configuration (Fig. 1) closely resembles that of *Sturnus;* but the mandible, instead of being bent upwards, is straight. Like it, the palatines are narrow and approximate; the antero-internal angles of the posterior portions of those bones are reduced and rounded off, as is sometimes the case with *Sturnus* (Mus. Roy. Col. Surg. No. 1539, Ost. Coll.). The vomer is completely truncated in front, and is not prolonged forwards at its external angles, as in *Corvus* and its allies.

The zygoma is not so slender as in *Sturnus;* but the curves are similar. The articular surfaces on the quadrate bone for the mandible are proportionally very large.

The anterior extremities of the pterygoid bones articulate with the sphenoidal rostrum much as in *Corvus*, meeting in the middle line behind the posterior extremities of the palatines for a short distance.

Page 646. The maxillo-palatines in their approximate portions are shorter from before backwards than in *Sturnus*, and much resemble those of *Corvus*.

The antero-inferior processes of the orbit are large and spongy; they almost touch the zygoma. But the most characteristic portion of the skull of *Heteralocha* is the occipital region; and in this it presents a great exaggeration of the peculiarities of *Sturnus* and its allies.

In *Corvus* (Fig. 4) and most Passerines the digastric muscles occupy a narrow space intervening between the auditory meatus and the mass of occipital muscles, not extending so high up the skull as the latter. The occipital ridge encloses a space elongated from side to side and of but little depth.

In *Sturnus* the digastrics are much broader, and they narrow the occipital space; they also extend up the skull to so great an extent that they nearly meet in the middle line above the origin of the biventres cervicis muscles; but in *Heteralocha* (Fig. 3) they are of still greater size, and meeting above the middle line they form a strong ridge, which extends for some distance into the parietal region vertically. This peculiar development of these muscles produces a corresponding change in the shape of the space enclosed by the occipital ridge. In *Heteralocha* it is almost circular, and it extends some way above the foramen magnum. In *Sturnus* there is an approximation to this condition.

A vertical parieto-occipital ridge in many other birds closely resembles that of *Heteralocha;* but it is the median limit of the temporal fossa in most.

Correlated with this extensive digastric origin is a large surface for its insertion. The angle of the mandible (see Fig. 1, p. 647) is prolonged directly backwards for this purpose, in a manner unique among Passerine birds, but well seen in the *Anatidæ.* In *Sturnus* the angle of the mandible is slightly prolonged backwards for a similar purpose.

In comparing the skulls of others of the *Sturnidæ* the following is a graduated series, based on the development of the digastric fossæ in those birds I have had the opportunity of examining, commencing with *Heteralocha* and ending with *Corvus.*

Heteralocha.
Sturnella.
Sturnus.
Icterus.
Pastor jalla.
Gracupica.
Quiscalus.
Cassicus.
Acridotheres.
Pastor griseus.
Molothrus.
Corvus.

The palates in most of these birds were not in a fit condition for study; and, as will be clearly seen, geographical range has not been attended to.

In the sternum, *Heteralocha* differs in no important point from *Sturnus*, except that the posterior notches tend to be converted into foramina, as observed by Mr. Eyton in his "Osteologia Avium."

The following muscles were dissected, and found to agree precisely with the corresponding ones in a Rook. Page 647.

Pectoralis major.
Pectoralis minor.
Coraco-brachialis longus.
Coraco-brachialis brevis.
Tensor patagii longus.
Tensor patagii brevis.
Sartorius.
Semimembranosus.
Semitendinosus.
Adductor magnus.
Biceps.
Femoro-caudal.

In conclusion, it may be stated that the anatomy of *Heteralocha* shows clearly that it is truly Passerine, and not related to *Upupa*, as was previously supposed by most authors.* When examined more in detail, its relation to the *Sturnidæ* is found to be very intimate, and its structure is clearly not closely allied to that of the *Corvidæ.* In its relation to *Sturnus* it seems to present an exaggeration of the peculiarities of that bird, which would place it at the head of the family.

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* Mr. G. R. Gray has placed *Heteralocha* in the *Sturnidæ* is his "Hand-list of Birds."

17. NOTE ON THE TONGUE OF THE PSITTACINE GENUS *NESTOR*.*

Page 787. On the death of a specimen of *Nestor hypopolius* in the Society's Gardens, a short time ago, Mr. Sclater kindly directed my attention to the peculiarity of its tongue, and referred me to Dr. Finsch's work on the Parrots, where *Nestor* is placed among the *Trichoglossinæ*, though the author states that he is not possessed of any very precise information on the subject.

Mr. Gould, in his "Birds of Australia" (vol. 5, plate VI), partly describes the tongue of this bird, and shows that it is not that of a Lory; but he has omitted to note its chief peculiarity.

Dr. Buller, in the recently published first part of his "Birds of New Zealand," has also described the tongue quite correctly, though not much in detail—but nevertheless places *Nestor* close to the Lories, mentioning that this affinity was first shown by MM. Blanchard and Pelzeln.

As, however, the tongue of *Nestor* does not in reality resemble that of the *Trichoglossi* at all, it may be of interest to describe it more fully.

As far as I have had opportunity of observing, in all Parrots the fleshy tongue ends anteriorly by a dilated portion, supported on a narrower neck. This tip is much like the end of a human finger, as mentioned by most observers: and its function is similar also; for it is employed by the bird as a third prehensile organ in connection with the upper and lower beak, any solid substance being held by the tongue and upper beak, while the mandible is freed to give another bite.

Continuing the simile of the finger, the tip is directed forwards with the nail-like portion downwards, the part corresponding to the free edge of the nail appearing along the lower margin of the anterior rounded surface.

This unguis, or nail-like portion, appears to me further to resemble a nail in that its anterior edge is not quite regular and is free, while the posterior margin is continuous with the neighbouring epithelium, which is almost enough to show that it grows forwards, and is worn down, as is a nail, by constant contact with foreign substances.

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* "Proceedings of the Zoological Society," 1872, pp. 787–9. Read, June 18, 1872.

In the typical Parrots this unguis of the tongue is broader than long, horny in texture, semicylindroid, with its lateral margins extending up the sides of the organ and encroaching on the borders of the superior surface for a short distance; not imbedded at the sides as is a nail. Its anterior border is nearly straight.

In the *Trichoglossi* this horny plate is also present, and is similarly Page 788.
constructed; but on the superior surface of the tongue, between the lateral edges of the unguis, in the part which in others is covered by a smooth longitudinally plicated epithelium, there is an arrangement of retroverted papillæ forming a spinous covering; and their mechanism is such that when the tongue is protruded beyond the mouth to grasp

Fig 1

Fig.2

Fig.4

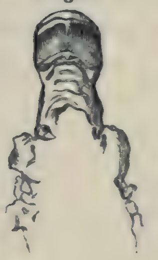

Fig. 5

Fig.3

Fig. 1. Head of *Lorius tibialis*, showing the bird stretching out its bill for food, in which case, the tongue being protruded, the spines covering the superior surface of its apex are directed forwards instead of being recurved and inconspicuous, which is the case when it is at rest.

Figs. 2 and 3. Inferior and superior views of the tongue of *Nestor hypopolius*, showing the fringe of hairs which springs from the anterior border of the margins, and which extends forwards beyond the tip.

Figs. 4 and 5. Inferior and superior views of the tongue of *Stringops habroptilus*, which is like that of the typical Parrots.

any object, the papillæ stand upright or are even directed somewhat forward.

In *Nestor* there are no papillæ of this description, but the tongue is here, as Dr. Buller says, " soft, rounded on the edges, with a broad central groove," and it is as smooth as in other Parrots. Therefore Page 789. the Ka-Ka Parrot cannot in this point be said to approach the *Trichoglossi* (badly so called).

The peculiarity of the tongue of *Nestor* consists in the fact that the anterior edge of the unguis, always free (though for a very short distance) and jagged, as mentioned above, in the other birds of the class, is here prolonged forwards, beyond the tip of the tongue, for about $\frac{1}{10}$ inch as a delicate fringe of hairs, with a crescentic contour. This fringe seems to result from the breaking up into fibres of the forward-growing plate, which is always marked by longitudinal striations, clearest anteriorly, the result of unequal density and translucency of the tissue composing it, though on making a cross section I was not able to find any of the longitudinal papillary ridges which are present in the human nail and which the striation led me to expect. The unguis is also longer than broad, and very narrow considering the size of the bird, as is also the whole tongue, though the length is greater than in others of the class. In the living bird the mouth is moist, as in the Lories, and not, as in the Cockatoos and others, dry and scaly.

From these considerations, and a comparison of the accompanying drawings of the tongues of *Stringops*, *Nestor*, and *Trichoglossus*, it is evident that the structure of this organ would lead to the placing of *Nestor* among the typical Parrots, though an aberrant one, and not with the *Trichoglossinæ ;* and other points in its anatomy favour this conclusion.

18. NOTE ON SOME OF THE CRANIAL PECULIARITIES OF THE WOODPECKERS.*

CONSIDERING the method adopted by the Woodpeckers for obtaining their food, it is hardly surprising that they possess cranial features peculiar to themselves; for it is scarcely conceivable that the head, the most delicately constructed portion of the body, should be employed as a powerful hammer or axe whose stroke can be heard at a considerable distance, without some modifications in structure which would assist in increasing its efficiency for the purpose. Page 357.

Accordingly, we find that the bones are thicker and stronger than in most birds, and there is only a slight movement possible of the upper jaw on the head proper. The interorbital septum is thick and nearly complete, supporting a median protrusion on the front of the skull, which is so considerable as to throw the free extremities of the hyoid bones one side or the other, thus causing the skull to be slightly unsymmetrical. Further, the axis of the upper beak is peculiarly low, being continuous with that of the basicranium; and this results from the lowness in position of the points of junction of the superior processes of the præmaxillæ with the frontal region of the skull, which renders the angle between the beak and skull less obtuse than is generally the case. Page 358.

In those birds in which there is considerable hinge-motion of the upper beak on the head, as in the Parrots, the basisphenoid rostrum is generally long and of uniform thickness for some distance, and the conjoined palatine bones, with the vomer between them and the pterygoids articulated behind, form a longitudinal flange along the upper service of the median junction, which runs backwards and forwards on the rail formed by the basisphenoid rostrum during the movements of the beak. In the Woodpeckers any considerable articulation of this kind would reduce the value of the head as an axe; consequently the posterior ends of the palatine bones are not well developed, and they scarcely unite in the middle line, while further forwards the vomer is not seen in the maxillo-palatine region, and these latter bones also are only slightly developed. A similar tendency among Passeriniform birds to the reduction of the vomer in

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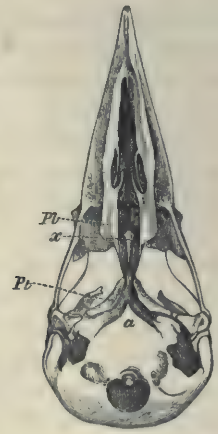
* "Ibis," 1872, pp. 357–60. October 1.

front is found, combined with a complete absence of the maxillo-palatines, in *Menura.*[*]

Professor Huxley in his paper "On the Classification of Birds,"[†] has entered into considerable detail respecting the Woodpecker's palate, and from not finding a vomer present, and observing the peculiar longitudinal bony spicula connected with the inner edges of the palatine bones, opposite to and behind the fenestræ they assist to
Page 359. enclose, is led to think that these spiculæ are the rudiments of the vomer, which has not ossified across the middle line. But in carefully prepared skulls they look much more like the inner edges of the imperfectly ossified palatines, as they are connected completely with them at both ends. Further, in most of the specimens of *Gecinus viridis* and its allies that I have had the opportunity of examining, I have found a median bone, situated between the palatines, and supported like a vomer on the basisphenoid rostrum, at the anterior ends of its broader portion. This bone is small, and shaped very much like a spear-head with the tip directed forwards, whilst posteriorly it gradually becomes fibrous and tends to bifurcate, but not in the ossified part. It does not extend backwards quite so far as the pterygo-palatine articulation.

The accompanying sketch will enable its shape and position to be more clearly perceived.



Palate of *Gecinus viridis*, showing the vomer *x*, between the palatines *Pl.* The pterygoids are marked *Pt*, and the spine of the basicranium *a*.

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[*] Since the above has been in print, I find that the maxillo-palatines are not absent in *Menura*, but are long and slender, differing somewhat from the ordinary Passerine type, but separate from one another and from the vomer.

[†] "Proceedings of the Zoological Society," 1867, pp. 415–472.

Though this bone is situated rather further back than the vomer in most birds, yet it is found similarly placed in some, as in *Megalæma*, which by the way has the anterior termination of its vomer truncated in front, and produced forwards at the corners, as in the Crow, though in the former bird these processes articulate, and do not anchylose with the posterior ends of the palatine plates of the maxillo-palatines.

On cutting the palatine bones of *Gecinus* from the anterior part of the skull, and disarticulating them from the pterygoids, the bone which I suppose to be the vomer comes away with the palatines, as would be expected were such the case. Page 360.

The absence of truncation in the vomer of the Woodpeckers tends by itself to remove them from a close relationship with the Passerine birds; but, as I before remarked, this peculiarity may depend on their special habits. There is, however, in the shape of the pterygoid bones a character which tends to bring them together again.

In Passerine birds the pterygoids extend forwards for a considerable distance in front of the point of contact or articulation with the palatines. These anterior processes are vertically expanded and in contact with the rostrum, and probably sometimes with the crura of the vomer; they are situated above (that is, deeper than) the posterior internal angles of the palatines, and therefore are not seen while looking at the surface of the palate, but only on a side view. In the Woodpeckers and other birds related to them these processes are also present, but they are absent in most others, though the Anserine birds possess them. In the Woodpeckers also there is a very peculiar anteriorly directed process arising from the upper part of the middle of the body of the pterygoid bone, which is quite independent of the one above described.

19. NOTE ON THE PLACENTA OF THE HIPPOPOTAMUS.*

Page 821. NOT knowing of any description of the placenta of *Hippopotamus amphibius*, I think it desirable to record the condition of that obtained after the birth of the calf, which occurred on the 5th of this month.

The placenta is a long cylindrical bag, 3½ feet from end to end and 1½ feet across. There is only one aperture; and that is not more than a foot long, and is situated at one of the ends. The other end is rounded, and quite complete. It is evident that the whole viscus is much the shape of the enclosed fœtus, and must have closely covered it. The end at which the rupture had occurred, that is the one situated at the os uteri, is a little constricted, as may be inferred from the above statement of its diameter. The umbilical cord is attached to the placenta at one of the sides, about halfway between the two ends. It is 1½ feet long, and ragged at its free extremity. It is 1½ inches in diameter in the middle, and gets larger as it approaches its attachment, near which there are many spherical bodies, as big as peas and yellow in colour, supported on short amniotic pedicles. The Page 822. outer surface of the whole viscus is covered uniformly with villi of a bright red colour; and there is no reduction of their number, nor in their size, at the cæcal end at all. At the lacerated extremity, close to the rupture, they are paler and more scattered. The walls of the viscus are of uniform thickness, except for a few inches round the point of attachment of the cord, where the vessels commence to diffuse themselves.

When received, the whole sac was turned inside out; and this was probably the result of the gradual contraction of the uterus from fundus to orifice. It may be remarked that for a few days after the birth of the calf, the mother had a considerable prolapse of the vagina, which gradually diminished, and is now very slight.

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* "Proceedings of the Zoological Society," 1872, pp. 821-2. Read, Nov. 19, 1872.

20. ON THE ORDER DINOCERATA (Marsh).*

It is very seldom that specimens are now obtained, either fossil or Page 267. recent, of mammalian forms that have, provisionally at least, to be placed in a new order by themselves, on account of the presence of peculiarities hitherto quite unknown and unexpected. Such, however, is the case with a large series of fossils which have been, within the last two years, obtained from the Eocene deposits of Wyoming in North America. Our chief source of information respecting these remains consists of a series of papers by Professor O. C. Marsh, of Yale College, abstracts of which have recently appeared in "The American Journal of Science," and in "The American Naturalist." Professor E. D. Cope has also published several papers on the subject, and some excellent photographs of one of the most important forms sent by him to this country it has been my good fortune to see. Professor Leidy has also named one of the genera. Most of my information is obtained from the papers by Professor Marsh on the Order Dinocerata, together with the critical remarks made by him on Professor Cope's descriptions, which I have also by me.

Dinoceras mirabilis is the name given by Marsh to a huge ungulate animal, of which there is an almost complete skeleton in the museum of Yale College. Its size must have been very nearly that of a full-grown elephant, as the length of the skull of a closely allied genus was a little more than a yard. The skull was peculiarly long and narrow, and supported three pairs of horn cores in rows, on its superior surface. The anterior pair were situated on the anterior ends of the nasal bones; they were short, conical, and directed nearly straight upwards. The median pair were conical prolongations upwards from the maxillaries; they were longer and more cylindrical than those on the nasals, and the fangs of the huge canine teeth entered their bases. The posterior pair, the largest, were very peculiar, being extensions upwards from near the middle of large lateral longitudinal crests, which were formed by the occipital, parietals, and Page 268. frontal bones. The dentition was peculiar; the upper incisors were deficient, and the premaxillæ consequently small. The upper canines formed huge downwardly directed tusks, nearly straight, but directed somewhat backwards. These, after a gap equal to their

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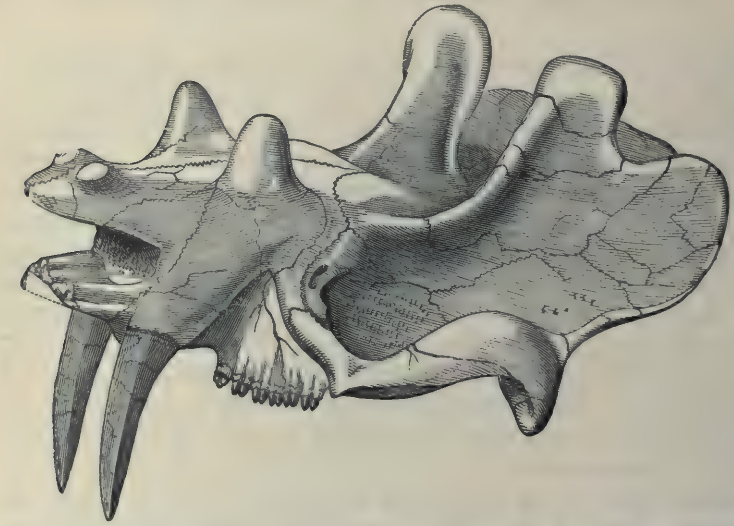
* "Journal of Anatomy and Physiology," VII. pp. 267–270. June, 1873.

breadth, were followed by six small molar teeth. Each of these were composed of two well developed, nearly straight, transverse ridges, which joined at the inner border of the tooth, and diverged as they ran outwards, so forming a simple >-shaped pattern, that continued well marked till the tooth was much worn. The posterior of the two ridges was quite transverse, and the anterior was slightly concave backwards, and ran obliquely forwards and outwards. These teeth diminished in size from before backwards gradually, and there were no intervals between them. All that I can find about the lower jaw is that it was slender, and its tusks small.



Skull of *Dinoceras mirabilis*, copied from Professor Marsh's figure, and kindly lent by the Proprietors of "Nature."

The orbit was not separated from the temporal fossa, which latter Page 269. was large, extending up the outer side of the lateral parieto-occipital crest. The malar completed the anterior portion of the zygomatic arch; the lachrymal was large, forming the anterior border of the orbit; a large oval foramen perforated its facial surface. The squamosal sent down a large post-glenoid process. The nasals were massive, and greatly prolonged forwards, at the tip carrying the anterior horn-cores; they also sent slight processes up the inner faces of the maxillary horn-cores. The premaxillaries were peculiar in that they almost enclosed the anterior nares; they united posteriorly with the maxillaries just in front of the canines, and then divided into two branches, one of which, the lower, corresponding to the premaxillary of the Rhinoceros, ran forwards free; the other, closely uniting with the adjoining nasal, went upwards to strengthen the support of the horn-cores.

The extremities were tetradactylate, and in the pes the astragalus articulated with the cuboid as well as with the scaphoid bone. The humerus was short and massive, with the great tuberosity not rising above the articular head, and the condylar ridge of the distal end not continued up the shaft. The radius, which was free, was not so oblique as in the Elephant.

The femur had no pit on its head for the ligamentum teres, and there was not any third trochanter. The phalanges were short, as in the Elephant.

The number of the vertebræ are not noted by Marsh, so that I cannot say how many there were in the dorso-lumbar region, a point of great importance. There were four in the sacrum, the last being small and supporting a slender tail. The ribs had rudimentary uncinate processes.

The name *Tinoceras* has been given by Marsh to a very closely allied species, which differs from *Dinoceras* in having the anterior or nasal horn-cores compressed on the top, larger, and projecting more forward; the maxillary horn-cores are also proportionately longer, more cylindrical, and directed slightly forward. The photographs of this genus above referred to show very clearly that the palate was completed opposite the posterior molars by the palatine bones. The differences between *Tinoceras* and *Dinoceras* seem to be scarcely generic. Another closely allied genus, of which I have seen no description, is the *Uintatherium* of Leidy. The name *Eobasileus*, introduced by Professor Cope, is a synonym of *Tinoceras*, and being of later introduction, must be sunk. Page 270.

From the facts given above, Professor Marsh is led to placing these undoubtedly peculiar animalia in an order different from any yet established, intermediate between the Proboscidia and the Perissodactylata. To me it seems much more probable that they belong to the Ungulata proper, and that no separate order is necessary for their reception. In the characters I have given, there are none which show them to have any true Proboscidian affinities, whilst there are several which seem to indicate that they belong to a family of the Artiodactylata, and not to the Perissodactylata. Among the reasons in favour of *Dinoceras* and its allies being Artiodactylate are the following:—

1. The astragalus has a well-developed cuboid facet.
2. The palate is complete between the posterior molars.
3. There is no third trochanter to the femur.
4. The premaxillæ are edentulous.
5. The anterior premolar is not developed.

21. ON THE VALUE IN CLASSIFICATION OF A PECULIARITY IN THE ANTERIOR MARGIN OF THE NASAL BONES IN CERTAIN BIRDS.*

Page 33. SINCE commencing the study of the anatomy of birds, it has always appeared to me that two distinct types of nasal bones can be distinguished among them without difficulty—and that if those which present the abnormal characters are considered separately, they present other features in common which justify their being placed in the same class, and their entire separation from those which present the less modified arrangement.

In most birds the anterior margin of the nasal bone is concave, with the two cornua directed forwards—one along the outer edge of the nasal splint of the præmaxilla, to form the inner margin of the osseous external nares, whilst the other, which is free, descends as part of the external boundary of the same aperture in connection with the ascending process of the maxilla, which it joins. These two processes become continuous behind with the body of the bone, and with one another, there being no interruption of any kind between them. Such a condition is found in its simplest form in *Otis* and the Gallinæ proper; and birds possessing the bone so constructed may be termed *holorhinal:* in them a transverse straight line, drawn on the skull from the most backward point of the external narial aperture of
Page 36. one side to that of the other, always passes in front of the posterior terminations of the nasal processes of the præmaxillæ.

But several birds present a very different condition. In *Grus*, for example, the posterior contour of the osseous external nares, instead of being rounded, as in holorhinal birds, is apparently formed by the divergence of two straight bars of bone, which enclose an angular space between them. These two processes evidently correspond to the two anteriorly directed cornua of the holorhinal skull described above; but they appear in many cases to be so different in density, and the outer one joins the body of the bone so abruptly, that it seems at first sight to be an independent ossification; however, I have no reason to believe that such is the case. As in holorhinal birds, so in those under consideration, which may be termed *schizorhinal*, the internal process of the nasal bone runs forwards along the outer border of the

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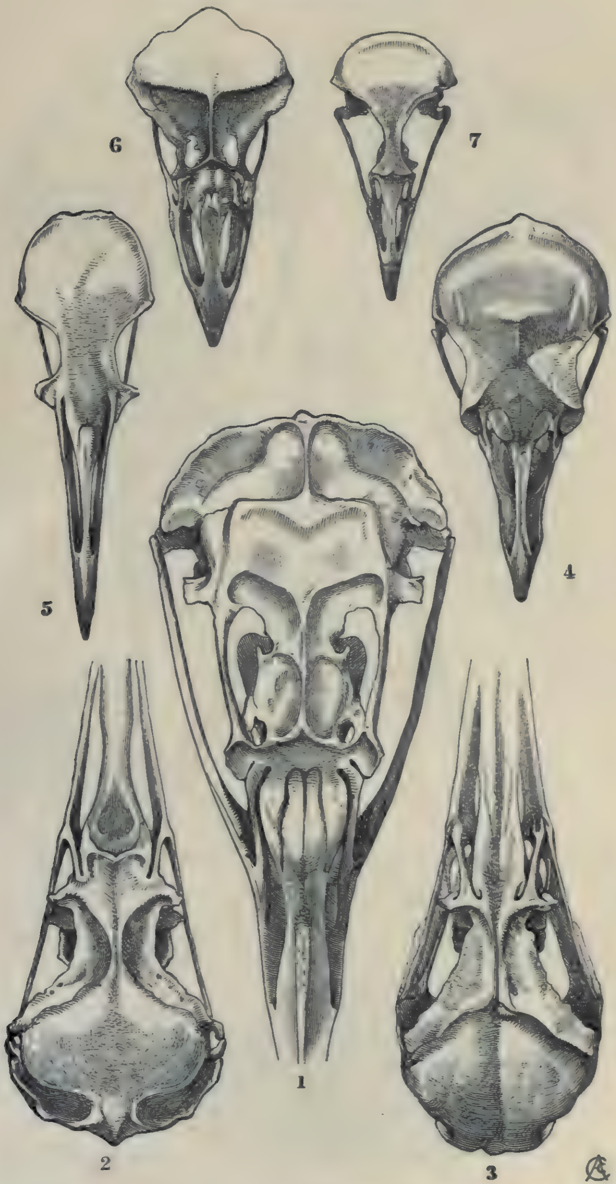
* "Proceedings of the Zoological Society," 1873, pp. 33–8. Read, Jan. 7, 1873.

Skulls of Schizorhinal Birds.

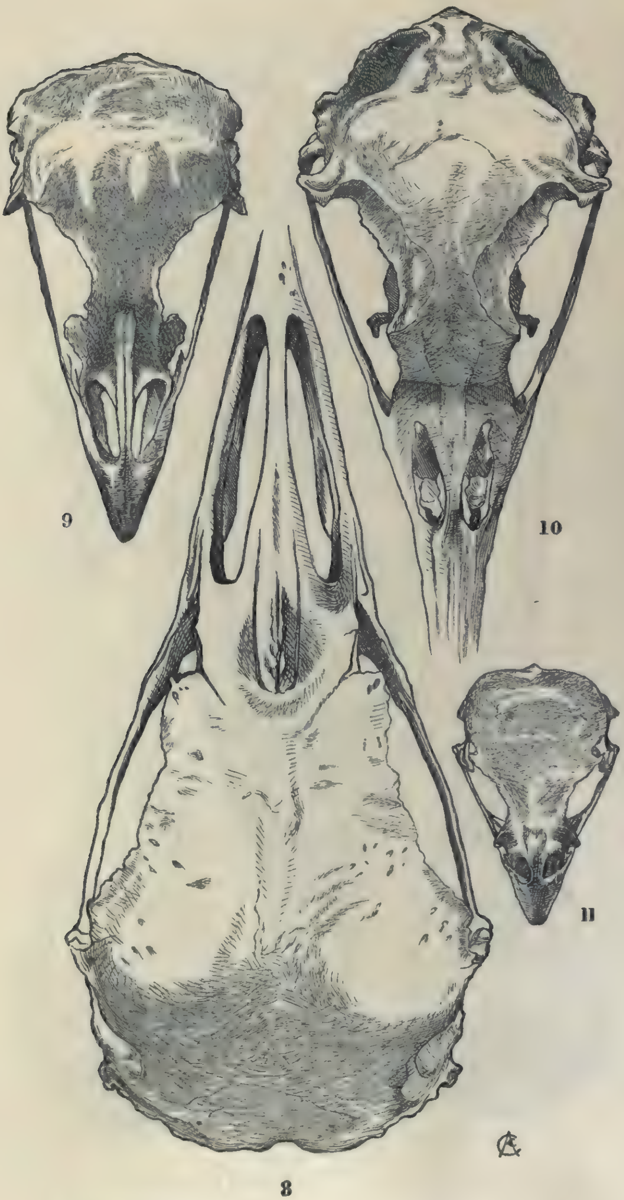
Page 34.



1. *Alca impennis.*
2. *Larus argentatus.*
3. *Numenius arquatus.*
4. *Columba livia.*
5. *Parra (Hydralector) cristata.*
6. *Arctica alle.*
7. *Pedionomus torquatus.*

Page 35.

Skulls of Holorhinal Birds.



8. *Otis tarda.*
9. *Gallus domesticus.*
10. *Daption capensis.*
11. *Coccothraustes vulgaris.*

nasal process of the præmaxilla, and the outer descends free to join the maxilla. In these birds there is considerable variation in the manner in which the almost detached outer of the two nasal processes joins the body of the bone. In *Numenius*, *Hæmatopus*, and many of the Limicolæ they proceed directly upwards and expand, becoming slightly fanned out where they join the rest of the bone by a straight transverse line. In *Ibis* and *Grus* they are of uniform size from end to end, whilst in the Auks, and to a less degree in the Gulls, at its origin the process is slightly curved, being directed outwards for a short distance, and after that straight downwards and forwards.

In most schizorhinal birds, a transverse line joining the extreme posterior point of one external nasal aperture to the similar one of the opposite side is situated behind the posterior ends of the nasal processes of the præmaxilla; but in some of the short-beaked broad-mouthed species of the class it is situated in front of them. Such is the case in *Pterocles* and *Syrrhaptes;* and this peculiarity renders it at first sight uncertain whether they are schizorhinal at all; but as every intermediate condition may be found between the strictly schizorhinal skull of the Columbidæ proper, and the very similar but less strongly marked skull of *Pterocles*, there is no real reason to doubt that the modification only depends on the great breadth of beak in the latter bird. The curious development of the superficial nasal turbinal bone of *Pterocles* is also a Columbine character, as is also the great length of the inner of the two nasal processes, which, in a manner quite unlike that of the Gallinæ, extends on each side for a long way forwards under the premaxillary nasal splint.

Subjoined is a list, alphabetically arranged, of the genera in which I have observed the schizorhinal arrangement:—

SCHIZORHINAL BIRDS.

Alca.
Anous.
Anthropoides.
Arctica.
Cataractes.
Charadrius.
Chionis.
Dromas.
Eurypyga.
Fratercula.
Gallinago.
Glareola.
Grus.
Hæmatopus.
Ibis.
Larus.
Lestris.
Limosa.
Machetes.
Numenius.
Parra.
Platalea.
Pterocles.
Recurvirostra.
Rhinochetus.
Rhynchops.
Rissa.
Sarciophorus. Page 37.
Scolopax.
Sterna.
Totanus.
Tringa.
Turnix.
Uria.
Vanellus.

And all the Columbidæ proper.

From the above list it is evident that nearly all the schizorhinal birds are included among Professor Huxley's Schizognathæ. Going further into detail, they may be said to embrace all the Charadriomorphæ, with the exception of *Œdicnemus* (I have not seen *Cursorius*). Among the Geranomorphæ, they comprise the Gruidæ, together with *Rhinochetus* and *Eurypyga*, but not the Rallidæ (from which family *Parra* should be removed to the Charadriomorphæ), nor *Psophia*, *Otis*, and *Cariama*. Among the Cecomorphæ they include the Laridæ and Alcidæ, but not the Procellariidæ nor the Colymbidæ. Among the Speniscomorphæ none are schizorhinal. Among the Alectoromorphæ *Turnix* and the Pteroclidæ are so; and the Peristeromorphæ are all schizorhinal. In the other main divisions, the Desmognathæ and the Ægithognathæ, only the Hemiglottides of Nitzsch, belonging to the Pelargomorphæ, are schizorhinal.

The linking together of the Plovers and the Gulls by any osteological feature has long been a desideratum, as Professors Newton and Huxley have remarked;* and the facts brought forward by the latter have greatly assisted in this respect. But Professor Huxley's classification does too much; it places the Petrels nearer to the Gulls than the latter to the Plovers, and it includes the Rails in the same category as the Cranes, which is more than collateral evidence justifies. If the nasal bones have the significance in classification which I would put upon them, and their conformation be employed in dividing up the schizognathous birds (with which, notwithstanding their desmognathism, *Platalea* and *Ibis* must be placed), a result is arrived at which pterylosis and internal anatomy greatly tend to justify.

The following table represents my idea of such an arrangement, though I do not wish to give my sanction to the naturalness of the non-schizorhinal schizognathous group, which I believe to be open to criticism:—

SCHIZOGNATHOUS BIRDS (Huxley) + Hemiglottides (Nitzsch).

Schizorhinal Birds.

1. Columbæ, Pteroclidæ, and Turnicidæ.
2. Limicolæ (excluding *Œdicnemus*, and including *Parra*).
3. Laridæ.
4. Gruidæ.
5. Eurypygidæ and Rhinochetidæ.
6. Hemiglottides.
7. Alcidæ.

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* "Ibis," 1868, pp. 92 and 360.

Holorhinal Birds. Page 38.

1. Impennes.
2. Procellariidæ.
3. Colymbidæ.
4. Gallinæ (excl. *Pterocles* and *Turnix*).
5. Rallidæ (excl. *Parra*).
6. Otidæ (incl. *Œdicnemus*).
7. Cariamidæ.
8. Psophiidæ.
9. Opisthocomidæ.
10. Podicipidæ.

In his paper "On the Osteology of the Kagu," Mr. Parker, in speaking of the nasal bone, says, "this part of the face is thoroughly Gruine in both the *Eurypyga* and the Kagu; the long open nasal fossa, so sharp above at the bifurcation of the nasals, gives a character to the face common to large groups of Grallæ and Palmipeds." Otherwise he does not employ this character in classification, as is evident when it is seen that he places the Kagu close to *Psophia* and the Rails, which are holorhinal birds.

It may be mentioned that the external nasal process of the nasal bone is weak or obsolete in the Struthious birds.

22. ON THE VISCERAL ANATOMY OF THE SUMATRAN RHINOCEROS (*CERATORHINUS SUMATRENSIS*).*

Page 92. THE death on September 21st, 1872, of the only English specimen of the Sumatran Rhinoceros has afforded me an opportunity of determining many points in its anatomy previously unknown; and Professor Owen's excellent memoir on *Rhinoceros indicus*, in the fourth volume of the Society's "Transactions," has made it possible to compare the details of structure in the two species.

The differences in the shape of the stomach, and the character of the mucous membrane of the small intestine, together with the peculiarities of the skin, including the presence of a second horn, the absence of a gland behind the foot, and the smallness of the folds, which cannot accurately be termed shields, appear to me quite to justify the separation, into a distinct genus, of the Sumatran Rhinoceros from its Indian ally, as has been done by Dr. Gray from a study of its osteology only.

The specimen upon which these observations are based is said to have been captured in Malacca:† it is an aged female: its skin is of a dark slate-colour, and is covered thinly with black hairs, which are more than an inch long, situated mostly on the middle line of the back and on the outer sides of the limbs. Its length from the tip of the nose to the base of the tail is 96½ inches. The tail is 22 inches long; from its base to the transverse shoulder-fold is 44 inches; and from the latter to the occipital crest is 22 inches. The ears are lined, and not fringed (as are those of the *Ceratorhinus lasiotis*) with black hairs. No traces could be found at the back of the feet of the glands described by Professor Owen in the Indian Rhinoceros.

The skull, the only part of the skeleton which I have examined, is 21⅞ inches from the tip of the nasal bones to the middle of the occipital crest, following its longitudinal direction. From one lachrymal tubercle over the head to that of the opposite side is 8 inches. The conjoined nasal bones in their broadest part are 6⅜ inches across from their lower margins over the insertion of the anterior horn.

The lower incisors and the first premolars are lost; Professor

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* "Proceedings of the Zoological Society," 1873, pp. 92–104. Read, Jan. 21, 1873.

† See for an account of its history Mr. Sclater's notes, "Proceedings of the Zoological Society," 1872, p. 494.

Flower informs me that a specimen in the Museum at Brussels has also lost its lower incisors. The premaxillary bones are anchylosed to the maxillaries, a condition I have not found in any other specimen, and which is probably dependent on the loss of the lower cutting-teeth.

Including the present one, I have seen eight skulls of Asiatic two-horned Rhinoceroses (*Ceratorhinus*)—four in the College of Surgeons' Museum, two in the British Museum, and one at the Museum at Cambridge. The present specimen agrees very closely with that at the last-named place, and with No. 1461 *a*, adult, from Pegu, in the British Museum. It being that of an aged individual, comparison with most of the others referred to is more difficult, as they are nearly all immature. The skeleton mounted at the College of Surgeons, No. 2933, obtained by Sir S. Raffles from Sumatra, is aged also; but there are points in which it differs materially from the present specimen. It is of slighter build, and the nasal bones are narrower.

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A much larger skull, not quite adult, in the Museum of the College of Surgeons, No. 2935, stated to be that of a "male Sumatran Rhinoceros," and presented by Sir S. Raffles, is evidently from a larger animal, and agrees also with *Ceratorhinus lasiotis* in being proportionately broader in the parietal regions. In this skull also the posterior of the submental foramina is situated in front of the second premolar, while in all the others (except No. 2936, R.C.S., which is young, but peculiarly massive) it is situated, when present, behind that tooth.

Subjoined is a table giving a few of the measurements in the skulls above referred to:—

	No. 2935, R. C. S.	Zool. Soc. specimen.	No. 1461*a*, B. Mus.	No. 2933, R. C. S.	Cambridge specimen.
	in.	in.	in.	in.	in.
Length of skull from tip of nasals to middle of occipital crest................	23	21·875	21·925	21·25	22·125
Breadth across nasal bones	5·25	6·375	—	4·75	6·75
Length of 2nd upper molar at base	2	1·775	1·7	1·6	
Length of 1st upper molar at base	1·75	1·5	1·375	1·35	
Length of 4th upper premolar at base	1·6	1·25	1·255	1·225	

The following is an account of the various features of the viscera that were observed in the Sumatran Rhinoceros.

Alimentary Canal.—The palate, which is covered with a smooth epithelium, is marked by conspicuous transverse angular ridges. There are eleven of these on each side; and they are not continuous anteriorly across the middle line, but the prominences of one side are carried on as the fossæ on the other. The posterior ridges are continuous from one side to the other; and they, instead of being transverse, as are those in front, are arranged in the form of a V, the concavity of the V being directed forwards. On the soft palate, which is $4\frac{3}{4}$ inches long, these ridges disappear. The palate is narrow, as can be readily seen by an inspection of the skull; anteriorly its breadth is $2\frac{3}{4}$ inches, and posteriorly $3\frac{1}{2}$ inches, gradually increasing from before backwards.

In no part of the alimentary canal, except on the surface of the tongue, were there any papillæ visible to the naked eye.

Page 94.

The *cheeks* form pads on either side, composed of areolar and muscular tissue, which project into the cavity of the mouth. These pads are shaped like prominent blunted triangles, with their apices directed

Fig. 1.

Tongue of *C. sumatrensis* (superior surface).
p, soft palate, embracing the root of the tongue *epig*, epiglottis.

forwards; they are 3½ inches deep behind, where they are lost on the fauces, and they are about 9 inches long. The epithelium covering them is nearly smooth, and is very thick.

The *tongue* is elongate, and in shape much like that of the Ruminants, being thin from above downwards in front, and deep behind, with a somewhat sudden transition from one to the other. From the apex to the posterior of the circumvallate papillæ is 15 inches, and from the epiglottis to the same papillæ is 2¾ inches. In the middle of the anterior thin portion the breadth is 2¾ inches, and in the middle of the posterior moiety it is 4½ inches.

There are many circumvallate papillæ, 33 on one side and 26 on the other, forming two clusters, separated by a smooth median longitudinal line. Each cluster is triangular in shape; and the two acute-angled triangles they form lie side by side and have their apices directed backwards. The individual papillæ which go to form them are largest posteriorly, reaching a diameter of ⅙ inch; anteriorly they get smaller, and cease by becoming more and more scattered. The rest of the tongue is covered uniformly with filiform papillæ, among which no fungiformes are to be seen. Page 95.

The soft palate runs downwards as well as backwards; and its posterior portion, as Professor Flower specially pointed out to me, so closely embraces the base of the tongue that, except when in the act of swallowing, the epiglottis always projects quite into the posterior narial chamber, as in the horse and many other animals. The anterior portion of the soft palate is ¾ inch thick, and very glandular. A collection of glands of considerable size on each side of the fauces are the only representatives of the tonsils.

The *salivary glands* present the usual characters. The *parotid* is much the largest. It weighs 1 lb. 1 oz., and is of an irregular semilunar shape, the concavity embracing the superior portion of the angle of the jaw; it is mostly situated between the body of the masseter and the posterior insertion of the sterno-mastoid muscle. It lies almost entirely below the level of the zygoma, sending up a small portion into the interval between it and the external auditory meatus. Its duct, which is 14 inches long, commences at the inferior angle of the gland, and, as in the Ungulata generally, runs round the lower margin of insertion of the masseter muscle, and up along its anterior border till it pierces the buccinator, to terminate by a simple orifice in the well-marked fossa between the cheek-pad described above and the superior gum, in a line with the interval between the first and second upper true molar teeth.

The *submaxillary* gland weighs 2½ oz., and is irregularly cubical in shape. It is situated just under the angle of the jaw, covered by the digastric muscle. The duct is 13½ inches long; anteriorly it is closely bound to the inner surface of the sublingual gland; and it opens far forwards, close to the frænum of the tongue, on either side of it.

The *sublingual* gland weighs 2 oz., and is composed of several small portions which open separately, almost in one straight line, about half an inch apart, below the sides of the tongue, and parallel with the ramus of the jaw. The whole gland is about 6 inches long and 1 inch deep.

The *œsophagus* is thick and muscular, not of large calibre; it has the mucous membrane but loosely connected with the muscular parietes, and arranged in bold longitudinal folds.

The *stomach* is of a very different shape from that of the Indian Rhinoceros as figured and described by Professor Owen, and in most respects resembles that of the horse. It forms a broad tube much bent upon itself, with the cardiac and pyloric orifices approximated, and a deep and narrow interval between them, in which the main vessels and nerves run, and across which the peritoneum extends. There is no definite constriction between the cardiac and pyloric portions of the viscus; but there is a peculiar diverticulum from the outer portion of the cardiac extremity, of a subconical form, in which the base of the cone is the attached end. The whole organ is therefore somewhat globose, with the above-mentioned cardiac cæcum projecting to the left side. Page 96.

Fig. 2.

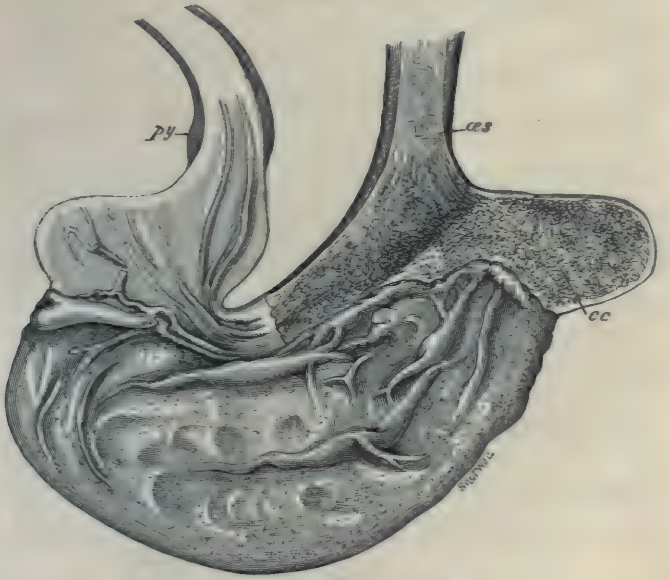
Stomach of *C. sumatrensis* (inferior or parietal surface).
œs, termination of œsophagus; *py*, commencing duodenum, just beyond pylorus.

With regard to the size of the stomach, the greater curvature is 62 inches in length, and the lesser 6 inches; the greatest breadth from side to side, including the cardiac diverticulum, is 26 inches; the greatest depth is 18 inches; and the length of the diverticulum is 11 inches, whilst it is 5¼ inches in diameter. The diameter of the undistended œsophagus where it enters the stomach is 2 inches, and of the commencing duodenum 1½ inch. There is not a trace of enlargement of the duodenum at its pyloric end, like the considerable dilatation in the Indian species. A large portion of the pyloric portion of the stomach is situated beyond, or to the right of, the pylorus itself; but it is only a direct continuation of the cavity of the viscus, and hardly forms a true *cul-de-sac*. The great omentum, which does not cover the intestines, is of considerable size; it contains no fat, and is not in any way attached to the colon, but runs up, behind the stomach, free to the vertebral column.

The interior of the stomach presents a similar condition to that found in the Tapir and Horse, the mucous membrane being of entirely different characters in the cardiac and pyloric portions. That in the cardiac end, and in its diverticulum, is much plicated in all directions, and has a white opaque appearance; while the pyloric portion is covered with a thick and apparently smooth mucous membrane of the ordinary colour. The line of junction of these two portions is abrupt;

Page 97.

Fig. 3.



Stomach of *C. sumatrensis* (inner surface).
œs, œsophagus; *py*, pylorus; *cc*, cardiac cul-de-sac.

and its position can be best understood from the accompanying drawing, in which it is seen that the corrugated white opaque epithelium only covers about one-fourth of the whole cavity—namely, the margins of the œsophagus for about an inch, and the diverticulum, from which it extends to the right, and backwards for a short distance. The walls of the stomach are nearly uniform in thickness, being a little more muscular at the cardiac extremity and along the lesser curvature than elsewhere. When the organ is fully distended the diverticulum becomes less conspicuous, the direction of its superficial fibres being from its base to its apex. The pyloric muscular ring is strong and nearly an inch thick, projecting into the tube.

The small intestine is 36 ft. long, and of a nearly uniform circumference of 6 inches, reaching 7 inches in the duodenum. For the first six inches after the pylorus the mucous membrane is smooth and simple, much like that in the pyloric portion of the stomach. The seventh and eighth inches present irregular folds, which immediately give place to a perfectly uniform series of thin, continuous (or nearly continuous), transverse foldings, just like the valvulæ conniventes of the human

Fig. 4.

Mucous membrane of the small intestine, natural size, showing the valvulæ conniventes.

small intestine. There are nineteen of these folds in each six inches of
the intestine; and they continue unchanged to within half an inch of the Page 98.
ileo-cæcal valve, where they cease. Their great number (over 1,300), extreme simplicity, and uniformity is very striking; they project nearly $\frac{1}{4}$ inch into the intestine. Many are continuous right round the tube; but where two approach one another, as is frequently the case, an intermediate one frequently ceases after having made nearly a complete circle. A few are to be seen extending for only about an inch; but most are either that size or considerably longer. There are no traces of any triangular or cylindrical papillæ the whole length of the intestine.

The bile and pancreatic ducts open on a papilla situated a foot from the pylorus, among the valvulæ conniventes, on the mesenteric border of the gut. This papilla is conical and rounded, projecting half an inch, with a single orifice at its apex. There is a second smaller orifice for a duct two inches further on, between two of the valvulæ and on one side of the main one.

No Peyer's patches could be found; and in their usual situation there was no irregularity of the valvulæ conniventes.

The ileo-cæcal valve does not project to any extent into the colon; Page 99.
but where the small intestine ceases, on the border of the ileo-cæcal orifice which is nearest the caput cæci, there are two closely approximated globose, apparently glandular masses, about the size of Tangerine oranges, situated in the walls of the intestine.

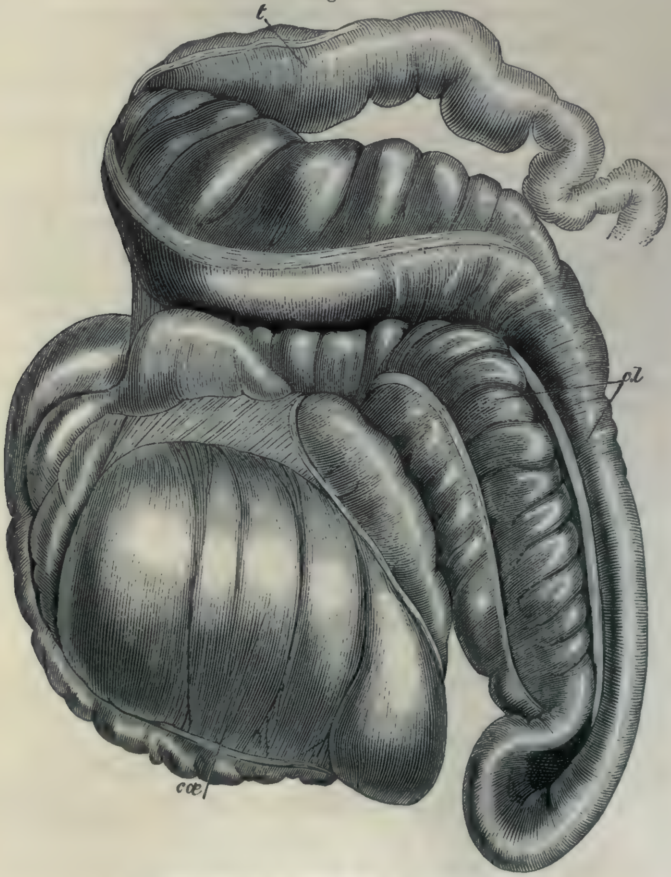
The *colon* presents features of great interest, and agrees in its convolutions with the Indian Rhinoceros. When the abdomen is opened by a ventral longitudinal and transverse incision, the posterior portion,
or the hypogastric region, is seen to be occupied entirely by a Page 100.
large, apparently globose viscus, which is the ventral wall of the cæcum: anteriorly to this, in the umbilical region, is seen a very capacious and sacculated tube, running nearly transversely and a little backwards as it tends to the left side; this is the posterior moiety of the enormous loop of the first part of the colon (ascending colon in man). Further forward, in the epigastric region, and somewhat covered by the ribs, is seen another transverse, but less considerable, sacculated tube, which is the anterior moiety of the same loop. There is no omentum covering these viscera. Nothing more can be seen without moving these parts.

When the intestines are removed from the abdomen, the following disposition of the viscera is observed. From the huge subglobose cæcum, which is median in position, with its axis slightly obliquely
backwards and to the left, the colon is directed forwards and to the Page 101.
right; but it almost immediately gives rise to the very considerable colic loop, which is directed first transversely to the left, and con-

tinues on obliquely backwards, the anterior returning portion of which returns to the right hypochondriac region, where its mesentery is very incomplete, and it is firmly bound down to the adjacent parietes. The transverse colon, running from this point, is situated quite above the colic loop, and is also bound down at the left hypochondrium as at the right. The third part of the colon (the descending in man) is very sinuous in its course; it ends by a very simple sigmoid flexure, and is continued on as the capacious rectum.

The *cæcum* is 3 feet long, and of nearly the same diameter; it is pyriform in shape, and much like that of the Tapir, the blind end being the narrower. It is traversed by three long longitudinal bands, between which it is folded in large sacculi. The colon springs from

Fig. 5.



Inferior view of the colon of *C. sumatrensis*.
cæ, cæcum; *c.l*, colic loop; *t*, transverse colon, placed above the colic loop to show it more clearly.

the anterior end of the cæcum, and immediately makes a short sigmoid curve to the right. Its interior is lined with a smooth, simple, irregularly plicated epithelium, the folds of which are quite removed when the organ is distended.

From the ileo-cæcal valve to the anus is 16 feet; and in its broadest part the colon is 39 inches in circumference. It is peculiar that, as in the Horse and also in the Tapir, the tube is of very different diameters in its different parts, the bend of the colic loop being very narrow in comparison with its main parts.

The proximal $\frac{7}{8}$ of the colic loop is sacculated, and, at its middle, 13 inches in diameter; but at its bend, where it is situated in the left iliac fossa, it is much smaller, being only $6\frac{1}{2}$ inches across, and not the least sacculated. It continues thus uniform on its surface, and gradually dilating for about $2\frac{1}{2}$ feet till in the epigastric region it again becomes sacculated and very capacious, reaching a diameter of

Fig. 6.

Superior view of the colon of *C. sumatrensis*.
si, small intestine ; *cæ*, cæcum ; *c.l*, colic loop, with the tranverse colon between it and the cæcum.

16½ inches. From this point it rapidly reduces in the transverse colon, remaining somewhat sacculated, with only one longitudinal band, which is at the mesenteric border, till at the sigmoid flexure the diameter is 6½ inches. The colic loop is just 5 feet long. There are no regular folds of the mucous membrane of the large intestine, but many minor ones, which disappear when the tube is distended. The rectum is nearly 7 inches in diameter.

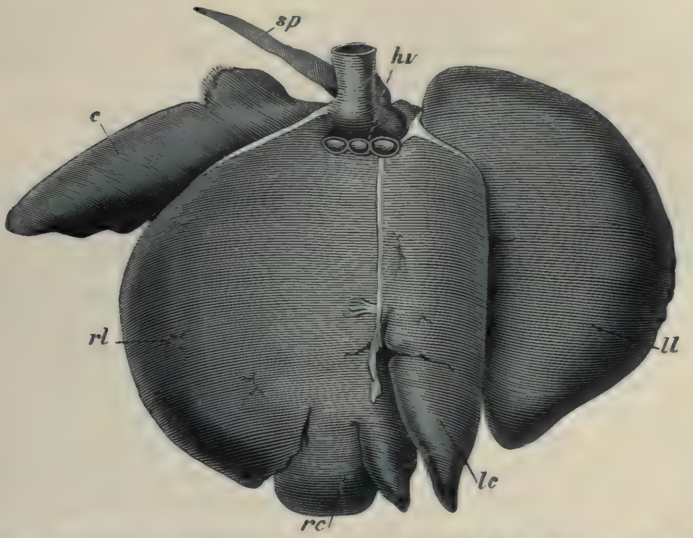
This arrangement of the colon is different from that of the Horse in that the portion corresponding to the ascending colon is longer in the latter. In the Horse and Tapir the colic loop is formed from the transverse colon, in this Rhinoceros more from the right hypochondriac angle of that viscus. In the direction of the cæcum, namely backwards and to the left, the Rhinoceros agrees with the Tapir and differs entirely from the Horse.

The *liver* is not large, considering the size of the animal. It weighs slightly over 15 lb., is flattened, and has no gall-bladder. Adopting Professor Flower's method of describing this organ, all the main divisions are indicated, though most of the fissures are not deep. The left lateral lobe is the largest, and is overlapped by the left central
Page 103. along its median border. On the anterior surface the fissure between the two extends upwards to the left lateral suspensory ligament, and therefore nearly through its whole surface; posteriorly it only extends up to about two thirds the distance. The median suture, between the left and right central lobes, extends halfway up the organ anteriorly and not quite so far posteriorly, where it is stopped abruptly by a transverse bridge of hepatic tissue. The left central lobe is triangular, prismatic, and elongate, coming to a point below on a level with the general contour-line. One flat surface of this prism, the largest, is directed forwards; and the other two are wedged between the left lateral and right central lobes.

The right central lobe is less differentiated from the right lateral than those just described are from one another, the fissure only extending upwards a short distance; and it is itself cleft to nearly the same extent near the middle of its truncated inferior border. The right lateral, the lobe second in size, is suboval and simple, with the margin entire. Mesially it slightly overlaps the right central lobe at its inferior corner.

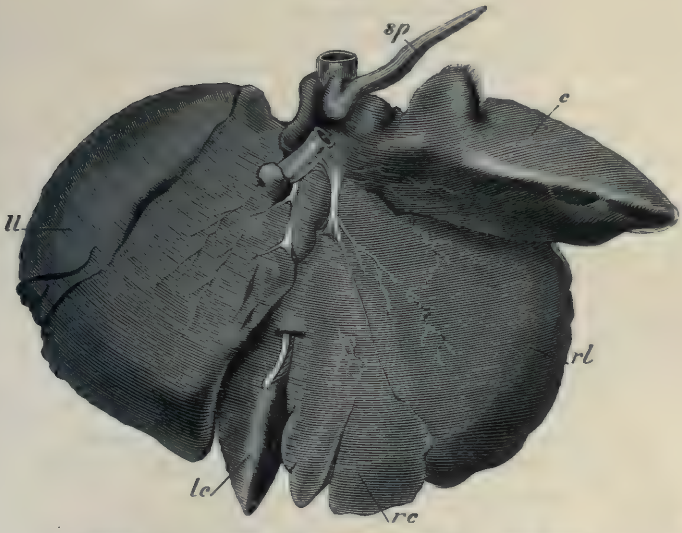
The caudate is a very considerable lobe, shaped much like the left central, but larger; it is elongate, ovate, prismatic, and pointed at its free end. The largest side is directed forwards; and the external margin of the right lateral overlaps it considerably. It is 15½ inches long, the whole liver, when lying on a flat slab, measuring 22 inches across, and 14 inches from above downwards. In no part does it measure more than 3½ inches from before backwards.

Fig. 7.



Anterior or diaphragmatic surface of liver of *C. sumatrensis*.
rc, right central lobe ; *rl*, right lateral ; *lc*, left central lobe ; *ll*, left lateral ;
c, caudate lobe ; *sp*, Spigelian lobe ; *hv*, hepatic veins.

Fig. 8.



Posterior or abdominal surface of liver of *C. sumatrensis*.
rc, right central lobe ; *rl*, right lateral ; *lc*, left central lobe ; *ll*, left lateral ;
c, caudate lobe ; *sp*, Spigelian lobe.

The Spigelian lobe is most peculiar, mainly consisting of a thin strip of hepatic tissue, 8 inches long, uniformly ¾ inch wide, and ¼ inch deep. At its attached end it becomes somewhat larger, and presents a free border superiorly for about an inch.

There are three large hepatic veins, which spring just above and behind this lobe, on their way to the vena cava.

The *pancreas* is irregular, not large nor concentrated.

The *spleen* is very thin and flat; it forms an elongated oblong, rounded at one end and squared at the other. Its length is 25 inches, and breadth 8 inches. It is slaty in colour, and weighs 2¾ lb.

The *kidneys* are flattened and oval in form. One is 6 inches broad by 2 inches long. They are nearly equal in size, and together weigh 10 lb. The hilum is linear, and on the inferior surface, not at the margin. They are lobulated externally, but not so much as the Seals.

The *heart* presents no peculiar features. The whole organ weighs 10 lb. when emptied of clots. The annulus ovalis is well marked, and forms a considerable fold over the fossa ovalis. The commencing aorta, which is 4 inches long and 3½ inches across, divides into two nearly equal branches, one of which is continued on as the arch of the aorta, with a diameter of 1·85 inch; the other gives off the vessels to the head in the following manner. Immediately after the main division of the vessel into two parts, the innominate gives off the left subclavian, which, again, is much divided up. The innominate then, 3 inches above its origin, divides into the right subclavian and the Page 104. common carotid trunk, which latter, after a simple course of 2½ inches, divides into the right and left common carotids. This disposition is very much like that of the Llama as drawn by Professor Owen. The thickness of the ventricular septum is 1½ inch.

The *lungs* are extremely simple, coniform, and undivided, except at their apices, where, as in many animals, they send down small lobes which overlap the auricles of the heart. They are nearly equal in size, being 25 inches long by 15 deep and 5 broad. They weigh each 9½ lb. (uncongested).

The *uterus* is two-horned. The corpus uteri is 3½ inches long by 2½ inches broad; the cornua are 16½ inches, by 2 inches broad; they are both very distinctly longitudinally plicated. The os uteri is much folded, and the orifice is quite small; from it to the orifice of the urethra is 12 inches. The vagina is lined with a squamous epithelium, and it presents a few transverse folds about 3 inches apart. Its circumference in the middle is 15 inches, at its orifice 9 inches. The urethra is 2 inches long, and admits two fingers.

The length of the elongate fringed orifices of the Fallopian tubes is 5 inches.

The clitoris and vulva are similar to those of the Indian species.

23. ON THE BRAIN OF THE SUMATRAN RHINOCEROS (*CERATORHINUS SUMATRENSIS*).* Page 411.

[Plate IV.]

In a communication to this Society, published in its "Proceedings" in 1873 (p. 92), I had the opportunity of describing the visceral anatomy of the Sumatran Rhinoceros (*Ceratorhinus sumatrensis*) from the first specimen received by the Society. A second individual of the species, a female (as was the first), was deposited in the Gardens by Mr. C. Jamrach in July 1875, and was subsequently purchased. It unfortunately died on May 30th of this year, with symptoms of lung disease, a post-mortem examination demonstrating that both lungs were uniformly and throughout implicated. My friend Dr. James F. Goodhart, of Guy's Hospital, late Pathological Registrar at the College of Surgeons, has kindly examined these organs, and reports to me that they "show a very extensive catarrhal pneumonia, degenerating in the centres of most of the patches. There is, in addition, some peribronchial inflammation, evidenced by a large growth of nuclei in the submucous and deeper tissues of the bronchi. The disease therefore precisely corresponds with the caseous pneumonia to which man is subject."

The specimen is the one referred to by Mr. Sclater in his valuable and superbly illustrated memoir in the Society's "Transactions," vol. ix. p. 651 (foot-note [3]).

Feeling how important it is to obtain all possible information with reference to the species, and not having removed the brain in the earlier specimen, I took the opportunity of doing so in the second, and on the present occasion place before the Society the drawings of the brain from different aspects (Plate 4, [LXX]), for verification of which I would refer the reader to the Museum of the College of Surgeons, where the original will be found preserved and mounted.

The brain of the Indian Rhinoceros (*Rhinoceros unicornis*) is represented in its different aspects, and in its internal detail, by Professor Owen, in the "Transactions" of this Society, vol. iv. pls. 19—22, and is described shortly on page 58 *et seq.* of the same volume. To this it is my desire that the figures here given should form a companion.

By comparison it will be seen at a glance that the brain of *Rhinoceros unicornis* is slightly more simple than that of *Ceratorhinus*

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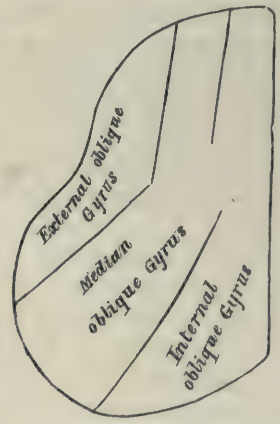
* "Transactions of the Zoological Society," X. pp. 411–3, pl. LXX. Read, June 19, 1877.

sumatrensis, although the greater size of the former species would have favoured an opposite conclusion.

So complicated and numerous are the convolutions that the general type-plan of their disposition is to a considerable extent disguised. Page 412. They very closely resemble the same in the Equidæ, as might have been surmised. The whole brain, however, is broader, especially near the posterior portion of the cerebral hemispheres, where the breadth is considerably greater than further forward.

The accompanying diagram will facilitate the description. It represents the disposition of the main convolutions upon the superior aspect of one hemisphere, and exhibits the direction of the sulci which divide them. Two diagonal sulci cut up the posterior part of each lobe into three oblique gyri, which may be called the (1) external, (2) middle, and (3) internal gyrus. The middle and internal of these fuse together near the transverse line which joins the two rudimentary Sylvian fissures, anteriorly to which there is, in the Equidæ, no indication of further primary longitudinal division. The external oblique gyrus continues, from this line, directly forwards, and independent.



Upper view of left cerebral hemisphere of *Ceratorhinus sumatrensis*, showing general direction of sulci.

In *Ceratorhinus sumatrensis* the internal oblique gyrus is triangular in shape, its inner boundary being the great longitudinal fissure of the hemispheres, into which it descends a short distance. In the Equidæ the inner boundary of this gyrus is more superficial, and can be seen as a straight longitudinal line, just external to the fissure itself, in the superior view of the brain. The whole gyrus is much broken up by minor foldings of its elements, especially in its median portion, its outer moiety consisting of a minor gyrus, whose general direction is a continuous oblique line, fairly regularly bent upon itself, first one way and then the reverse.

The median oblique gyrus is divided into two nearly equal moieties by a fissure running parallel to its direction, each half being much doubled upon itself. Anteriorly bridging minor convolutions blend it with the internal oblique gyrus, about one third distant from the anterior extremity of the hemisphere, in front of which the broad oblong cerebral surface is divided by a longitudinal sulcus into two equal moieties, both convoluted. In the great breadth and division of this anterior portion the Rhinoceros under consideration differs from the Equidæ, and agrees with *Rhinoceros unicornis.*

The external oblique gyrus is much doubled on itself, and separated from the Sylvian fissure, which it surrounds, by minor convolutions, more strongly differentiated anteriorly.

On the inner surface of the hemisphere the hippocampal gyrus is seen to be traversed by minor sulci and slight folds which run parallel to its length, as in the Equidæ, the calloso-marginal sulcus following the anterior bending of the corpus callosum, and not, as in so many Artiodactyla (but not in the Equidæ), becoming superficial anteriorly.

The fissure of Sylvius forms an open angle, at the bottom of which Page 413. are situated a number of small convolutions radiating from a point, which I take to be the island of Reil.

The under surface of the brain exhibits the smooth surfaces of the middle lobes of the hemispheres and the smooth broad roots of the equally broad olfactory nerves, which are not lobate at their anterior extremities. The optic chiasma is short, the two optic nerves springing from its anterior surface quite close together. The pons Varolii is not large, the reverse being the case with the crura cerebri and the corpora albicantia.

The lateral lobes of the cerebellum are small compared with the median portion, as is the case in the Ungulata generally.

DESCRIPTION OF PLATE 4 (LXX).

Brain of *Ceratorhinus sumatrensis.*

Fig. 1. Lateral view of right cerebral hemisphere,
2. Inferior view of left half of brain.
3. Superior view of left half of brain.
4. Internal view of right cerebral hemisphere.

Page 2. 24. ON THE DEATH OF A RHINOCEROS IN THE SOCIETY'S GARDENS, AND ON SOME POINTS IN ITS ANATOMY.*

"Mr. A. H. Garrod, in drawing attention to the death on December 14th of the female *Rhinoceros unicornis*, which had lived in the Society's Gardens for more than twenty-three years, remarked that the only pathological sign detected was the enlargement of the lymphatic glands at the base of the heart. Mr. Garrod's observations on the visceral anatomy of this Rhinoceros were quite confirmatory of those of Professor Owen. In addition, he mentioned that there was a minute *os cordis* at the attached margin of one of the aortic valves, and that in the Perissodactyla this bone is not always absent, as by some supposed, he having found a large one in a Sumatran Tapir. The remarkable difference between the arrangement of the mucous membrane of the small intestine in the Indian and Sumatran Rhinocerotes (that of the former being produced into villi nearly an inch long through its whole length, whilst in the latter these were represented by valvulæ conniventes) was also illustrated from specimens in spirit."

Page 707. 25. ON SOME POINTS IN THE VISCERAL ANATOMY OF THE RHINOCEROS OF THE SUNDERBUNDS (*RHINOCEROS SONDAICUS*).†

Our present knowledge of the visceral anatomy of the Rhinocerotidæ is confined to that of the two species *Rhinoceros unicornis* and *Ceratorhinus sumatrensis*. Professor Owen has given us, in the "Transactions" of this Society (vol. iv. pp. 31 *et seq.*) an exhaustive account of the former of these animals; and in the "Proceedings" (1873, pp. 92 *et seq.*)‡ it has been my endeavour to indicate most of the important features in the latter, which, as Professor Flower has kindly pointed out to me, were briefly described by Sir E. Home in the

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* "Proceedings of the Zoological Society," 1874, p. 2. Read, Jan. 6, 1874.

† "Proceedings of the Zoological Society," 1877, pp. 707–11. Read, Nov. 6, 1877.

‡ *Suprà*, p. 130.

"Philosophical Transactions" (1821, p. 271). On the present occasion I bring before the Society my notes on a young female of the Sondaic Rhinoceros (*Rhinoceros sondaicus*), which died in the menagerie of Mr. C. Jamrach, after having been in this country for a little more than half a year. It was only the skinned trunk which came into my possession. It is the nature of the mucous membrane of the small intestine which was certain to be of greatest interest; and this I am able to describe in detail.

The individual under consideration measures, stuffed, 6 feet 2 inches from the tip of the nose to the base of the tail. The tail itself is a foot long, whilst the height of the animal at the shoulder is 3 feet. From the middle of the occipital crest, along the curve of the superior surface of the skull, to the tips of the nasal bones is 13½ inches, the same measurement in adult animals being 22 inches.

The single milk-incisor on each side of each jaw is still in place, as are all the milk-molars. The first true molar has not cut the gum; but its cap is seen within the bony alveolus. No traces of the other molars are visible.

Mr. E. Gerrard has kindly lent me the skull for examination. In Page 708. its base it exhibits the characteristic peculiarities of the species so clearly enunciated by Professor Flower,[*] the vomer being free behind and developed into a tongue-shaped process; the mesopterygoid fossa being expanded, and the free ends of the pterygoids everted at the same time that they are broad. No second combing-plate is present on the uncut first upper molar tooth.

The animal is too young to be contrasted advantageously with Professor Peters' drawing[†] of *Rhinoceros inermis*, Lesson. I have, however, taken the opportunity of comparing that figure with the skulls of *R. sondaicus* in the College of Surgeons' Museum, and fail to see that there are sufficient differences to justify specific differentiation. Professor Flower had previously done the same, and had arrived at a similar conclusion, as he found that even greater differences than those pointed out by Professor Peters are to be detected in individuals which are all undoubtedly of Indo-Malay origin.

In skin-folding and surface-texture the Sunderbund and Javan Page 709. specimens agree exactly; the young Sunderbund animal presenting a most striking uniformity in the size of the epidermic tuberculation, except in the gluteal region, where the boiler-bolt-shaped tubercles are somewhat larger than elsewhere. Along the back the scattered brown hairs, which spring from the yielding linear intertubercular surfaces, are also well developed.

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[*] "Proceedings of the Zoological Society," 1876, p. 447.

[†] "Monatsb. der königl. Akad. zu Berlin," 1877, p. 68, pl. ii.

Fig. 1.

Mucous surface of duodenum of *Rhinoceros sondaicus.*

The following are the lengths of the alimentary viscera:—

Small intestine,	26 feet 2 inches.
Large intestine,	9 feet 10 inches.
Cæcum,	1 foot 3 inches.

The stomach, in shape, is very much like that of *R. unicornis* as figured by Professor Owen. Its cardiac surface is lined with the smooth white squamous epithelium found in all the Perissodactyla. This occupied about one third of the total gastric area, extending along most of the lesser curvature, the rest being covered with a Page 710. smooth and thick digestive coat. There is no trace of any œsophageal valve like that found in the Horse.

The small intestine is somewhat larger in the duodenal region than elsewhere. Its first three inches are destitute of the flattened papillæ found elsewhere; but here, as all along the small intestines, minute villi are present everywhere. Three inches from the pylorus the papillæ commence, and resemble those similarly situated in *Rhinoceros unicornis*,* except that they are not quite so long. They are repre-

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* *Vide* Professor Owen's figure, "Transactions of the Zoological Society," IV. pl. XII. fig. 1.

sented in Fig. 1 [p. 148], where they are seen to consist of flattened, round-tipped processes of the mucous membrane, several of which are blended at their bases, in transverse lines. None are more than ·3 of an inch in length, and most about ·6 inch broad where they first become free. They give the impression of being incomplete valvulæ conniventes which have been cut and deeply jagged at their free edges. The opening of the bile-duct is 7 inches from the pylorus, being a nipple-like tubular projection, nearly an inch long, among the papillæ. From the spot where they commence, all the way to the ileo-cæcal valve, these papillæ are found—those near the last-named situation differing from those in the duodenum in being more scattered and freer from one another, many in the ileum springing independently from the mucous membrane. Nowhere, however, are they otherwise **Page 711.** than flattened, broad, and blunt-tipped, none anywhere being circular and slender like those in the ileum of *R. unicornis*,* the existence of which I have had the opportunity of verifying. They never exceed ·3 of an inch in length. Numerous Peyer's patches exist in the ileum, as may be inferred from Fig. 2, which is a representation of

Fig. 2.

Mucous surface of ileum of *Rhinoceros sondaicus*.

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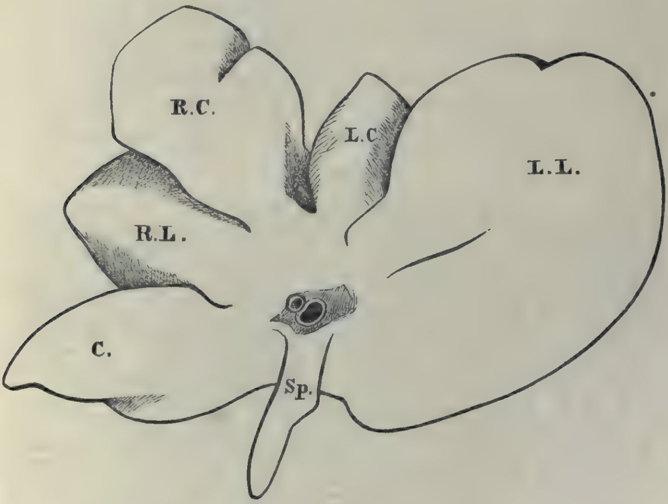
* "Transactions of the Zoological Society," IV. pl. XII. fig. 3.

a portion of the inner surface of the small intestine quite close to the ileo-cæcal valve.

Such being the case, *R. sondaicus* differs from *R. unicornis* in that the papillæ of the ileum are short, flat, and broad, instead of long, cylindrical and narrow, " like tags of worsted " (Owen).

The cæcum coli is a short blunt cone, with the diameter at its base as great as its length (1 foot 3 inches); and comparing the disposition of the colic flexures and proportionate diameter, I found them identical with those of the Sumatran species as I have figured them.*

Fig. 3.



Liver of *Rhinoceros sondaicus*. Visceral surface.
L.L. Left lateral. *L.C.* Left central. *R.C.* Right central. *R.L.* Right lateral. *C.* Caudate. *Sp.* Spigelian lobe.

The liver wants the gall-bladder, and differs but little from that of the Sumatran species. Fig. 3 is an outline-sketch of its abdominal surface, which, when compared with that of *Ceratorhinus sumatrenis* ("Proceedings of the Zoological Society," 1873, p. 102),† shows that the right central lobe is larger than the right lateral, instead of smaller. The Spigelian lobe is equally long and slender.

The pancreas is of good size and fairly concentrated.

The uterus is bicorn, each cornu measuring 8 inches, at the same time that the corpus uteri is 3 inches long. Each ovary is situated in a pocket of the peritoneum.

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* " Proceedings of the Zoological Society," 1873, pp. 99, 100. (*Suprà*, pp. 137, 138.)

† *Suprà*, p. 141.

26. ON THE *TÆNIA* OF THE RHINOCEROS OF THE SUNDERBUNDS (*PLAGIOTÆNIA GIGANTEA*, PETERS).*

Page 788.

IN 1856† Dr. Wm. Peters described a tapeworm which he found in an African Rhinoceros from Mossambique, which he named *Tænia gigantea.*

In 1870‡ Dr. Murie described the adult proglottides of a tapeworm passed by an Indian Rhinoceros (*Rhinoceros unicornis*) living in the Society's Gardens at the time, which he named *Tænia magna ?*.

In 1871§ Dr. Peters communicated to the Society a Note on the results of a comparison of his specimens of *Tænia gigantea* with Dr. Murie's description and figures of his *Tænia magna ?*, showing their identity, and suggesting the generic name *Plagiotænia* for the species.

During this summer I have had the opportunity of eviscerating a half-grown female of *Rhinoceros sondaicus*, from the Sunderbunds, which had been a little more than six months in this country. In the commencement of the colon I found three tapeworms with their heads (scoleces), together with several detached groups of proglottides,|| these latter being quite undistinguishable from those figured by Dr. Murie, in form as well as size.

Dr. Peters has figured the scolex in his species, which is evidently in a powerfully contracted condition, to which one of my three specimens closely approaches. My other two specimens are not so, and, as a result, differ so much in appearance that I subjoin a figure of one of them.

Scolex of *Plagiotænia gigantea*, much enlarged; superior and lateral view.

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* "Proceedings of the Zoological Society," 1877, pp. 788, 9. Read, Nov. 20, 1877.

† "Monatsb. der Akad. der Wissensch. zu Berlin," 1856, p. 469.

‡ "Proceedings of the Zoological Society," 1870, p. 608.

§ "Proceedings of the Zoological Society," 1871, p. 146.

|| In his account of his specimens Dr. Murie has most curiously mistaken the groups of proglottides (which he figures) for single segments.

Of the specimen here figured the breadth (after being kept in alcohol) of the scolex, opposite the suckers, is 4 millimetres, whilst the depth, to the lower of the two more strongly marked transverse Page 789. lines below the suckers (the proliferating area), is 3 millimetres. The breadth of the largest of the proglottides is 3·1 centimetres, their depth being 4·5 millimetres. One decimetre from the end of the scolex the proglottides are 1·42 centimetre in breadth.

In one respect the scolex differs from that described by Dr. Peters, the rostellum or little conical elevation between the suckers being scarcely even indicated as such. This, however, seems hardly sufficient to justify specific separation.

It is an interesting fact that three different species of *Rhinoceros*, so separated in their distribution, should be troubled with the same tapeworm, which must therefore, unvarying, have followed the ancestral species in its different variations, now so easily distinguishable.

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27. NOTES ON THE ANATOMY OF THE BINTURONG (*ARCTICTIS BINTURONG*).[*]

Certain points in the anatomy of the soft parts of the Binturong, a knowledge of which is necessary to assist in substantiating the generalisations of Mr. H. N. Turner[†] and Professor Flower[‡] as regards the correct classification of the Carnivora, being as yet undetermined, the recent death of a male specimen enables me to supply them.

Dr. Cantor[§] and Professor Owen[||] have described the alimentary canal, noting some of the most important points; but neither has entered much into detail, and the generative organs in the male are not included in their descriptions.

Alimentary Canal.

With regard to the *palate*, there are ten transverse ridges extending across its anterior part; they are not very strongly marked. The

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[*] "Proceedings of the Zoological Society," 1873, pp. 196–202. Read, Feb. 18, 1873.

[†] "Proceedings of the Zoological Society," 1848, p. 63 *et seq.*

[‡] "Proceedings of the Zoological Society," 1869, p. 4 *et seq.*

[§] "Journal of the Asiatic Society of Bengal," 1846, p. 192.

[||] "Anatomy of Vertebrates," 1868, III. p. 445.

anterior five form continuous curves, convex forwards, the first being just behind the incisor teeth; the posterior five, starting from the sides forwards and inwards, turn suddenly backwards at right angles to their former direction, and, meeting in the middle line, produce V-shaped patterns, with the concavities directed forwards; they are also somewhat further apart than those in front, and have one or two rows of mammillated projections in the spaces thus left. The back part of the palate is not ridged; and the uvula is represented by two slight projections, one on each side of the middle line, with a very shallow notch between them.

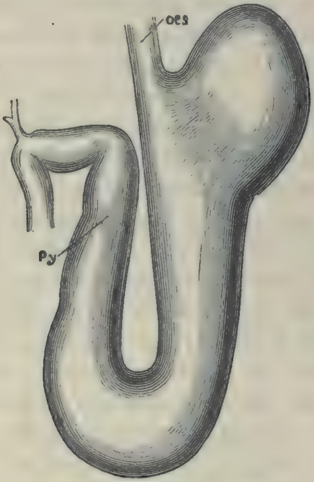
Page 197.

The *tongue* is 3 inches long from the tip to the posterior of the circumvallate papillæ; its sides are nearly straight and parallel, converging slightly in front; at its base the breadth is 1 inch, and in front it decreases to $\frac{7}{8}$ inch. The mucous membrane covering its lower surface and the floor of the mouth is smooth; and the superior edge of the frænum linguæ is $1\frac{1}{2}$ inch from the tip, which latter is simply rounded. The mucous membrane of the superior surface, which is thickly set with papillæ, extends up to and slightly over the margins of the tongue in its anterior part, forming a thin-edged fringe all along the border. The anterior half of the superior surface is covered with easily visible, hispid, feline, retroverted papillæ, particularly large at the centre, diminishing in size laterally and forwards, where, at the extreme margin, some fungiformes are mixed up with them. In the back part of the tongue the papillæ fungiformes are sparsely scattered among the diminished filiformes; and the papillæ circumvallatæ, nine in number and not equal in size, form the usual V, four on each side, with one median and posterior. Between these and the epiglottis the mucous membrane is soft and covered sparsely with thin cylindrical papillæ, some of which reach $\frac{1}{6}$ inch in length; these are most uniform in diameter from end to end near the middle line, and towards the sides they become shorter and broader at their bases, till they blend with and become undistinguishable from their filiformes. No ossified lytta could be found.

The parotid is slightly the largest of the *salivary glands;* it is irregularly shaped and thin at its edges, where it is interpolated between the muscles. The submaxillary gland is egg-shaped, and about $\frac{3}{4}$ inch in average diameter; its duct runs far forwards on the floor of the mouth, opening within $\frac{1}{8}$ inch of that of the opposite side, upon the symphysis of the jaw and closely bound to it, just behind the canine teeth and half an inch behind the incisors. The sublingual gland is elongate, and nearly as large as the submaxillary.

The *stomach* has a very peculiar shape, being elongated longitudinally, and consisting of a longitudinal cylindrical portion running backwards, and, after an abrupt bend, returning chestwards, the parallel tubes thus formed being closely approximate. By this arrangement, notwithstanding the considerable length of the lesser curvature, the cardiac and pyloric orifices are not far from one another; and they would be nearer were it not for the fact that the second or returning portion of the tube is a little shorter than the first. The cardiac portion of this stomach-tube has a diameter in the undistended organ of 1 inch, which gradually reduces to $\frac{3}{4}$ inch near the pylorus. A globose cardiac *cul-de-sac* throws the œsophageal opening quite to the right of that portion of the organ, and so brings it into contact with the commencing duodenum, which, before its first flexure, is a direct continuation forwards (chestwards) of the second Page 198. or pyloric portion of the stomach. The greatest length of the undistended organ, which is from the cardiac *cul-de-sac* to the middle of the bend above described, is $4\frac{3}{4}$ inches, and from the same bend to the pylorus is $2\frac{3}{4}$ inches; the *cul-de-sac* is $1\frac{1}{2}$ inch across.

Fig. 1.



Stomach of the Binturong.
œs, œsophagus ; *py*, pylorus.

Dr. Cantor says, "The stomach is remarkably lengthened, cylindrical, the parietes much thickened towards pylorus. Œsophagus enters close to fundus ventriculi, in consequence of which there is but a slight difference between the curvatures. Length along the greater curvature 1 foot 2 inches, along the smaller curvature 1 foot 1 inch."

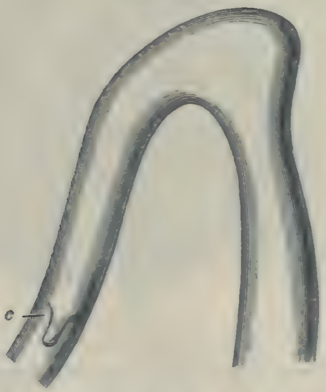
Prof. Owen remarks of the stomach of the Lion that it "lies less transversely to the abdomen than in Man." In a Leopard Cat (*Felis bengalensis*) that I have lately dissected the shape of the stomach was almost exactly the same as that of the Binturong; and it was similarly situated—namely, with its two moieties running longitudinally and not transversely.

The *intestines* are evidently much shorter in the specimen that I dissected than in those described by others, as may be seen from the following Table :—

	Dr. Cantor's Specimen.		Prof. Owen's Specimen.		Present Specimen.	
	ft.	in.	ft.	in.	ft.	in.
Small intestine	7	11	7	0	4	9
Large intestine	1	10	2	0	1	1½
Cæcum	0	0½	0	0½	0	0⅕
Length of specimen, without tail	2	3	2	0	2	3½

The bile-duct joins that from the pancreas for ¼ inch before it enters the intestine, which it does 2½ inches from the pylorus, at the second bend of the duodenum. The intestines are thick, as in the Cats; and there are no permanent folds in any part of the mucous membrane of the alimentary tract. The *cæcum* is situated, as in the Felidæ generally, in about the centre of the abdomen, on the inferior surface of the diagonal portion of the intestine, which runs to the left hypochondriac region, and then, after, in *Arctictis*, dilating slightly at the angle, goes straight backwards to the rectum. It is very much like that in the Herons, being of considerably less diameter than the Page 199.

Fig. 2.



Portion of the colon of the Binturong, showing the small cæcum (*c*), and the dilatation at the angle of the colon, which is situated in the left hypochondrium.

gut itself; the colon and small intestine are of nearly equal diameter and uniformly cylindrical. The omentum only covered the intestines to a small extent, not going more than half down the abdomen.

The *liver* presents all the known lobes; and the left lateral, right central, and right lateral are large. The lateral fissures extend deeply into the organ. The right central lobe is considerably cut up; the fissure of the gall-bladder is deep; and a small supplementary lobule covers the fundus of that viscus on its abdominal surface. The left central lobe is much more conspicuous on the diaphragmatic than on the abdominal surface. The caudate lobe is larger than usual, and quadrangular, presenting the renal fossa well developed, and being perforated by the vena cava inferior. The Spigelian lobe is elongate-oval, pointed at its free end, and it does not reach as far as the left

Fig. 3.

Liver of the Binturong.

The various lobes are lettered as follows:—LL, left lateral; LC, left central; RC, right central; RL, right lateral; S, Spigelian; C, caudate; and GB is the gall-bladder.

In order to facilitate comparison, the direction of the shading in the different lobes is varied, all parts of the same lobe being shaded in the same direction, whilst the lobes on each side are differently shaded; the left lateral, however, so far overlaps the left central as to appear to be connected with the right central.

margin of the liver. The general contour of the lobes is even, with a few slight irregularities now and then.

The *spleen* is long and thin; it is $6\frac{1}{4}$ inches long, $\frac{3}{4}$ inch across, tapering and rounded at the ends.

The *kidneys* are smooth and reniform.

Each lung is divided into distinct lobes, the left into three, and the right into four, the extra one on the right side (the azygos) being Page 200. behind and nearly in the middle line.

The *urinary bladder* in this specimen was very much distended, and ascended a considerable way into the abdomen as a narrow pyriform sac.

The *testes* were situated in the scrotum, which projected backwards from the greatly developed mass of perineal glands. Of these last-mentioned glands Dr. Cantor remarks:—"Between the anus and penis is situated a large pyriform gland, exceeding 2 inches in length, partially divided by a deep naked fossa, commencing from the latter organ. The gland secretes a light-brown oily fluid, of a peculiar intense, but not fœtid or sickening odour." The deep cleft above mentioned is longitudinal; and it is over its naked approximated sides that the orifices of the numerous simple, pyriform, yellowish, translucent glands open. Each separate gland is about $\frac{1}{2}$ or $\frac{3}{4}$ inch long, and $\frac{1}{8}$ inch across at its broadest part, near its base. The two Page 201. lateral aggregated collections of these glands make up the oval or nearly circular mass in front of the testes; and the raphe of the perineum runs at the bottom of the cleft between them. The penis, in its non-erect condition, does not project more than $\frac{1}{4}$ inch beyond them.

The *prostate* is present, but only forms a small glandular mass round the sides and inferior portion of the urethra. It is situated $3\frac{1}{2}$ inches from the base of the bladder, being simple, $\frac{1}{2}$ inch broad, and $\frac{3}{8}$ inch long. *Cowper's glands* are situated $1\frac{1}{2}$ inch in front of it; they are oval, and each is $\frac{3}{16}$ inch broad and $\frac{1}{2}$ inch long. The testes measure $1\frac{1}{8}$ inch by $\frac{9}{16}$ inch. There is no os penis. The glans penis is conical and pointed, $\frac{3}{4}$ inch long, and presents round its base several small dark brown hard flattened papillæ, about $\frac{1}{12}$ inch long.

The vesiculæ seminales are absent.

The anal glands are simple, globose, and thin-walled, about $\frac{1}{2}$ inch in diameter; their orifices, one on each side, are extremely small.

The brain presents the feline characters so clearly pointed out by Prof. Flower;* and, as in *Felis*, it differs from that of *Viverra* in

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* "Proceedings of the Zoological Society," 1869, p. 478.

having the posterior and not the anterior of the limbs of the internal circumsylvian gyrus of greater breadth.

Fig. 4.

Brain of the Binturong.

The Sylvian fissure tends to be vertical, but is directed somewhat backwards as well as upwards. It is surrounded by three gyri. The inner commences behind, near the lower border of the temporal lobe, and, after ascending as high as the top of the fissure, bends round it and descends on the frontal lobe to the supraorbital fissure, when it again doubles forwards to form the commencement of the middle gyrus. Its posterior limb is twice the breadth of the anterior, and is bisected by a vertical fissure which extends down as far as the horizontal temporal fissure. The middle gyrus is of uniform breadth throughout, and, commencing at the folding of the inner gyrus on the frontal lobe, goes round it and terminates at the lower border of the temporal lobe behind; there is no fold in it at its posterior superior angle. The third or outer gyrus is but slightly bent in its anterior Page 202. limb, which commences at the supraorbital fissure; it embraces the middle gyrus, and does not cease opposite its posterior superior angle, but descends about halfway down its posterior limb to end by a point.

The whole brain narrows in front; and the crucial sulcus is not at all strongly marked. The corpora albicantia are separated behind; and the optic nerves in front of the chiasma run forwards close together. The pituitary body is of fair size.

28. NOTE ON THE ANATOMY OF THE BINTURONG (*ARCTICTIS BINTURONG*).*

Page 142.

In an earlier communication† I was able to confirm the observations of others, and to add fresh details, with reference to the anatomy of *Arctictis binturong*. Since that paper was published, two other specimens of the species have passed through my hands, the earlier of which differed in no respect from the one which I have previously described. The last, however, which died on January 4, 1878, presented a peculiarity which I feel to be deserving of record. It was a female, apparently adult, having lived in the Gardens of the Society since October 19, 1875. The abnormal feature which it presented was the total absence of any trace of the colic cæcum, which, as is shown in a drawing accompanying my former paper, is normally extremely small.

The line of separation between the small and large intestines is well defined; and there is no valvular constriction between the two tubes, as is the case in the Arctoidea generally. There is a large Peyer's patch quite close to the termination of the small gut.

The non-constancy of the presence of the diminutive cæcum in *Arctictis binturong*, and its total absence in *Nandinia binotata*,‡ makes it evident that the existence of the cæcum is a less important diagnostic character than was inferred by earlier investigators.

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* "Proceedings of the Zoological Society," 1878, p. 142. Read, Feb. 5, 1878.

† "Proceedings of the Zoological Society," 1873, p. 196. (*Opp.*)

‡ *Vide* Prof. Flower's "Note," "Proceedings of the Zoological Society," 1872, p. 683.

Page 202. 29. ON THE CAUSE OF DEATH OF A BLACK-FACED KANGAROO (*MACROPUS MELANOPS*).*

THE cold weather of the first week of this month coming on rather suddenly, seems to have been the cause of the death of three animals in the Gardens, in all of which, on *post-mortem* examination, it was found that the lesion was the result of excessive and abnormal movement in the abdominal viscera. A Paradoxure died from intussusception of the small intestine, part going through the ileo-cæcal valve into the colon; an Emu from prolapse of a considerable length of the alimentary canal; and the above-named Kangaroo from strangulation of a loop of small intestine by the tight twisting round it of the cæcum—a most uncommon lesion, which proves that the possession of that appendage has its disadvantages as far as the individual is concerned—just as in several human subjects death has been proved to have occurred from impaction of small bodies, like cherry-stones, in the appendix vermiformis.

In the Kangaroo under consideration, on opening the abdomen the attention was immediately drawn to a large loop of strangulated small intestine, quite black from congestion, and partly covered with flakes of recent lymph, the result of the induced peritonitis, which was inconsiderable. The length of gut involved was nearly two yards after it had been detached from the mesentery; but in the body of the animal it appeared considerably shorter, from being convoluted in the ordinary manner. The last foot or so of the small intestine was not included in the diseased loop, which consisted of the portion immediately preceding it. The cæcum was about a foot and a half long, and was situate in the right iliac region, from which it extended to the left superficially, and then again to the right behind the loop of intestine which it encircled, so that the caput cæci could be seen, distended with grumous matter (as was the strangulated portion), to the right. With care, while the viscera were *in situ*, the little finger could be introduced into the ring thus artificially formed; and it was evident that the constriction was mostly produced by the mesenteric band which attaches the proximal portion of the cæcum to the small intestine. There were no adhesions of importance. The viscera were removed *en masse;* and afterwards, without the least difficulty, the cæcum was uncoiled, and the intestine was then left quite pervious.

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* "Proceedings of the Zoological Society," 1873, pp. 202–3. Read, Feb. 18, 1873.

The mesenteric border of the cæcum was nearly as black as the strangulated part; but it was more normal in colour elsewhere. The alimentary canal was not at all over-distended with food; and the colon was nearly empty. Page 203.

Till the attack came on which caused its death, the animal was in excellent health. It was ill only forty hours. At first it lay out straight on its back for some hours; but during the last day of its life it was much doubled up, with its head between its legs.

30. ON THE CAROTID ARTERIES OF BIRDS.* Page 457.

Between the years 1825 and 1830 three anatomists published the results of their independent observations respecting the number of and the variations in the carotid arteries of the different members of the class Aves. The first of these was Bauer,† who, in 1825, pointed out some of the most noteworthy peculiarities, which have been subsequently verified. Meckel,‡ in 1826, was enabled to demonstrate the existence of other marked variations; and his observations, extending over a considerable period, are incorporated in his "Comparative Anatomy." In 1829, C. L. Nitzsch selected the same subject for a disquisition before the University of Halle.§ Since that time scarcely any further additions have been made, and the subject has been almost entirely neglected. It is not easy to understand the reason of this; for it is generally acknowledged that what has been already done by the above-named authors is extremely valuable as an assistance towards a knowledge of the correct classification of birds, and yet they have left much for other workers in the same field. The opportunities afforded me by this Society, as their Prosector, and by many kind friends, who have supplied me with specimens, in spirit, of genera and species otherwise unobtainable, have enabled me to collect together a sufficient number of facts, previously unrecorded, to make me feel justified in presenting to this Society a fresh list, in which is recorded the arrangement of the carotids of the various birds examined by myself, at the same time that the previously known results of Bauer, Meckel,

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* "Proceedings of the Zoological Society," 1873, pp. 457–72. Read, May 6, 1873.

† Disquis. circa nonnullarum Avium systema arteriosum (Berol. 1825).

‡ "Beitrag zur Geschichte des Gefäss-Syst. der Vögel," Meckel's Archiv, 1826.

§ Observationes de Avium arteria carotide communi (Halæ, 1829).

and Nitzsch, and a few others, are incorporated in the general statements.

In birds, the aorta, immediately after it has sprung from the heart, divides, as stated by Meckel, and contrary to the opinion of Cuvier, into two branches, the left innominate and the continuation of the main trunk. This latter again almost immediately divides into the right innominate and the descending aortic arch. Each innominate, after sending off pectoral and subclavian branches, continues to ascend Page 458. a short way; and when near the superior aperture of the thorax it divides into the carotid, vertebral, and thyroid branches, except in those in which the carotid of one side is deficient. In what may be called the typical arrangement, the carotids, equal in size or nearly so, run up the front of the neck from the inner side of each thyroid gland, converging until they meet in the middle line, at which spot they enter the median intermuscular septum, and continue up to the head, on the front of the bodies of the remaining cervical vertebræ, in the hypapophysial canal, covered by the lateral cervical muscular masses, and, where they are present, threading the bony arches. Birds with this arrangement are said to have two carotids, and may be termed *aves bicarotidinæ normales* (see Fig. 1).

Fig. 1.*

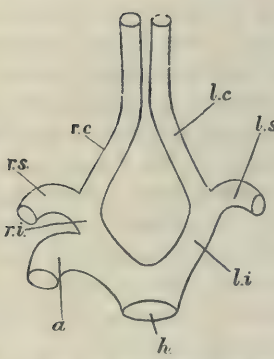

Fig. 2.

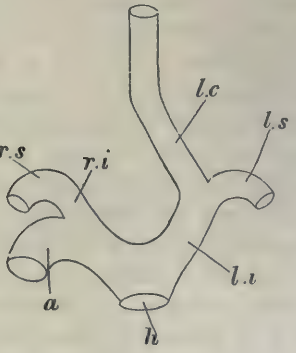

Fig. 1. Carotids at the base of the neck in *aves bicarotidinæ normales.*
Fig. 2. Carotids at the base of the neck in *aves lævo-carotidinæ.*

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* In these diagrams, which represent the main arteries at the root of the neck, the following is the explanation of the abbreviations:—*h*, origin of the aorta at the heart; *a*, arch of the aorta; *l.i*, left innominate artery; *r.i*, right innominate artery; *l.s*, left subclavian, and *r.s*, right subclavian artery; *l.c.* left carotid, and *r.c*, right carotid artery.

A second group is peculiar in having the right carotid branch of the innominate undeveloped, when the left only traverses the hypapophysial canal, being of large size; it bifurcates shortly before it reaches the head, thus producing a vessel on each side, to be distributed in the same way as the terminations of the carotids in the previous group. Such birds are said to have a left carotid, and may be termed *aves lævo-carotidinæ* (see Fig. 2).

In a third arrangement, found only in certain Parrots (see Fig. 3), the right carotid artery runs in the hypapophysial canal, and the left at the side of the neck superficially along with the corresponding pneumogastric nerve and jugular vein. Birds with this arrangement Page 459.
may be termed *aves bicarotidinæ abnormales* (see Fig. 3).

Fig. 3.

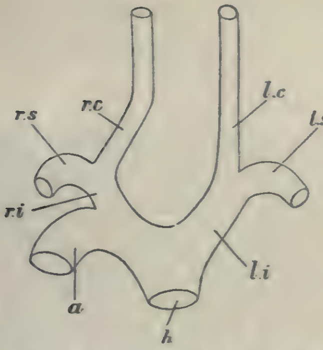

Fig. 4.

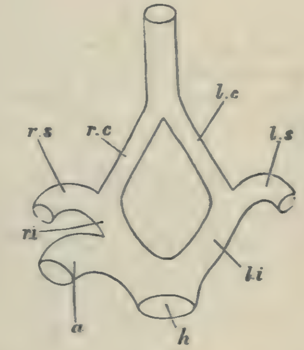

Fig. 3. Carotids at the base of the neck in *aves bicarotidinæ abnormales.*
Fig. 4. Carotids at the base of the neck in *aves conjuncto-carotidinæ.*

Fourthly, the two carotids, running apparently as usual, directly they meet, join and continue as a single trunk till near the head, where the single vessel bifurcates, as in birds with a left carotid only. These may be termed *aves conjuncto-carotidinæ.* In the common Bittern, where this condition obtains, the arteries (Fig. 4) are equal in size or very nearly so; but in the Flamingo (Fig. 5) the left is extremely small, and has been on this account overlooked by previous observers, Meckel, Nitzsch, and Owen stating that there is only a Page 460.
right carotid in *Phœnicopterus.* I have had the opportunity of examining two specimens of *Phœnicopterus antiquorum* and two of *P. ruber;* and in all of them both carotids were present in the lower part of the neck, the right being much the larger and being joined by the left to form one trunk at the point in the neck where they first meet, as in *Botaurus stellaris.* Both vessels carried blood; but the calibre of the

left was extremely small, and that of the right was nearly the same as it would have been if it alone had been present.

Fig. 5.

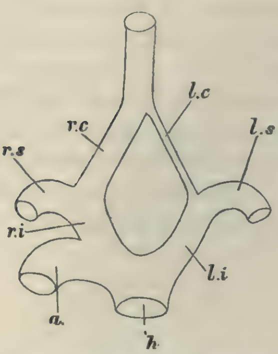

Fig. 6.

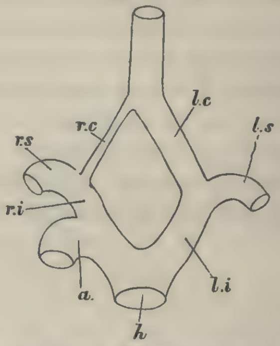

Fig. 5. Carotids at the base of the neck in the genus *Phœnicopterus*, as found by myself in all specimens.

Fig. 6. Carotids at the base of the neck in *Cacatua sulphurea*, according to Meckel.

From the list at the end of this paper it is shown that of 300 genera in which the arrangement of the carotids has been observed, in 193 of them both are present, in 107 the left only; in one only are both equal when they join in the neck; in another they join, the left being the smaller; and in one other the right is the smaller under similar conditions; whilst perhaps one possesses the right only. So it may be generally stated that in birds either both carotids are present separate, or the left only exists. Several attempts have been made by different authors to account for these peculiarities. According to Bauer, the simplicity of the carotids (in other words, the presence of the left instead of two) is dependent on the size of the individual, the smaller species having the single trunk. Undoubtedly the great majority conform to this rule; but there are too many exceptions, as shown by Meckel, to make the generalization of much value, *Rhea*, *Podiceps*, *Cacatua*, *Talegalla*, and *Menura* possessing only the left. Meckel originally thought that a correlation existed between the length of the neck and the simplicity of the carotids; but when he found two carotids in *Struthio*, *Dromæus*, *Cygnus*, and *Ardea* he acknowledged that such was not the case. Prof. Owen remarks*, "Birds as a rule are peculiar in sleeping with their long necks much bent or twisted; and this position might be expected to exercise some effect on the vessels subject thereto. Accordingly we find that the

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* "Anatomy of Vertebrata," vol. ii. p. 190.

carotids are frequently of unequal size; in the Dabchick* the left is the largest; in an Emu I found it the smallest." I may here remark that on several occasions I have watched the Flamingos sleeping; and they do so, some with the neck bent one way and some the other, in a manner quite independent of the constant peculiarity in the arteries of their necks.

All these explanations, therefore, fail to show why birds should have two or only one carotid artery; and it is the last of them only that takes into consideration which carotid would be absent when there is any deficiency. If it were proved that all birds with a left carotid slept with their necks bent in one direction, the only explanation would be, that they did so because the arrangement of their cervical vessels would not allow of their doing otherwise, and consequently an argument in a circle would be the only result. The ultimate cause is most probably as yet some way beyond our grasp; but I would offer the following as a step towards it. In birds possessing Page 461 two carotids those vessels, after they have once met, run close together in the hypapophysial canal, but do not blend or anastomose in any way.

In *Botaurus stellaris*, *Cacatua sulphurea* (according to Meckel, as shown in the diagram, Fig. 6 [p. 164]), and the genus *Phœnicopterus*, the carotids join to become one vessel at the spot where, in others, they come into contact, each proximal portion persisting. What I desire to show is, that on simple mechanical principles it is much more likely, when the two vessels do so blend, that the right should disappear, leaving the left solely to maintain the cerebral and cervical circulation; in other words, the assumption that there is a blending of the left with the right carotid in early life is sufficient to explain the absence of the right in birds thus affected. The diagram, Fig. 4, [p. 163] (which shows the distribution of the arteries at the base of the neck as they would appear immediately after the fusion of the carotids), will help to explain my meaning. The blood-current, almost immediately it has passed the aortic valve, divides into two, one going along the left innominate, and the other following the course of the aorta until it very shortly further divides into that traversing the right innominate, and that which continues on to the abdomen and posterior extremities. Such being the case, and the two carotids being of equal calibre, it is evident that, just as in Wheatstone's Bridge the electric current is less intense in the bridge itself than in the branches, the current in the right carotid, which, in the case under consideration, connects the left carotid with the aorta distad of the point at which

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* In the Grebes (*Podiceps*), according to my observations, the right carotid is not found to be present at all.—A. H. G.

the left innominate springs, is less than in the vessels it connects; consequently the current there tends to stagnate; but a tendency to stagnate in blood is a tendency to coagulation, as is seen in the proximal end of a ligatured arterial trunk; and the tendency to coagulation is a tendency to obliteration of the vessel in which the coagulation occurs; consequently the right carotid must tend to disappear, which it does in nearly every case. Since this explanation occurred to me, I have not had the opportunity of examining any of the birds in which the right artery persists after it has fused with the left, to see if there is any peculiarity in their vascular arrangement which will account for its persistence. When the carotids do not blend there is evidently no reason why either should disappear; and when they do join, the presence of a large pectoral and subclavian branch from each innominate does not alter the problem; it only indicates that the obliteration must occur distad of it, as is the case.

The following list includes all those species of birds in which I have had the opportunity of observing the disposition of the carotid arteries. They are arranged nearly according to the classification adopted in Mr. Sclater's revised List of the Vertebrated Animals in the Gardens of this Society.

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PASSERES.

All the Passeres examined possess the left carotid only.

Species examined.

OSCINES.

a. Oscines dentirostres.

Turdus merula.
—— *grayi.*
Sylvia hippolais.
Luscinia vera.
Erithacus rubecula.
Pratincola rubetra.
Ruticilla phœnicura.
Myiadestes obscurus.
Sialia wilsonii.
Troglodytes parvulus.
Mniotilta varia.
Cinclus aquaticus.
Motacilla flava.
Anthus pratensis.
Parus major.
Sitta europæa.
Lanius collurio.
Sigmodus caniceps.
Struthidea cinerea.
Oriolus, sp.
Artamus, sp.
Graucalus macei.
Dicrurus leucops.
Muscicapa griseola.
Ptilogonys cinereus.
Ampelis garrulus.

b. Oscines latirostres.

Hirundo rustica.
Chelidon urbica.

c. Oscines tenuirostres.

Nectarinia, sp.
Zosterops albogularis.
Dicæum, sp.
Anthornis melanura.
Prosthemadera novæ-zealandiæ.
Tropidorhynchus, sp.
Diglossa baritula.
Cœreba cyanea.

d. Oscines conirostres.

Tanagra cana.
Euphonia violacea.
Cissopis leveriana.
Estrelda melpoda.
Quelea occidentalis.
Euplectes capensis.
Ploceus manyar.
Hyphantornis castaneo-fuscus.
Padda oryzivora.
Munia maja.
Poëphila cincta.
Donacicola castaneothorax.
Cyanospiza ciris.
Cardinalis virginianus.
Coccothrastes vulgaris.
Hedymeles ludoviciana.
Pyrrhula vulgaris.
Corythus enucleator.
Linaria cannabina.
Emberiza, sp.
Alauda arvensis.
Melanocorypha calendra.

e. Oscines cultrirostres.

Icterus abeillæi.
Molothrus bonariensis.
Cassicus persicus.
Agelæus ludovicianus.
Sturnus vulgaris.
Gracula religiosa.
Cyanocorax cyanopogon.
Cissa speciosa.
Ptilonorhynchus holosericeus.
Heteralocha gouldi.
Corvus corax.
—— *frugilegus.*
—— *australis.*
Garrulus glandarius.
Strepera graculina.

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Tracheophonæ.

Pitta, sp.
Rupicola crocea.
Lipaugus cineraceus.
Tyrannus satrapa.
Pitangus sulphuratus.
Hylactes megapodius.
Menura superba.

MACROCHIRES.

Trochilidæ.

The left carotid only is present in

Patagona gigas.
Chlorolampis osberti.

Cypselidæ.

The left carotid only is present in the following species :—

Cypselus apus.
Cypselus alpinus.

Chætura vauxi.
—— *spinicauda.*
Chætura caudacuta.
Dendrochelidon coronata.

But both carotids were found to be present in a specimen of *Cypseloides fumigatus.*

CAPRIMULGIDÆ.

Both carotids are present in these birds.

Species examined.

Caprimulgus europæus.
Chordeiles texensis.

STEATORNITHIDÆ.

Both carotids are present in *Steatornis caripensis.*

PICI.

PICIDÆ.

The left carotid only is present in the Woodpeckers.

Species examined.

Picus major.
—— *minor.*
Picoides tridactylus.
Tiga javensis.
Leuconerpes candidus.
Chloronerpes yucatanensis.
Melanerpes formicivorus.
Mulleripicus fulvus.
Gecinus viridis.
Yunx torquilla.

COCCYGES.

CORACIIDÆ.

Both carotids are found in these birds.

Species examined.

Coracias garrula.
Eurystomus, sp.

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TROGONIDÆ.

The left carotid only is present in these birds.

Species examined.

Trogon mexicanus.
Trogon puella.

MEROPIDÆ.

The left carotid only is present in these birds.

Species examined.

Merops apiaster.
Merops ornatus.

MOMOTIDÆ.

Both carotids are present in these birds.

Species examined.

Momotus lessoni.
Eumomota superciliaris.

Galbulidæ.

Both carotids are present in these birds.

Species examined.

Galbula albirostris.
Urogalba paradisea.

Alcedinidæ.

Both carotids are present in these birds.

Species examined.

Alcedo ispida.
Halcyon, sp.
Dacelo gigantea.
—— *cervina.*
Ceryle amazona.
—— *maxima.*
Cittura cyanotis.

Bucerotidæ.

Both carotids are present in these birds.*

Species examined.

Buceros rhinoceros.
—— *plicatus.*
—— *bicornis.*
Buceros coronatus.
—— *atratus.*

Upupidæ.

The left carotid only is present in
Upupa epops.

Musophagidæ.

Both carotids are present in these birds.

Species examined.

Musophaga violacea.
Schizorhis africana.
Corythaix albocristata.

Cuculidæ.

Page 465.

Both carotids are present in these birds.

Species examined.

Cuculus canorus.
Cacomantis sepulcralis.
Chrysococcyx, sp.
Centropus senegalensis.
Guira piririgua.
Phœnicophaes, sp.

Ramphastidæ.

The left carotid only is developed in these birds.

Species examined.

Ramphastos cuvieri.
—— *ariel.*
Ramphastos carinatus.

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* P.S., Sept. 4.—In a specimen of *Toccus melanoleucus* just dissected I find the left carotid only present.

CAPITONIDÆ.

The left carotid only is present in these birds.

Species examined.

Megalæma asiatica.
Barbatula duchaillui.
Indicator major.

PSITTACI.

The Parrots are peculiar for the variation that occurs in their carotids, which show four different arrangements: first, there may be two in the normal position; secondly, the right may, as it usually does, traverse the hypapophysial canal, whilst the left, in a manner quite exceptional, runs superficially along the side of the neck in company with the left pneumogastric nerve and the left jugular vein; thirdly, the right may be very small, and blend with the much larger normally situated left (in *Cacatua sulphurea*, according to Meckel); and fourthly, the left may alone be developed, as in the Passeres. The first of these four conditions is only found in Old-World Parrots; and the last two are restricted to the Cacatuinæ.

Species examined.

In the following species the first plan prevails, the two carotids running normally:—

Stringops habroptilus.
Calopsitta novæ-hollandiæ.
Eolophus (*Cacatua*) *roseicapillus.*
Euphema pulchella.
—— *splendida.*
—— *bourkii.*
Melopsittacus undulatus.
Agapornis roseicollis.
Prioniturus, sp.
Eos cardinalis.
—— *indica.*
Trichoglossus concinnus.
Loriculus, sp.
Aprosmictus scapulatus.
Palæornis alexandri.

The following species belong to the second division, the right carotid running normally, whilst the left runs up the side of the neck, together with the left pneumogastric nerve and jugular vein:—

Ara macao.
Conurus cruentatus.
Page 466. —— *xantholæmus.*
—— *jendaya.*
—— *petzi.*
—— *holochlorus.*
Caïca melanocephala.
Psittacus erithacus.
Nestor notabilis.
—— *hypopolius.*
Brotogerys tiriacula.
—— *virescens.*
—— *tui.*
Pionus menstruus.
Chrysotis festiva.
—— *ochrocephala.*

Chrysotis levaillantii.
Psephotus hæmatogaster.
Cyanorhamphus auriceps.
—— *novæ zealandiæ.*
Platycercus eximius.
—— *pallidiceps.*
Psittacula passerina.
Lathamus discolor.

In the following species, forming the fourth section, the left carotid only is developed:—

Cacatua galerita.
Cacatua cristata.

I have not yet had an opportunity of examining the third condition, *i.e.* that said to occur in *Cacatua sulphurea.*

ACCIPITRES.

Both carotids are present in all these birds.

Species examined.

Cathartidæ.

Cathartes atratus.
Gyparchus papa.

Vulturidæ.

Neophron percnopterus.
Gyps fulvus.

Serpentariidæ.

Serpentarius reptilivorus.

Falconidæ.

Polyborus brasiliensis.
Milvus ictinus.
Buteo vulgaris.
Archibuteo lagopus.
Helotarsus ecaudatus.
Haliaëtus albicilla.
—— *vocifer.*
Aquila nævioïdes.
—— *audax.*
Spilornis cheela.
Thrasaëtus harpyia.
Falco peregrinus.
—— *melanogenys.*
Hypotriorchis subbuteo.
Tinnunculus alaudarius.
Melierax monogrammicus.
Astur palumbarius.
Circus cineraceus.

Strigidæ.

Both carotids are present in these birds.

Species examined.

Strix flammea.
Otus vulgaris.
Syrnium aluco.
—— *nebulosum.*
Bubo maximus.
—— *virginianus.*
—— *bengalensis.*
—— *capensis.*
Bubo poensis.
—— *fasciolatus.*
Ketupa javanensis.
Scops zorca.
Athene noctua.
—— *passerina.*
—— *brama.*
Pholeoptynx cunicularia.

Glaucidium, sp.
Pulsatrix torquata.
Surnia funerea.

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STEGANOPODES.

Both carotids are present in these birds.

Species examined.

Fregata aquila.
Sula bassana.
Phalacrocorax carbo.
Phaëthon, sp.

HERODIONES.

ARDEIDÆ.

Both carotids are present in the following species:—

Ardea cinerea.
—— *goliath*.
—— *purpurea*.
—— *alba*.
Ardea egretta.
—— *garzetta*.
—— *candidissima*.
Nycticorax europæus.

But the two carotids join at the lower part of the neck directly they meet in

Botaurus stellaris.

CICONIIDÆ.

Both carotids are present in these birds.

Species examined.

Ciconia nigra.
—— *alba*.
Leptoptilus crumeniferus.

PLATALEIDÆ.

Both carotids are present in these birds.

Species examined.

Ibis rubra.
—— *melanocephala*.
—— *strictipennis*.
Ibis nippon.
Platalea leucorodia.

PHŒNICOPTERIDÆ.

The right carotid is much larger than the left, which joins it low down in the neck.

Phœnicopterus antiquorum.
Phœnicopterus ruber.

ANSERES.

Both carotids are present in all these birds.

Species examined.

Anser segetum.
Bernicla canadensis.

Chloëphaga, sp.
Cygnus nigricollis.
—— *buccinator.*
—— *coscoroba.*
Dendrocygna autumnalis.
—— *viduata.*
—— *fulva.*
Tadorna rutila.
Aix galericulata.
Mareca penelope.
Dafila spinicauda.
Querquedula crecca.
Metopiana peposaca.
Fuligula cristata.
Mergus castor.
—— *albellus.*

COLUMBÆ.

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Both carotids are present in all these birds.

Species examined.

CARPOPHAGIDÆ.

Carpophaga globicera.
—— *ænea.*
Lopholæmus antarcticus.
Ptilopus melanocephalus.
—— *mariæ.*
Treron calva.

COLUMBIDÆ.

Columba œnas.
—— *livia.*
—— *leucocephala.*
—— *picazuro.*
—— *maculosa.*
—— *vinacea.*
Geopelia striata.
—— *placida.*
—— *cuneata.*
Geopelia humeralis.
Turtur senegalensis.
—— *aldabranus.*
Metriopelia melanoptera.
Chamæpelia talpacoti.
Leptoptila jamaicensis.
Chalcopelia chalcospilos.
—— *puella.*
Tympanistria bicolor.
Ocyphaps lophotes.
Chalcophaps chrysochlora.
Phaps chalcoptera.
Phlogœnas cruentata.
Calœnas nicobarica.
Didunculus strigirostris.
Goura coronata.
—— *victoriæ.*

GALLINÆ.

Both carotids are present in all this Order, except in the Turnicidæ and Megapodidæ, in which the left only is developed.

Species examined.

With both carotids.

PTEROCLIDÆ.

Pterocles alchata.
—— *arenarius.*

TETRAONIDÆ.

Tetrao tetrax.
Tetrao urogallus.

PHASIANIDÆ.

Francolinus vulgaris.
—— *afer.*
—— *ponticerianus.*

Francolinus gularis.
—— *clappertoni.*
Arboricola torqueola.
Perdix cinerea.
Coturnix communis.
Rollulus coronatus.
Odontophorus dentatus.
Ortyx virginianus.
Eupsychortyx cristatus.
Caccabis chukar.
Phasianus colchicus.
—— *versicolor.*
—— *reevesii.*
Thaumalea picta.
—— *amherstiæ.*
Euplocamus erythrophthalmus.
—— *vieilloti.*
Euplocamus pyronotus.
—— *horsfieldii.*
—— *albo-cristatus.*
Gallus bankiva.
Ceriornis temminckii.
Pavo nigripennis.
—— *muticus.*
Argus giganteus.
Meleagris gallopavo.
Numida meleagris.

CRACIDÆ.

Crax globicera.
—— *incommoda.*
Penelope cristata.
Ortalis albiventris.

Page 469. With the left carotid only present.

TURNICIDÆ.

Hemipodius tachydromus.

MEGAPODIDÆ.

Talegalla lathami.
Megacephalon maleo.

ALECTORIDES.

Both carotids are present in all this order.

Species examined.

OTIDÆ.

Houbara macqueeni.
Œdicnemus grallarius.
—— *bistriatus.*

CARIAMIDÆ.

Cariama cristata.
Chunga burmeisteri.

GRUIDÆ.

Grus antigone.

EURYPYGIDÆ.

Rhinochetus jubatus.

RALLIDÆ.

Rallus aquaticus.
Aramides cayennensis.
Porzana americana.
—— *carolinensis.*
Crex pratensis.
Ocydromus sylvestris.
Porphyrio madagascariensis.
—— *melanotus.*
Gallinula chloropus.

PARRIDÆ.

Parra africana.

GRALLÆ.

Both carotids are present in these birds.

Species examined.

Charadriidæ.

Vanellus cristatus.
Charadrius pluvialis.
—— *hiaticula.*
Hæmatopus niger.
Strepsilas interpres.

Scolopacidæ.

Numenius arquatus.
—— *phæopus.*
Limosa lapponica.
Totanus calidris.
—— *solitarius.*
Gambetta flavipes.
Machetes pugnax.
Scolopax rusticula.
Gallinago scolopacina.
—— *gallinula.*
Tringa canutus.
—— *cinclus.*
Glareola, sp.

GAVLÆ.

Both carotids are present in all these birds.

Species examined.

Laridæ.

Lestris antarcticus.
Larus argentatus.
Larus glaucus.
Sterna hirundo.

Procellariidæ.

Page 470.

Both carotids are present in all these birds.

Species examined.

Thalassidroma pelagica.
—— *fregata.*
—— *bulweri.*
Æstrelata lessoni.
Prion vitatta.

PYGOPODES.

Both carotids are present in the following species:—

Colymbidæ.

Colymbus glacialis.

Alcidæ.

Alca torda.
Uria troile.

The left carotid only is present in the following species:—

Colymbidæ.

Podiceps cristatus.
—— *minor.*

Alcidæ.

Arctica alle.

IMPENNES.

Both carotids are present in these birds.

Species examined.

Spheniscus demersus.	*Aptenodytes pennantii.*
—— *humboldtii.*	

CRYPTURI.

Both carotids are present in these birds.

Species examined.

Rhynchotus rufescens.	*Crypturus sallæi.*

STRUTHIONES.

Both carotids are present in
Struthio camelus.

The left carotid alone is present in
Rhea americana.

Both carotids are present in

Casuarius bennettii.	*Dromæus novæ-hollandiæ.*
—— *bicarunculatus.*	

The left carotid only is present* in

Apteryx mantelli.	*Apteryx owenii.*

Page 471. In reviewing the above facts, for the purpose of forming an estimate as to the significance in classification of the arrangement of the carotid arteries in birds, the following conclusions may be drawn, if the Psittaci be omitted from consideration, which, from the great peculiarities they present among themselves, it will be better to do at present:—

1st. In many cases the uniformity of the carotids is of *ordinal* importance, all Passeres possessing the left carotid only, whilst both are present in all Columbæ, Anseres, Grallæ, and Accipitres.

2nd. As a *family* character, the distribution of the carotids is very suggestive, in some cases presenting a well-marked difference between

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* In his "Anatomy of Vertebrates" (vol. ii. p. 199), Prof. Owen remarks:—"In the Apteryx I found that the left carotid alone passed to the usual place in the neck, and divided at the third cervical vertebra, to supply the head in the usual way." But in the original memoir on the bird ("Transactions of the Zoological Society," vol. ii. p. 273) the same author has stated that both are present, which is not the case in the specimens examined by me.

families otherwise closely allied. For example, the Megapodidæ, together with the Cracidæ, as Professor Huxley has so clearly shown,* from a well-established suborder of the Gallinæ, and osteologically it is not easy to separate them; but in the Cracidæ both carotids are present, whilst in the Megapodidæ the left only is found. The Phœnicopteridæ also present a condition peculiar to themselves.

In the somewhat ill-defined group, the Coccyges, the carotids give rise to family characters of value. The Bucerotidæ and Ramphastidæ differ in the latter possessing only a left carotid, whilst the former have both present; and the affinities of the Upupidæ may be considered nearer to the Ramphastidæ, on account of their agreeing with them in this point.

The Apterygidæ, as well as the Turnicidæ and Podicipidæ, are also well distinguished from their allies by their single carotids.

3rd. That *Struthio* and *Rhea* must be more than generically distant from one another is indicated by many characters; and the difference in their carotids favours their being placed in separate *subfamilies;* no such difference tends to divide up the Casuariidæ in a similar manner.

4th. Respecting *genera*, there are none in which the peculiarities of the carotids are not constant in them; but there are some which are separated from others by a difference in the arrangement of these vessels. *Cypseloides fumigatus*, a Swift, apparently not at all peculiar otherwise, undoubtedly possessed, in the only specimen I have had the opportunity of dissecting, two carotids. That this was an individual peculiarity is extremely improbable, as no similar case has been recorded in any other genus; consequently this genus (or species as it may be) differs from all its allies, which only possess the left carotid. A similar case, resting on similar evidence (a single specimen) is that of *Arctica alle*, which differs from *Alca* and *Uria*, with which its affinities are very close, in having the left carotid only, instead of both. *Botaurus*, amongst the Ardeidæ, has also an arrangement peculiar to itself.

As previously remarked, the Psittaci present greater differences among themselves respecting the disposition of the arteries of their necks than all the other orders of birds taken together, one condition being peculiar to them, and the other conditions being all represented amongst them. Without entering into further details regarding these birds it is impossible to make any generalizations of importance; and I will leave the subject for a special paper on the order. Page 472.

It is not until the different conditions of the carotid vessels are

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* "Proceedings of the Zoological Society," 1868, p. 298.

taken in connexion with the pterylosis, as well as the anatomy of the viscera and muscles, that a correct idea can be formed as to their true value in the classification of birds. The work of the illustrious Nitzsch assists much in this direction; and it is to be hoped that as facts become more numerous, ornithologists will realize that a correct arrangement will not be arrived at until anatomy is more thoroughly studied.

In conclusion, I have to present my best thanks to Mr. Sclater for the kind way in which he has on all occasions throughout this inquiry assisted me with suggestions and advice—also to Professor Flower, Mr. O. Salvin, Mr. Sharpe, and Mr. Howard Saunders, for their so willingly putting at my disposal specimens in spirit of species which I should not otherwise have had the opportunity of examining.

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31. ON SOME POINTS IN THE ANATOMY OF *STEATORNIS*.*

THROUGH the kindness of Prof. Flower, I have had the opportunity of examining two specimens of *Steatornis caripensis* preserved in spirit, as well as the skeleton of another; and Mr. Sclater has also kindly given me a skin to assist in the study of the pterylosis, and a nestling, which I have dissected.

Page 527. Many points in the osteology of this bird, as well as the description of the larynx, are to be found in a paper by Johannes Müller†; and further details are given in the works of L'Herminier‡, Sclater§, and Murie||. The following notes relate almost entirely to the pterylosis and the anatomy of the soft parts, the skull being only described so far as to make it comparable with those in Prof. Huxley's paper on the classification of Birds¶.

Pterylosis (fig. 1, p. 180).—All the top of the head is covered with a scattered feathering, which is very much the strongest between the eyes. There is no tendency to the formation of longitudinal bands in

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* "Proceedings of the Zoological Society," 1873, pp. 526–33. Read, June 3, 1873.

† "Müller's Arch. f. Anat." 1842, p. 1–11, and elsewhere.

‡ "Nouv. Arch. du Mus." tom. iii. 1834, p. 321, and elsewhere.

§ "Proceedings of the Zoological Society," 1866, p. 126.

|| "Ibis," 3rd ser. vol. iii. No. 9, p. 81.

¶ "Proceedings of the Zoological Society," 1867.

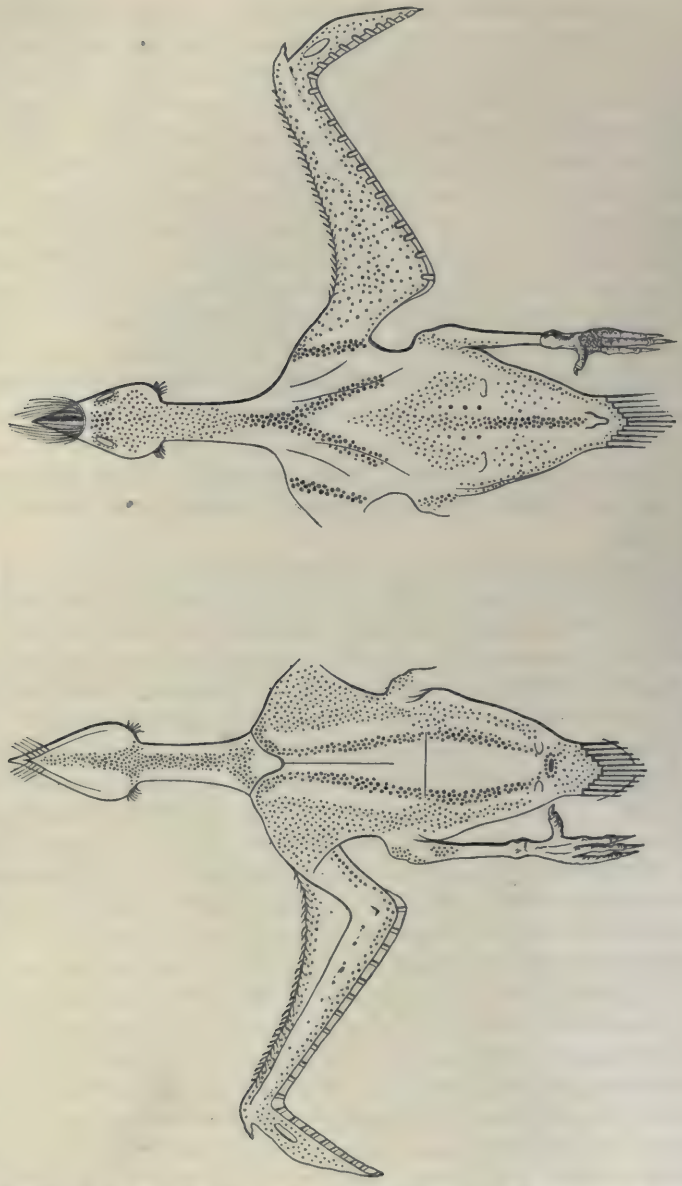
this region, like those in the Caprimulgidæ. Above each eye there are two rows of closely set very stiff feathers, running parallel to one another and to the border of the upper eyelid, forming a double eyebrow. The upper of these is slightly the stronger; it is situated $\frac{1}{6}$ of an inch above the lower one, with a bare space intervening. The stiff feathers of which it is composed are slightly more than $\frac{1}{4}$ of an inch long and are directed outwards. The lower eyebrow is $\frac{1}{8}$ of an inch above the margin of the lid, which has no eyelashes and is bare: it does not extend quite so far forward or backward as the one above it; and its component feathers are not quite so long. The external auditory orifice is nearly circular and $\frac{1}{3}$ of an inch in diameter; there is no operculum. It is surrounded by a single row of feathers, much like those of the eyebrows; they are all directed backwards, the anterior being slightly the longer and acting as a protection to the entrance of the ear. Several (about a dozen on each side) stiff simple vibrissæ, many more than $1\frac{1}{2}$ inch long, spring from the side of the upper beak, and run directly forwards, partially covering the apertures of the nostrils.

The dorsal tract, where it commences, is narrowed on account of there being a bare space above each ear; but when it reaches the upper part of the neck it broadens, and continues down the back of the neck as a not strong tract, which becomes narrower and stronger as it descends, till at a short distance above the tops of the shoulder-blades it is very strong indeed. It continues on in this condition, and bifurcates between the scapulæ to form a well-developed fork, with long branches, which become considerably weakened near their extremities. Between the lower ends of this fork the continuation of the dorsal tract commences, not connected with it at all, but quite free, as an upward-turned weak arrow-head, situated in the middle line. The axis or shaft of this arrow-headed tract, as it descends, becomes narrower and stronger till it ceases abruptly at the base of the long infundibuliform nude oil-gland, which closely resembles that of the Owls. In the upper part of the loins, above the arrow-head, at a short distance on either side of, and parallel with, the mid-dorsal tract, is a single row formed by four strong feathers, which are distinctly separated from the rest. All over the loins, behind the Page 529.
acetabula, there is a weak feathering which blends with the lumbar tracts. These last are consequently not very distinctly defined, and consist mainly of weakly feathered tracts, running from the knee obliquely downwards and backwards, leaving the tibiæ almost bare, with the exception of a few semiplumes which are scattered below the front of the knee.

Between the rami of the jaws the large triangular surface is naked at the sides and weakly feathered along the middle line up to the

Page 528.

Fig. 1.



Pterylosis of *Steatornis*. *a*, ventral surface; *b*, dorsal surface.

symphysis (as in the Owls), where there are a few vibrissæ, directed forwards. From this submaxillary feathered portion the inferior neck-tract springs; and behind the angle of the jaw a weak branch is sent up, on each side, to join the dorsal tract and head-covering behind the ears. A little lower down the inferior tract becomes more defined, though not strong; it continues simple as it descends, being of the same breadth as the lateral neck-spaces. Just above the upper or scapular extremities of the furcula it ceases in the middle line, leaving a bare interclavicular space; but it develops a branch on either side, which expands over the chest to form the pectoral tracts. The pectoral tract of each side is double, the inner of its divisions being the continuation of the main tract, which descends, narrow and strong, close to the carina sterni in its upper part, but further separated below, leaving over the epigastric region of the abdomen a considerable median space, which lower down is again reduced by their convergence to the anus, just in front of which they terminate.

Each outer pectoral branch of the inferior tract is weak and very diffused, covering the sides of the body, leaving a narrow space between it and the main stem, except at the points just in front of the scapular ends of the furcula, from which they spring, and below the inferior margin of the sternum, where they again blend, and continue down side by side, after their contact, nearly to the anus, the outer branch being the weaker and less defined.

There is a weak hypopteral tract continued from the outer margin of the external pectoral branch. The under wing-surface is feathered along the forearm in several rows. The margin of the patagium is thickly set with short strong plumes. The humeral tract is strong and separated by a narrow space from the well-covered upper wing-surface.

There is no aftershaft to the feathers.

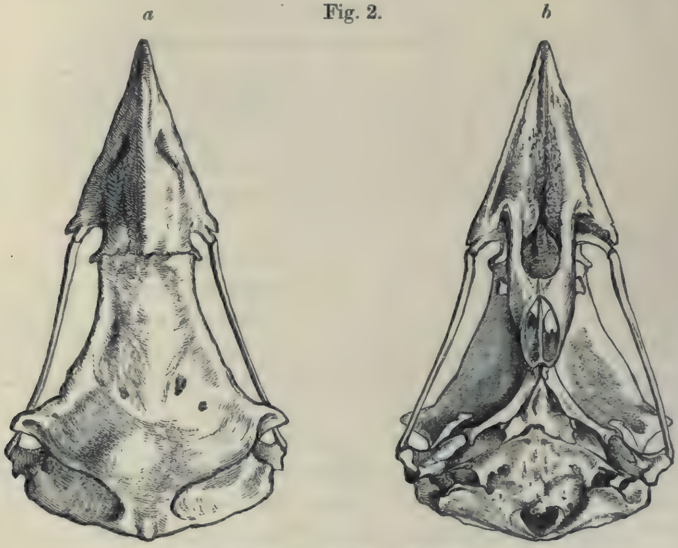
There are ten primary remiges, and twelve secondary, of which the ten distal resemble each other, and the two at the elbow are reduced in size. The upper wing-coverts do not extend more than or quite so much as halfway down the secondary remiges. There are ten rectrices.

The above described pterylosis clearly indicates that in the arrangement of its feathers *Steatornis* more closely resembles the Strigidæ than the Caprimulgidæ, though it differs considerably from both. It resembles the Strigidæ and differs from the Caprimulgidæ in having no aftershaft to the contour feathers, in not having the occipital tract divided up into narrow longitudinal rows, in having spaces on each side of the submaxillary tract, in having the pectoral portion of the Page 530.
inferior tract in two parts, of which the inner approaches the carina sterni above and separates from it as it descends, in having the upper wing-surface uniformly feathered, and in having a large infundibuliform oil-gland. In none of the Caprimulgidæ does the inferior tract continue simple down the neck, whilst in *Strix flammea* as in *Steatornis* it does not bifurcate till in the region of the furcula. But *Steatornis* resembles the Caprimulgidæ and differs from the Strigidæ in having

ten rectrices. It differs from both, however, in that the inferior portion of the dorsal tract does not unite at all with the scapular fork of the superior portion, in having the outer branch of the pectoral tract diffused and descending far over the abdomen, and in the general tendency to scattering of the feathers.

In the skull the lachrymal bones are not developed as they are in the Strigidæ and Caprimulgidæ. The palate is strongly desmognathous, as in the Falconidæ, and much more so than in the Strigidæ, which are almost schizognathous. The palatine bones also meet across the middle line for $\frac{1}{8}$ of an inch, in a manner which is quite peculiar, and can be best understood by a reference to the drawing, each bone being apparently folded on itself behind the point of junction with its fellow, and articulating with the basisphenoid rostrum, as well as anchylosing with the vomer by its inflected and upward-turned margin; each develops a very short slender anteriorly directed process close to the vomer, which projects forwards on each side of it near its middle.

Fig. 2.



Skull of *Steatornis*. *a*, base ; *b*, superior surface.

Page 531. The vomer itself is a quarter of an inch long, slender and quite blended with the palatines; its anterior pointed extremity advances as far forwards as the posterior border of the median palatine symphysis mentioned above. The posterior external angles of the palatines, so large in *Caprimulgus* and *Podargus*, are not developed. The basipterygoid facets are large. In the eye the sclerotic ossifications are not considerable, as in the Owls, being not at all unusually developed.

In the atlas the cup for articulation with the occipital condyle is incomplete behind; and the odontoid process of the axis is situated near its posterior margin. In this conformation, the classificational importance of which was first pointed out by Mr. Parker, *Steatornis* agrees with the Strigidæ and the Caprimulgidæ, but not with the Cypselidæ, in the one or two cases which I have had the opportunity of observing.

The well-known peculiarities of the sternum do not seem to point definitely in any special direction; and in the other bones I have not observed any demonstrable tendencies.

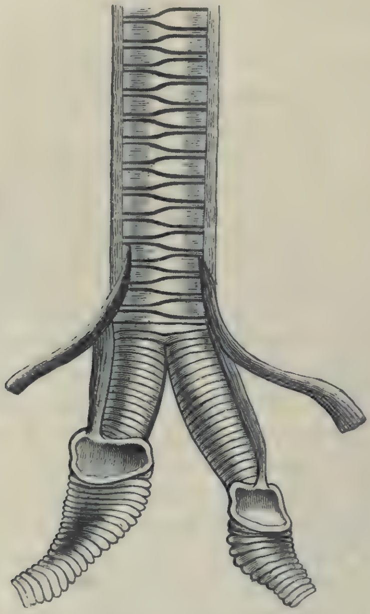
Digestive organs.—The *tongue* is thin, smooth, and triangular; it is $\frac{1}{4}$ inch broad at its base, and $\frac{5}{8}$ of an inch long; the posterior angles are prolonged backwards for $\frac{1}{6}$ of an inch as angular processes with small papillæ on them; the posterior border is simple. The *œsophagus* is capacious and uniformly cylindrical, with longitudinal plications in its mucous membrane. The *proventriculus* is zonary and well developed, the largest of its component glands, which are slightly racemose, being $\frac{3}{8}$ of an inch long. The *stomach* forms a thin-walled, globose, capacious gizzard, with its mucous membrane, as usually, longitudinally plicated. The *intestines* are 22 inches long, capacious throughout, and especially so near the pyloric portion; the biliary and pancreatic ducts open into it $2\frac{1}{2}$ inches from the pylorus, at the bend of the duodenal loop. The two intestinal *cœca* are $1\frac{1}{2}$ and $1\frac{1}{8}$ inch long, slender, and a little broader at the cæcal than at the open ends; they are situated 2 inches from the cloaca.

The *trachea* is a little more capacious above than below. As in many birds, the separate rings of which it is composed are not so deep in the middle line as they are laterally; and as in each ring the upper and lower margins of one side in one ring, and of the other side of the next above and below, are slightly everted, whilst those of the other half are inverted to the same extent, when the rings are superimposed they produce the appearance seen in the accompanying drawing, as if each ring were narrow on one side and broad on the other. The *syrinx* (fig. 3, p. 184), as has been described by others, is extremely peculiar, because it is formed in each bronchial tube, instead of at the bifurcation of the trachea. The trachea bifurcates at its lower end much in the same way that it does in Mammalia; and each bronchus continues down towards the lungs as a cylindrical or slightly flattened tube, composed of simple and entire rings of cartilage. In a specimen that I once saw, there were fourteen of these rings on each side; but in the one before me, which is figured here, the bronchi are not equal in length, the left bronchus containing thirteen and the right ten complete rings above the commencement of the syrinx. Each semisyrinx, as it may be termed, is formed on the same principle

Page 532.

as that of the combined organ in most of the non-singing birds. Taking for description that of the left side in the specimen figured, it is there found that the thirteenth bronchial ring is complete, though considerably flattened from side to side; the fourteenth is not complete in the middle of its inner surface, it is a little longer from before backwards than the one above, and not so long as the one following it. The fifteenth is only a half ring, its inner portion being deficient; it is slightly convex upwards, and articulates, both at its anterior and posterior ends, with the fourteenth incomplete ring and the sixteenth half ring. The sixteenth half ring is concave upwards, and so forms an oval figure in combination with the one above, which is filled with a thin membrane, to form part of the outer wall of the bronchus. There is a membrane also between the ends of these and the succeeding half rings, which completes the tube of the bronchus internally. The half rings which follow the sixteenth reduce in size, and are considerably smaller before they reach the lung. The lateral muscle of the trachea extends down the outer side of each bronchus, to be attached to the middle of the first fully developed half ring. The depressor muscles of the trachea are independent of these. Page 533.

Fig. 3.



Front view of the syrinx of *Steatornis*.

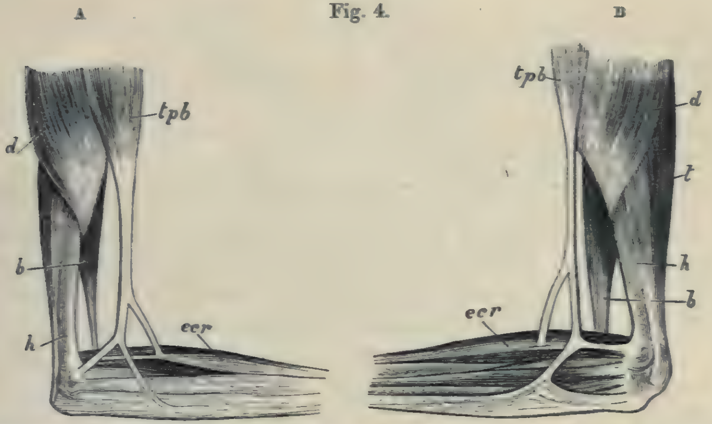
Steatornis has two carotid arteries, as have both the Strigidæ and Caprimulgidæ.

With regard to the myology of this bird, the only muscles which will be considered are those which have been found to have some bearing on the systematic position of birds generally.

In the thigh, the *ambiens* (Sundevall)—the slender muscle which in many birds runs from the innominate bone, just above the acetabulum, along the inner side of the thigh to the knee, which it crosses obliquely in the fibrous capsule below the patella, and then blends with the flexor perforatus digitorum—is absent, as it is in the Strigidæ and Caprimulgidæ.

The *semitendinosus*, the outer of the two muscles which form the lower fold of the thigh (the *semimembranosus* being the inner), and which runs from the region of the lower end of the innominate bone to the tibia, is present, as in the Caprimulgidæ, it being quite absent in all the Strigidæ. As in the Caprimulgidæ also, this muscle receives an accessory head from the lower end of the femur, which helps to send a partial insertion of the muscle down the leg.

Fig. 4.



Muscles at the outer side of the elbow ; A, of right wing of *Caprimulgus europæus* ; B, of left wing of *Steatornis*.

tpb, tensor patagii brevis ; *ecr*, extensor carpi radialis ; *b*, biceps ; *d*, deltoid ; *t*, triceps ; *h*, humerus.

The *femoro-caudal* (which runs as a narrow muscular ribbon from the middle of the linea aspera of the femur to the coccyx, covered by the semitendinosus and crossed superficially by the sciatic artery and nerve) is quite absent ; it is well developed in the Caprimulgidæ, small in the Strigidæ, and absent in very few birds.

In the upper limb the *second pectoral* (*subclavius* of Rolleston) is not large, extending about halfway down the sternum, as it does in Page 534.

the Strigidæ, whilst in the Caprimulgidæ it is more developed, reaching the lower margin of that bone.

The *tensor patagii brevis*—a muscle very constant in its insertion in the different families of birds, which arises mainly from the superior extremity of the furcula on each side, and is inserted, after running in the patagial fold parallel to the humerus, into the outside of the forearm near the elbow—in *Steatornis* agrees entirely with that of many of the Strigidæ, and differs slightly from that of the Caprimulgidæ, as may be seen from the accompanying drawings (fig. 4, p. 185), where, in the former, the main tendon becomes attached to the extensor carpi radialis longus directly, whilst in the latter it joins a second more superficial tendinous slip which runs back to the outside of the elbow, much as in the Passeres.

By placing the above-mentioned facts in a tabular form, the comparison between *Steatornis* and its allies will be more clearly seen.

	Steatornis.	*Strigidæ.*	*Caprimulgidæ.*
Number of carotids.......	2	2	2
Ambiens muscle..........	Absent........	Absent.........	Absent.
Semitendinosus muscle....	Present, with accessory head...	Absent.........	Present, with accessory head.
Femoro-caudal muscle	Absent.........	Present (small)..	Present.
Pectoralis secundus muscle.	Short	Short	Long.

The semitendinosus is a muscle very constantly present in birds, being absent only in the Owls, Eagles, true Vultures, Humming-birds, and Swifts; consequently its presence in *Steatornis* is in favour of its being related to the Caprimulgidæ rather than to the Strigidæ.

In endeavouring, from the facts recorded above, to form a correct notion as to the exact systematic position of *Steatornis*, the difficulties in the way are considerable. That it forms a family by itself there is little or no doubt, as it presents pterylographical and internal peculiarities found in no other birds. By a process of exclusion, an approximate idea of its position may be formed. The Strigidæ, Caprimulgidæ, Coraciidæ, Momotidæ, Galbulidæ, and Steatornithidæ all agree in possessing the following characters—two carotids, well-developed cæca, a nude oil-gland, and no ambiens muscle. Among these, the Strigidæ differ from all the rest and resemble the Eagles, in having no semitendinosus; and the Steatornithidæ are equally peculiar in having no femoro-caudal muscle. In its pterylosis, as shown above, *Steatornis* resembles the Strigidæ much more than any of the allied families, except that there are only ten rectrices. I have not dissected *Podargus;* but it agrees so closely with *Caprimulgus* in its pterylosis, according to Nitzsch, that it most probably must be included in the same family. As Mr. Sclater has shown, *Podargus* has no oil-gland, that organ being very small in the Caprimulgidæ generally, but large in *Steatornis*.

If the absence of the ambiens muscle in the Strigidæ has the significance which I put on it, and is sufficient justification, in conjunction with other differences, for the entire separation of this family from the other Accipitres, then the above mentioned group of families seems a natural one;* but if the Strigidæ are intimately related to the Falconidæ and Vulturidæ, it is so difficult to believe that the Coraciidæ and their allies are related to the Falconidæ, that the entire separation of the Strigidæ from the Caprimulgidæ seems essential, in which case the position of *Steatornis* becomes more doubtful. Page 535.

32. ON CERTAIN MUSCLES OF THE THIGH OF BIRDS, AND ON THEIR VALUE IN CLASSIFICATION. (Pl. V.) Page 626.

Part I.†

In their works on the general anatomy of the animal kingdom Meckel and Cuvier have devoted special chapters to the myology of birds. The dissections on which their observations were based were evidently undertaken more with the desire to determine the relations borne by the muscles of birds to those of Mammalia and Reptiles, than with the object of studying the variations in the arrangement of the muscles in the class itself. Nitzsch, Reid, Owen, Milne-Edwards, Coues, Selenka, and others have published their dissections of certain birds, as the Vulture, Penguin, Apteryx, Eagle, and Loon; and most of these are, from their accuracy and clearness, valuable additions to zoological knowledge. Sundevall seems to be the only ornithologist who has employed the variations that he has observed to be constant in different birds towards the furtherance of classification; and my results, on the points discussed by him, in most cases correspond with his.

The great opportunities afforded me by this Society for the study of a great many species of birds in the flesh, have reduced the diffi-

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* Prof. Newton has for some time believed the Steatornithidæ and Caprimulgidæ to be distinct families (*cf.* Zool. Rec. vi. p. 67).

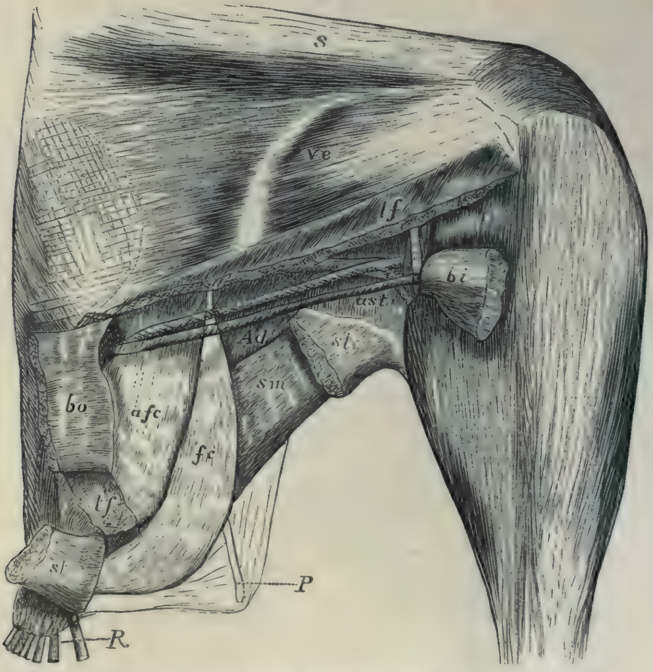
† Part I. "Proceedings of the Zoological Society," 1873, pp. 626–44. Read, June 17, 1873.

culties connected with the dissection of any special soft part to a minimum; and in the present communication the results are recorded of my dissection of the region of the thigh of the birds which have passed through my hands. In this region there are six muscles, or well-defined portions of muscles, which may or may not be present; and my chief object has been to note their presence or absence, which in some cases is far from easy, as modifications may occur which disguise the true connexions of a muscle, and thus lead to misinterpretation.

As a common Fowl happens to possess all these six muscles well developed and easily demonstrable, I will commence with a short Page 627. account of their condition and relations in it, from which a correct idea may be easily formed of their situation in other birds with the help of the accompanying details.

In commencing the dissection of the leg of a Fowl in order most easily to observe the arrangement of the muscles about to be described,

Fig. 1.



Outer view of right thigh of *Gallus bankiva*, partially dissected.

s, sartorius; *v e*, vastus externus; *bo* and *b i*, biceps, origin and insertion; *tf*, tensor fasciæ; *f c*, femoro-caudal; *a f c*, accessory femoro-caudal; *st*, semitendinosus; *ast*, accessory semitendinosus; *sm*, semimembranosus; *Ad*, adductor; *P*, pubis; *R*, rectrices.

the body, from which most of the feathers have been removed, should be laid on its side, and a section made in the skin, in a line parallel to and just over the femur, along its whole length; from the extremities of this line the sections should be continued at right angles to it, extending upwards and downwards from the end over the head of the femur, and along the outer side of the leg from that at the knee. The skin must be then dissected downwards as a flap off the muscular adductor mass below, and some way upwards above the level of the femur. After this has been done the following muscles will be found without difficulty:—

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Tensor fasciæ.—This is the superficial muscle of the outside of the thigh, covering the femur. It is flat and triangular in shape, and arises as a membranous expansion which covers the gluteus ii, from the lower two-thirds of the posterior border of the iliac fossa in which that muscle is situated, and from the fibrous septum which separates that muscle from the gluteus iii. Further down it has origin also from the whole length of the ridge which separates the postacetabular area from the external lateral surface of the ischium, and which may be termed the postacetabular ridge, as well as from the posterior border of the ischium, as far forwards as its junction with the pubis, being here slightly overlapped by the semitendinosus. The fibres converge towards the knee; and the deep portion of the muscle blends in its course with the vastus externus, together with which it continues forward to become part of the broad thin tendon which covers the knee and is inserted in the front of the tibia-head, the patella being situated in it, together with the long, slender, and flat tendon of the *ambiens* muscle, which is situated below it, running obliquely from inside and above, outwards and downwards. In many birds, as the Falconidæ and Psittaci, this muscle does not extend below the level of the femur, but ends inferiorly by blending with the vastus externus; and consequently, where such is the case, it evidently cannot, as it does otherwise, cover any of the flexors of the leg. In the Bucerotidæ it is entirely absent. Whether this postacetabular portion of the tensor fasciæ is present or absent has some bearing on classification, as in the different families it is a very constant feature.

Biceps cruris.—The anterior portion of this muscle may be seen in the Fowl's leg before the tensor fasciæ has been removed, just below it, near its insertion. This muscle is mostly covered by the tensor fasciæ, arising from the upper three-fourths of the postacetabular ridge, just in front of the origin of that muscle. Its fibres converge to form a round tendon, which in the outer side of the popliteal region is bent sharply downwards by passing through a tendinous sling which arises from the lower end of the femur, to be inserted on a prominence on the outer side of the fibula, about halfway down the leg. In the loop above this tendon, and consequently quite out of the way of compressing forces, one of the nerves to the leg and foot is continued. In one or two birds, as *Phaëthon*, the biceps does not pass through any loop, but is inserted directly by a broad flat tendon into the upper part of the fibula.

Semitendinosus.—This flat ribbon muscle runs nearly parallel with the lower fibres of the biceps, just below it. Its origin is mostly from the tip of the transverse process of the first free coccygeal vertebra, and from the fibrous membrane between it and the inferior border of the ilium. Near its origin it, being superficial, curves over the posterior inferior angle of the ilium, and covers the inferior fibres of origin of the tensor fasciæ, running upwards and forwards towards the inner side of the head of the tibia, and so getting covered anteriorly by the inserted end of the biceps. A rhomboidal sheet of muscle, arising from the anterior end of the linea aspera, descends to form an accessory head to this muscle, joining it anteriorly, on its outer side, by an oblique tendinous raphe, which continues down the
Page 629. back of the leg superficially. A small part of the main muscle, the inner, goes straight forward to end at the inner side of the upper extremity of the tibia by a flat tendon; but most of it joins the accessorius to be continued down the leg. Some birds, as the Eagles and Owls, have no semitendinosus at all; some, as the Anserine birds and Penguins, have no accessory semitendinosus, in which case all the fibres go straight to the tibia-head; whilst in most the above-described condition maintains.

Semimembranosus.—This ribbon muscle runs parallel to, deep of, and next to the semitendinosus. It arises from the outer border of the anterior margin of the ischium for about a third of an inch, at the place where it is in contact with the pubis, the origin extending down to the lower end of the slight prominence at the point where the ischium slightly overlaps the pubis. It is inserted along with the tibial end of the semitendinosus into the inner side of the head of the tibia by a broad flat thin tendon. This muscle is very constant in birds: in the Grebes it is extremely thin, and may sometimes be absent, as stated by Sundevall; but I have seen it in some fresh specimens of *Podiceps minor*, though but very slightly developed.

Ambiens.—This peculiar, small, but very long muscle is triangular or fusiform in shape. It arises from the tip of the short anteriorly directed spine which is situated just above the anterior border of the acetabulum, and runs along the inner side of the thigh to the inner side of the knee, where it is covered by the sartorius, which is above it in the former part of its course. Its thin tendon then crosses the knee, running in the substance of the fascial extensor tendon, just in front of the patella to the outer side, where it joins the fibres of origin of the flexor perforatus digitorum.

Femoro-caudal.—This long ribbon muscle is covered superficially by the tensor fasciæ and biceps above, as well as by the semitendinosus lower down. The sciatic artery and nerve cross it superficially at right angles close to its insertion as they course from the sciatic foramen, parallel to the femur, to the popliteal region. The femoral vein separates this muscle from the adductor muscles at their insertions, except in *Dacelo*, where it crosses the femoro-caudal superficially.* It arises from the (anterior) transverse processes of the two last coccygeal vertebræ, and is inserted into the linea aspera of the femur, at about one-third its length from the trochanter.

An accessory head, arising from the upper three-fourths of the postacetabular ridge, and from the ridge which forms the lower margin of the origin of the obturator externus, joins the tendon of insertion of this muscle, and is also partly inserted into the linea aspera, between it and the head of the femur. It is thin, muscular, and broad, covering the obturator externus superficially, and is partially intersected by a fibrous sheet where it crosses its anterior border. The sciatic artery and nerve cross it superficially; and the nerve to the semimembranosus is deep of it, whilst that to the semitendinosus is superficial in some cases; the biceps completely covers it.

Of the above-described muscles, five of them (the ambiens, the femoro-caudal, the accessory femoro-caudal, the semitendinosus, and Page 630. the accessory semitendinosus) vary; any one or more than one may be absent in different birds; and in my dissections my object has always been to record the conditions existing in the specimen under examination. The constancy of the peculiarities in the different individuals of each species, in the species of each genus, and very generally in the genera of each family, makes it evident to any one working at the subject, that much respecting the affinities of the different families of birds is to be learnt from the study of their myology, in connexion with the peculiarities of their other soft parts; and that these features will, in the long run, lead to a more correct classification than one based on the skeleton alone, becomes almost equally certain.

The variations in the five above-mentioned muscles form the subject of this communication, and the subjoined list contains the results arrived at by myself. A few of the facts now recorded will be found mentioned in the works of Meckel, Sundevall, and others. Re-

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* In *Centropus phasianus* the main artery of the leg is also the femoral, and not the sciatic, as in other birds; it therefore runs with the femoral vein in that bird.

ference to them is quite unnecessary, as they can easily be found in the works of those authors.

The *Passeres* possess the femoro-caudal, the semitendinosus, and the postacetabular portion of the tensor fasciæ; the accessory semitendinosus is present in all except *Dicrurus* (which has only ten rectrices); the ambiens and the accessory femoro-caudal are absent.*

The *Pici* possess the femoro-caudal, the semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens and the accessory femoro-caudal are absent; and they may be divided into two subfamilies, according to whether the accessory semitendinosus is present or absent.

The accessory semitendinosus is absent in

Picus major.
—— *minor.*
Picoïdes tridactylus.

The accessory semitendinosus is present in

Gecinus viridis.
Leuconerpes candidus.
Melanerpes formicivorus.
Chloronerpes yucatanensis.
Mulleripicus fulvus.
Hypoxanthus rivolii.

Yunx torquilla agrees in all these points with *Gecinus viridis.*

The *Steatornithidæ* possess the semitendinosus, and a very narrow accessory semitendinosus. The ambiens, the femoro-caudal, the accessory femoro-caudal, and the postacetabular portion of the tensor fasciæ are absent.

Species examined.

Steatornis caripensis.

The *Caprimulgidæ* possess the femoro-caudal, the semitendinosus,
Page 631. the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens and the accessory femoro-caudal are absent.

Species examined.

Caprimulgus europæus.
Chordeiles texensis.

The *Trogonidæ* possess the femoro-caudal and the semitendinosus; the ambiens, the accessory femoro-caudal, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are absent.

Species examined.

Trogon mexicanus.
Trogon puella.

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* In my paper on the carotid arteries of birds a long list is given of the Passeres in which the carotid vessels were examined; in all these the muscles of the thigh were dissected also. In a specimen of *Pomatostomus temporalis* there was an accessory femoro-caudal on the right side; on the left there was not a trace of it.

The *Meropidæ* possess the femoro-caudal, the semitendinosus, and the accessory semitendinosus; the ambiens, the accessory femoro-caudal, and the postacetabular portion of the tensor fasciæ are absent.

Species examined.

Merops apiaster.
Merops ornatus.

The *Cypselidæ* and the *Trochilidæ* agree in possessing the femoro-caudal, at the same time that the ambiens, the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are absent.

Species examined.

Cypseloïdes fumigatus.
Cypselus apus.
—— *alpinus.*
Chætura vauxi.
—— *caudacuta.*
Chætura spinicauda.
Dendrochelidon coronata.
Chlorolampis osberti.
Patagona gigas.

The *Coraciidæ* possess the femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens and the accessory femoro-caudal are absent.

Species examined.

Coracias garrula.
Eurystomus, sp.

The *Momotidæ* possess the femoro-caudal, the semitendinosus, and the accessory semitendinosus; the ambiens, the accessory femoro-caudal, and the postacetabular portion of the tensor fasciæ are absent.

Species examined.

Momotus lessoni.
—— *æquatorialis.*
Eumomota superciliaris.

The *Galbulidæ* possess the femoro-caudal and the semitendinosus; the ambiens, the accessory femoro-caudal, and the postacetabular portion of the tensor fasciæ are absent.

In *Galbula albirostris* the accessory semitendinosus is present; but it is absent in *Urogalba paradisea.*

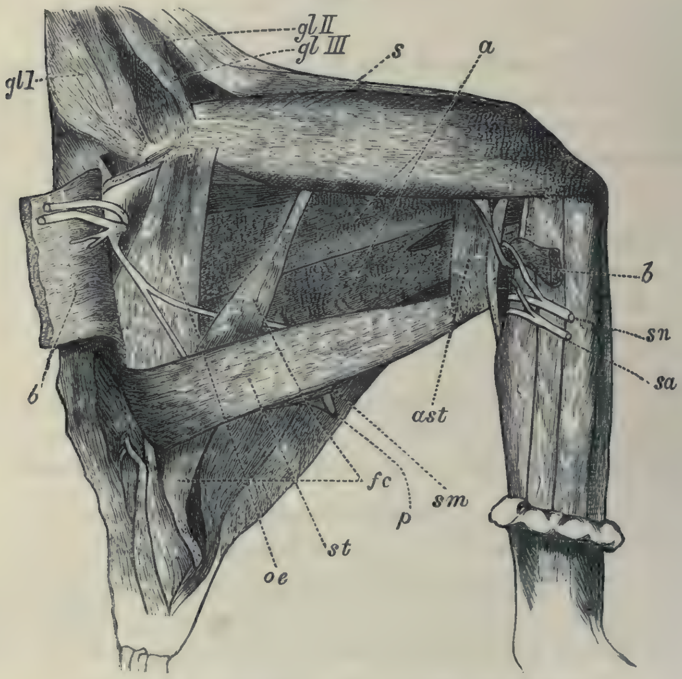
The *Alcedinidæ* possess the femoro-caudal and the semitendinosus; the ambiens, the accessory femoro-caudal, the accessory semitendinosus, and the postacetabular portion of the tensor faciæ are absent.

Species examined. Page 632.

Alcedo ispida.
Ceryle amazona.
Halcyon, sp.
Dacelo cervina.
—— *gigantea.*
Cittura cyanotis.

The *Bucerotidæ* possess the femoro-caudal, the semitendinosus, and the accessory semitendinosus; the ambiens, the accessory femoro-caudal, and the tensor fasciæ are absent.

Fig. 2.



Outer view of right thigh of *Buceros coronatus*, dissected.

b, biceps; *s t*, semitendinosus; *a s t*, accessory semitendinosus; *s m*, semimembranosus; *f c*, femoro-caudal; *o e*, obturator externus; *a*, adductors; *gl*, I, II, and III, glutei; *s*, sartorius; *s n*, sciatic nerve; *s a*, sciatic artery; *p*, pubis.

Species examined.

Buceros rhinoceros.
—— *plicatus.*
—— *bicornis.*
Buceros coronatus.
—— *atratus.*
Toccus melanoleucus.

The *Upupidæ* possess the femoro-caudal, the semitendinosus, and the accessory semitendinosus; the ambiens, the accessory femoro-caudal, and the postacetabular portion of the tensor fasciæ are absent.

Page 633.

Species examined.

Upupa epops.

The *Musophagidæ* possess the ambiens, the femoro-caudal, and the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ.

Species examined.

Musophaga violacea.
Schizorhis africana.
Corythaix albo-cristata.

The *Cuculidæ* possess the ambiens, the femoro-caudal, the semitendinosus and the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; they may be divided into two subfamilies, according to whether the accessory femoro-caudal is present or absent.

The accessory femoro-caudal is present in

Centropus senegalensis.
—— *phasianus.*
Guira piririgua.
Phœnicophaes, sp.

The accessory femoro-caudal is absent in

Cuculus canorus.
Chrysococcyx, sp.
Cacomantis sepulcralis.

The *Ramphastidæ* possess the femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens and the accessory femoro-caudal are absent.

Species examined.

Ramphastos carinatus.
—— *ariel.*
Ramphastos cuvieri.

The *Capitonidæ* possess the femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens and the accessory femoro-caudal are absent.

Species examined.

Megalæma asiatica.
Barbatula duchaillui.
Indicator major.

The *Psittaci* possess the femoro-caudal well developed, the semitendinosus, and the accessory semitendinosus; the accessory femoro-caudal and postacetabular portion of the tensor fasciæ are absent. The ambiens may be present normally; it may be differentiated in the thigh, but fail to cross the knee, being lost on the fascia over it, or it may be absent.

The ambiens is present in the following species:—

Psittacus erithacus.
Conurus xantholæmus.
—— *jendaya.*
—— *petzi.*
—— *holochlorus.*
Ara macao.
—— *chloroptera.*
Caïca melanocephala.
Nestor notabilis.
—— *hypopolius.*

The ambiens is present, but does not cross the knee in

Stringops habroptilus.

Page 634. The ambiens is absent in:—

Pyrrhura (Conurus) cruentata.
Brotogerys tiriacula.
—— *virescens.*
—— *tovi.*
—— *tui.*
Pionus menstruus.
Chrysotis festiva.
—— *ochrocephala.*
—— *levaillantii.*
Psephotus hæmatogaster.
Platycercus eximius.
—— *pallidiceps.*
Psittacula passerina.
Agapornis roseicollis.
Melopsittacus undulatus.
Euphema splendida.
—— *pulchella.*
—— *bourkii.*
Calopsitta novæ-hollandiæ.
Cacatua galerita.
—— *cristata.*
—— *roseicapilla.*
Calyptorhynchus banksii.
Eos cardinalis.
—— *indica.*
Tanygnathus muelleri.
Prioniturus, sp.
Trichoglossus concinnus.
Lathamus discolor.
Aprosmictus scapulatus.
Loriculus asiaticus.
—— *chrysonotus.*
Cyanorhamphus auriceps.
—— *novæ-zealandiæ.*
Palæornis torquata.

Accipitres.—The *Cathartidæ* possess the ambiens, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the accessory femoro-caudal is absent, and the femoro-caudal is present, though small, in

Cathartes atratus;

it is absent in

Gyparchus papa.

The *Serpentariidæ* possess the ambiens, the accessory femoro-caudal, the semitendinosus and the accessory semitendinosus; the femoro-caudal and the postacetabular portion of the tensor fasciæ are absent.

Species examined.

Serpentarius reptilivorus.

The *Vulturidæ* and *Falconidæ* agree in possessing the ambiens and the femoro-caudal; the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are absent in all.

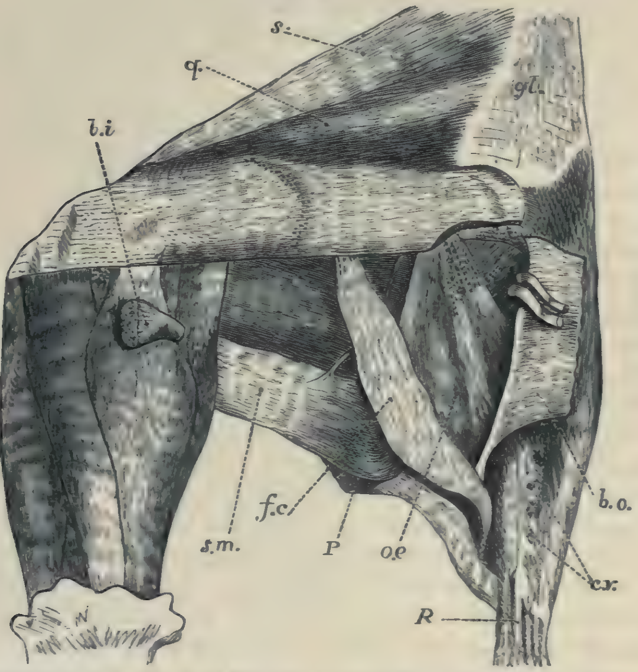
Species examined.

Neophron percnopterus.
Gyps fulvus.
Vultur auricularis.
Polyborus brasiliensis.
Milvus ictinus.
Buteo vulgaris.
Archibuteo lagopus.
Helotarsus ecaudatus.

Haliaëtus vocifer.
—— *albicilla.*
Aquila nævioïdes.
—— *audax.*
Spilornis cheela.
Thrasaëtus harpyia.
Falco peregrinus.
Falco melanogenys.
—— *lanarius.*
Hypotriorchis subbuteo.
Tinnunculus alaudarius.
Melierax monogrammicus.
Astur palumbarius.
Circus cineraceus.

Fig. 3.

Page 635.



Outer view of left thigh of *Neophron percnopterus*, partially dissected.

s, sartorius; *q*, quadratus femoris; *gl*, glutei; *b o* and *b i*, biceps, origin and insertion; *f c*, femoro-caudal; *s m*, semimembranosus; *o e*, obturator externus; *c v*, caudal vertebræ; *P*, pubis; *R*, rectrices.

The *Strigidæ* possess the femoro-caudal, which is always small; the ambiens, the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are absent.

Species examined.

Strix flammea.
Otus vulgaris.
—— *brachyotus.*
Syrnium aluco.
Syrnium nebulosum.
Bubo maximus.
—— *virginianus.*
—— *bengalensis.*

Bubo capensis.
—— *poënsis.*
—— *fasciolatus.*
Ketupa javanica.
Scops zorca.
Athene noctua.
Athene passerina.
—— *brama.*
Pholeoptynx cunicularia.
Glaucidium, sp.
Pulsatrix torquata.
Surnia funerea.

The *Steganopodes* must be considered in separate families. I have not dissected *Pelecanus*.

Page 636. *Fregata aquila* possesses the ambiens and the femoro-caudal, the latter being very slender; the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are absent.

Phaethon possesses the femoro-caudal (small), the semitendinosus (strong), and the accessory semitendinosus; the ambiens, the accessory femoro-caudal, and the postacetabular portion of the tensor fasciæ are absent. In this bird the biceps cruris is inserted into the fibula-head directly, without passing through a loop.

The family *Phalacrocoracidæ* possess the ambiens,* the femoro-caudal, and the semitendinosus; the accessory femoro-caudal, the accessory semitendinosus, and the postacetabular portion of the tensor
Page 637. fasciæ are absent. There is a peculiarity about the obturator externus of these birds, which is perplexing at first sight. In *Sula* this muscle, instead of, as usual, being inserted into the outside of the head of the femur, has its attachment further forward, to the outer edge of the linea aspera, or the bony surface corresponding to it, midway between the head of the bone and the attachment of the femoro-caudal muscle. In *Phalacrocorax* it is situated still further forward, being in contact by its anterior border with the posterior margin of the femoro-caudal, parallel to it in direction, and otherwise in situation exactly like an accessory femoro-caudal. However, that it is the obturator externus and not the accessory femoro-caudal is certain, from the facts that the nerve to the semimembranosus is superficial to it, that the whole upper part of its outer surface is covered with a tendinous layer, that none of its anterior fibres blend with the posterior margin of the upper end of the tendon of the femoro-caudal, and that the presence of this muscle is constant in birds. The accessory femoro-caudal is, on the contrary, superficial to the nerve to the semimembranosus; it is not tendinous externally up to its insertion; some of its fibres blend with the tendon of the femoro-caudal just before it joins the femur; and its presence is uncertain. In *Sula* the ambiens has a tendinous link at the outer

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* Meckel did not find the ambiens in the Cormorant; it is peculiar in that it runs through the substance of the large triangular patella, in a bony canal.

Fig. 4.

Outer view of right thigh of *Phalacrocorax carbo*, dissected.

t f, tensor faciæ; *gl* IV, gluteus quartus; *o e*, obturator externus; *f c*, femoro-caudal; *Ad*, adductor; *b*, biceps; *st*, semitendinosus; *sm*, semimembranosus; *Pb*, pubis.

side of the knee, which runs upwards from it to the outer side of the anterior fibrous expansion over the joint.

Species examined.

Sula bassana.
Phalacrocorax carbo.
Phalacrocorax lugubris.

The *Ardeidæ* possess the femoro-caudal—though in some, as *Ardea goliath*, it is extremely narrow—the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ which is very slightly developed; the ambiens and the accessory femoro-caudal are absent.

Species examined.

Ardea cinerea.
—— *goliath.*
—— *purpurea.*
—— *alba.*
Ardea egretta.
—— *garzetta.*
Nycticorax europæus.
Botaurus stellaris.

The *Ciconiidæ* possess the ambiens, the semitendinosus, and the accessory semitendinosus; the accessory femoro-caudal is absent. The femoro-caudal is very small in *Ciconia* and absent in *Leptoptilus;* and the postacetabular portion of the tensor fasciæ is the same.

Species examined.

Ciconia alba.
—— *nigra.*
Ciconia maguari.
Leptoptilus crumeniferus.

The *Plataleidæ* possess the ambiens, the femoro-caudal, the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ, which is small.

Page 638. Species examined.

Platalea leucorodia.
—— *ajaja.*
Ibis rubra.
—— *strictipennis.*
Ibis melanocephala.
—— *nippon.*
—— *spinicollis.*

The *Phœnicopteridæ* possess the ambiens, the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the femoro-caudal is absent.

Species examined.

Phœnicopterus antiquorum.
Phœnicopterus ruber.

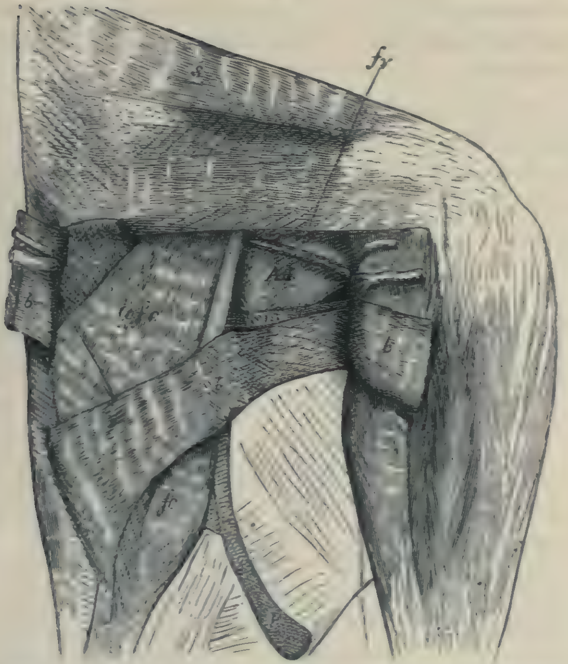
The *Anseres* possess the ambiens, the femoro-caudal, the accessory femoro-caudal (very large), the semitendinosus, and the postacetabular portion of the tensor fasciæ; the accessory semitendinosus is absent.

Species examined.

Page 639. *Anser segetum.*
Bernicla canadensis.
Chloëphaga, sp.
Cygnus nigricollis.
—— *buccinator.*
—— *coscoroba.*
Dendrocygna autumnalis.
—— *viduata.*
—— *fulva.*
Tadorna rutila.
Aïx galericulata.
Mareca penelope.
Dafila spinicauda.
Querquedula crecca.
Metopiana peposaca.
Fuligula cristata.
Mergus castor.
Mergellus albellus.

The *Columbæ* possess the femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the accessory femoro-caudal is present in all but *Lopholæmus antarcticus.* The ambiens may be present or absent; and this feature is probably a subfamily character.

Fig. 5.



Outer view of right thigh of *Bernicla brenta*, partly dissected.

s, sartorius; *o e*, obturator externus; *Ad*, adductor; *b*, biceps; *f c*, femoro-caudal, *a f c*, accessory femoro-caudal; *st*, semitendinosus; *sm*, semimembranosus; *P*, pubis; *f v*, femoral vein.

The ambiens is present in:—

Pterocles alchata.
—— *arenaria.*
Lopholæmus antarcticus.
Columba œnas.
—— *livia.*
—— *leucocephala.*
—— *picazuro.*
—— *maculosa.*
—— *vinacea.*
Turtur senegalensis.
—— *aldabranus.*
Chalcopelia chalcospilos.
Chamæpelia talpacoti.
Metriopelia melanoptera.
Tympanistria bicolor.
Leptoptila jamaicensis.
Chalcophaps chrysochlora.
Ocyphaps lophotes.
Phaps chalcoptera.
Carpophaga globicera.
—— *œnea.*
Calœnas nicobarica.
Didunculus strigirostris.

The ambiens is absent in:—

Goura coronata.
—— *victoriæ.*
Geopelia striata.
—— *placida.*

Geopelia cuneata.
—— *humeralis.*
Ptilopus melanocephalus.
—— *mariæ.*
Treron calva.
Phlogœnas cruentata.
Starnœnas cyanocephala.

The *Gallinæ* possess the ambiens, the accessory femoro-caudal, the semitendinosus (large), the accessory semitendinosus (large), and the postacetabular portion of the tensor fasciæ (large); the femoro-caudal is well developed in some, small in some, and absent in a few. An asterisk is placed by the name of those in which it is absent.

Species examined.

TETRAONIDÆ.

Tetrao urogallus.
—— *tetrax.*

PHASIANIDÆ.

Francolinus vulgaris.
—— *afer.*
—— *ponticerianus.*
—— *gularis.*
—— *clappertonii.*
Arboricola torqueola.
Perdix cinerea.
Coturnix communis.
Rollulus coronatus.
Page 640. *Odontophorus dentatus.*
Ortyx virginianus.
Eupsychortyx cristatus.
Caccabis chukar.
Phasianus colchicus.
—— *versicolor.*
—— *reevesii.*
Thaumalea picta.
—— *amherstiæ.*
Euplocamus erythrophthalmus.
—— *vieilloti.*
—— *pyronotus.*
—— *horsfieldii.*
—— *albo-cristatus.*
Gallus bankiva.
Ceriornis temminckii.
**Pavo nigripennis.*
*—— *muticus.*
Argus giganteus.
**Meleagris gallopavo.*
Numida meleagris.

CRACIDÆ.

Crax globicera.
—— *incommoda.*
Pauxis mitu.
Penelope cristata.
—— *pileata.*
Ortalis albiventris.

MEGAPODIDÆ.

Talegalla lathami.
Megacephalon maleo.

Of the *Alectorides* the families will be considered separately.

In the Bustards as represented by *Otis macqueeni* and *Eupodotis denhami* the ambiens, accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are present; the femoro-caudal is absent.

In the *Œdicnemidæ* the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are present. In *Œdicnemus bistriatus* and *Œ. super-*

ciliaris the femoro-caudal is present, but very slender. In *Œ. grallarius* it is absent. The ambiens is present in the three above-named species, but it is peculiar in being sometimes but imperfectly developed. It crosses the knee very externally, and was quite normally developed in a specimen of *Œ. bistriatus* and in one of *Œ. grallarius.* In another specimen of *Œ. grallarius* it was lost anteriorly on the fasciæ covering the knee; and in one of *Œ. superciliaris* it crossed the knee, but sent off a slip on the in- and outside to join the investing fascia.

In the *Cariamidæ* the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ are present. The ambiens was absent in a specimen of *Cariama cristata*, but present in one of *Chunga burmeisteri.* The femoro-caudal was absent in both. The accessory femoro-caudal was present in *Cariama cristata*, though extremely small. It was absent in *Chunga burmeisteri.*

Among the *Gruidæ*, *Grus antigone* possesses the ambiens, the femoro-caudal (very small), the accessory femoro-caudal (small), the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ, as does also *Anthropoides virgo.*

Among the *Eurypygidæ*, *Rhinochetus jubatus* possesses the ambiens, the femoro-caudal (extremely thin), the semitendinosus, and the accessory semitendinosus; the accessory femoro-caudal is absent.

The *Rallidæ* possess the ambiens, the femoro-caudal, the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ.

Species examined.

Rallus aquaticus.
Aramides cayennensis.
Porzana americana.
—— *carolinensis.*
Crex pratensis.
Ocydromus sylvestris. Page 641.
Porphyrio madagascariensis.
—— *melanotus.*
Gallinula chloropus.

The *Grallæ* possess the ambiens, the femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the accessory femoro-caudal may be present or absent.

It is present in:—

Glareola, sp.
Numenius arquatus.
—— *phæopus.*
Hæmatopus niger.
Charadrius hiaticula.
Himantopus nigricollis.
Parra africana.

It is sometimes present (very small), sometimes absent, in:—

Charadrius pluvialis.
Vanellus cristatus.

It is absent in :—

Strepsilas interpres.
Limosa rufa.
Totanus calidris.
—— *solitarius.*
Gambetta flavipes.
Machetes pugnax.
Scolopax rusticula.
Gallinago scolopacina.
—— *gallinula.*
Calidris canutus.
Tringa cinclus.

The *Gaviæ* possess the ambiens, the femoro-caudal, the semitendinosus, and the accessory semitendinosus; the postacetabular portion of the tensor fasciæ is slightly developed in *Larus* and *Lestris*, but not in *Sterna;* the accessory femoro-caudal is present, though small, in *Sterna*, but absent in *Larus* and *Lestris.*

Species examined.

Lestris antarcticus.
Larus argentatus.
Larus glaucus.
Sterna hirundo.

The *Procellariidæ* must be considered under two divisions, the Storm-Petrels and the true Petrels.

The Storm-Petrels possess the femoro-caudal, the accessory femoro-caudal, the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens were present in a black one, but quite absent in three specimens of a light-grey species.

Species examined.

*Procellaria pelagica ?**
Procellaria fregata ?†

The true Petrels possess the ambiens, the femoro-caudal, and the Page 642. semitendinosus; the postacetabular portion of the tensor fasciæ is very small, or absent, and the accessory femoro-caudal is present in all but *Bulweria bulweri.*

[The accessory semitendinosus is absent.]‡

Species examined.

Œstrelata lessoni ?
Prion vittata.
Daption capensis.
Bulweria bulweri.
Puffinus anglorum.

and some unnamed specimens.

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* [This is, in all probability, *Oceanites oceanica.* The true *Procellaria pelagica* lacks the accessory semitendinosus muscle.—Ed.]

† [An uncertain species.—Ed.]

‡ [This passage has been corrected; "semitendinosus" (on p. 642) being a misprint for "femoro-caudal," and the absence of the accessory semitendinosus muscle in the birds omitted in the original.—Ed.]

The *Pygopodes* consist of two distinct families.

Among the *Colymbidæ*, *Colymbus glacialis* possesses the ambiens, the femoro-caudal, the accessory femoro-caudal, the semitendinosus, and the postacetabular portion of the tensor fasciæ; the accessory semitendinosus is absent.

The *Podicipidæ* possess the accessory femoro-caudal, the semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens, the femoro-caudal, and the accessory semitendinosus are absent. In these birds the semimembranosus is very thin in *Podiceps minor;* in specimens preserved in spirit I have not seen it, probably because it is so slender.

Species examined.

Podiceps cristatus.
—— *minor.*
Podiceps novæ-hollandiæ.

The *Alcidæ* possess the femoro-caudal, the accessory femoro-caudal, the semitendinosus, and the postacetabular portion of the tensor fasciæ; the ambiens and the accessory semitendinosus are absent.

Species examined.

Alca torda.
Uria troile.
Arctica alle.

The *Impennes* possess the ambiens, the femoro-caudal, the accessory femoro-caudal, and the semitendinosus; the accessory semitendinosus and the postacetabular portion of the tensor fasciæ are absent. In *Eudyptes* the insertion of the femoro-caudal is much nearer the condyloid end of the femur than to the head.

Species examined.

Aptenodytes pennantii.
Spheniscus demersus.
Spheniscus humboldti.
Eudyptes catarractes.

The *Crypturi* possess the ambiens, the femoro-caudal, the accessory femoro-caudal (which has a slip arising above the sciatic foramen, found elsewhere only in the *Struthiones*), the semitendinosus, the accessory semitendinosus, and the postacetabular portion of the tensor fasciæ.

Species examined.

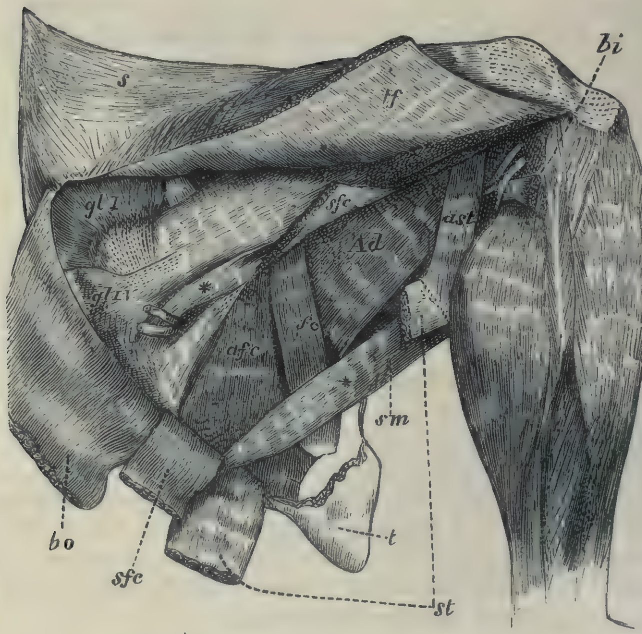
Rhynchotus rufescens.
Crypturus obsoletus.
Crypturus sallæi.
—— *noctivagus.*

The *Struthiones* present marked peculiarities. Page 643.

In *Apteryx* the postacetabular portion of the tensor fasciæ is very large, and slightly overlapped at the lowest point of its origin by the

posterior superior portion of the semitendinosus. The semitendinosus is well developed, and has a broad accessory head. The accessory femoro-caudal is peculiar; for, on removing the biceps cruris, its superficial portion is seen running obliquely upwards and forwards to the whole length of the linea aspera of the femur, from its usual origin. The sciatic artery and nerve are superficial to this muscle (adductor longus of Owen), and parallel to its insertion, as in most birds; but they, as is not the case except in the *Struthiones* and *Crypturi*, perforate it at the sciatic notch, leaving a small portion of the muscle (the adductor brevis of Owen) above them. The anterior
Page 644. terminal fibres of this muscle are situated external or superficial to the accessory semitendinosus.

Fig. 6.



Outer view of thigh of *Apteryx owenii*, dissected.

s, sartorius; *t f*, tensor fasciæ; *b o* and *b i*, biceps, origin and insertion; *gl*, I and IV, gluteus primus and quartus; *st*, semitendinosus; *a s t*, accessory semitendinosus; *sm*, semimembranosus; *s f c*, superficial femoro-caudal; *f c*, femoro-caudal; *a f c*, accessory femoro-caudal; *Ad*, adductor. The asterisk on the semimembranosus is on the spot at which its second or true insertion is; the other asterisk is placed on the slip of the accessory femoro-caudal (in this case specially modified), which is found in Struthious birds and the Tinamous only, above the sciatic vessel and nerve.

After this muscle has been removed or turned back, there is seen a deeper muscle, which, if the one described above did not exist, would be justly considered to be the femoro-caudal and the accessory femoro-caudal, part springing from the iliac ridge and part from the coccyx, whilst both are inserted into the posterior portion of the linea aspera and have the nerve to the semimembranosus situated between them and the adductor magnus.

The semimembranosus is also peculiar in having a second head of origin from the ischium, behind the femoro-caudal, and just in front of the origin of the semitendinosus, so that the femoro-caudal runs partly in a separate canal between the two heads of origin of this muscle and covered by it.

The other muscles are present as in most birds. The ambiens is strong.

Species examined.

Apteryx owenii. *Apteryx mantelli.*

In *Casuarius* the postacetabular portion of the tensor fasciæ is very large, and is overlapped below and behind by the semitendinosus near its origin; the femoral-caudal forms a small cylindroidal belly, which is continued upwards as a narrow tendon; the accessory femoro-caudal is enormous, being perforated by the sciatic artery and nerve; it replaces to a great extent the obturator externus, which is peculiarly small, and situated anterior to it in origin, as usual. The semitendinosus is present and has a broad accessory head. The ambiens is absent. The other muscles are as in most birds.

Species examined.

Casuarius bennettii. *Casuarius bicarunculatus.*
—— *galeatus.*

In *Dromæus novæ-hollandiæ* the semitendinosus is larger than in *Casuarius*, and the accessory head is large; the femoro-caudal is absent; and the accessory femoro-caudal is very large, being pierced by the sciatic artery and nerve. The biceps cruris is very peculiar in not being inserted in its usual characteristic manner, but ending a little anterior to the middle of the thigh very indefinitely, blending with the fasciæ in that region, and not being continued directly to the fibula at all. The semimembranosus also is peculiar in having an aponeurotic connection with the middle of the linea aspera, from about the middle of its course. The ambiens is absent.

In *Rhea americana* a somewhat similar condition is found. The biceps is normal; and the semitendinosus, the accessory semitendinosus, as well as the postacetabular portion of the tensor fasciæ are much as in *Casuarius* and *Dromæus*. The femoro-caudal is absent;

the accessory femoro-caudal is large, being perforated by the sciatic artery and nerve; and the ambiens is strong.

In *Struthio camelus* the ambiens is also well developed.

Part II.* (Plate V.)

Page 111. The facts contained in the former part of this communication ("Proceedings of the Zoological Society," 1873, p. 626) being in an expanded form, it is not easy to appreciate their full significance at a glance, nor without considerable difficulty. To obviate this inconvenience I have constructed the following table, which is so arranged that by a very simple method, it is possible to tell without further reference which of the five muscles—the ambiens, the femoro-caudal, the accessory femoro-caudal, the semitendinosus, and the accessory semitendinosus—are present or absent. To obtain this result the names of the muscles themselves have been omitted, and single letters of the alphabet used in their stead.

The femoro-caudal is represented by..............	A
The accessory femoro-caudal	B
The semitendinosus..........................	X
The accessory semitendinosus	Y

When these four muscles are present in a bird the formula A B. X Y expresses the fact; when any one is absent, that such is the case is indicated by the omission of the letter representing it. Thus the formula A. XY indicates that the accessory femoro-caudal muscle only is absent; A B. X that the accessory semitendinosus is missing; A. X that the femoro-caudal and semitendinosus only are to be found; and A that the femoro-caudal alone is present. These formulæ may be termed myological formulæ. No bird is known in which all these four muscles are deficient.

In the accompanying diagram (Plate [5] XVII.) all those birds which have the same myological formula are included together in one circle; and the circles are so placed in relation to one another that, if they were drawn on the surface of a sphere, there would be only a single operation of addition or subtraction necessary to move from any one to any of its immediate neighbours.

Of the four letters A, B, X, and Y the following are the sixteen possible combinations.

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* Part II. "Proceedings of the Zoological Society," 1874, pp. 111–23, pl. XVII. Read, Feb. 3, 1874.

AB.XY	A B	*B.XY*	*XY*
AB.X	*A.X*	*B.X*	X
A B.Y	A.Y	B.Y	Y
A.XY	*A*	B	0

Those printed in *italics* are those which, if considered as myological formulæ on the nomenclature above given, have been found amongst birds; in other words, there are eight different types of Page 112. muscular arrangement in the thighs of birds, as far as the four muscles now under consideration are concerned.

Each of the circles in the diagram is divided into two halves by a vertical line, so that the names of all those birds which are found to possess the ambiens muscle may be distinguished from those in which it is absent. The birds in which the ambiens is present are placed in the left-hand semicircles; those in which it is absent are to be found in the right-hand semicircles.

A few examples may illustrate the method of employing this table. Taking the *Musophagidæ*, for instance, they being found in the circle A B. X Y evidently possess all the four muscles—the femoro-caudal, the accessory femoro-caudal, the semitendinosus, and the accessory semitendinosus; and being on the left side, have also the ambiens. The *Strigidæ* being on the right side of the circle with the formula A, possess only the femoro-caudal, the ambiens being also absent, and so on. Those birds whose names appear partly in both semicircles may or may not possess the ambiens muscle in their different genera.

Before going further it will be necessary to show what degree of constancy is, as a rule, to be expected in the myology of birds. Respecting this point my experience is that individuals of a species agree precisely in their muscular arrangement. Many specimens of a considerable number of species have passed through my hands, and I have frequently dissected them one after another in order to detect, if possible, any individual variations; such, however, have not been forthcoming. It is true that in a single specimen of *Œdicnemus grallarius* the ambiens, instead of crossing the knee, ended on the inner side of the ligamentum patellæ; however, the muscle, though imperfectly developed, was undoubtedly there. The only other instance of an unexpected and abnormal individual structure was the presence in a specimen of *Pomatorhinus temporalis*, on one side only, of an accessory femoro-caudal, which I have not once seen in any other of at least 100 Passerine birds that I have examined.

From these observations it is evident that individuals of a species all agree in the arrangement of the muscles of the thigh at least—so much so that any peculiarity observed in a specimen dissected for the first time may be taken to be characteristic of the species itself.

The same remarks apply to the species of a genus. Of several genera I have had the opportunity of dissecting many species, seven of *Bubo*, six of *Ardea* and *Columba*, five of *Buceros*, *Francolinus* and *Ibis*, four of *Chrysotis*, *Brotogerys*, and *Geopelia*, three of a large number, and two of many more. In all these genera the myology of the species does not vary, and its constancy is sufficient to justify the suspicion that when there are muscular differences between the species of an accepted genus, it is because genera have been combined which ought to be kept distinct. Such is evidently the case with *Conurus*, in which genus those without the red tail differ from those possessing it (*Pyrrhura*), the ambiens muscle being present in the former and absent in the latter. There are also other anatomical differences Page 113. between them. The genus *Conurus*, therefore, as at present generally defined, is too extensive, and from it must be separated off the genus *Pyrrhura* of Bonaparte.

In *Euplocamus* there is an apparent slight exception to the uniformity in generic myology. In some species, as *E. erythrophthalmus*, *E. albocristatus*, and *E. horsfieldii*, the femoro-caudal is present, though very small indeed; in a specimen of *E. vieilloti*, however, it could not be found at all. This tendency to the entire disappearance of an almost obsolete muscle, however, can have but little weight in generalizations of the character under consideration.

Ascending to the next zoological grade, in the families of birds there may be myological differences, though in some, such as the Anatidæ, the Accipitres proper, the Strigidæ, and most of the smaller families, none have yet been found. The femoro-caudal is the muscle which seems to be the most susceptible of variation. Amongst the Cathartidæ it is present in *Cathartes* and absent in *Sarcorhamphus* and *Gyparchus*. Amongst the Gallinæ it is absent in *Pavo* and *Meleagris*, very small or absent as above mentioned in *Euplocamus*, and well developed in *Gallus* and *Argus*. The various genera of Columbæ and Psittaci may or may not possess the ambiens, as is the case with *Conurus* and *Pyrrhura* mentioned above. Amongst the Cuculidæ, the Ground-Cuckoos (*Centropus*, *Guira*, *Phœnicophaes*) differ from *Cuculus* and its allies in having the accessory femoro-caudal developed, whilst it is absent in the latter, their respective formulæ being A B. X Y and A. X Y. This peculiarity, when added to those in the pterylosis, justifies the division of the family into two subfamilies, which may be termed the *Centropodinæ* and the *Cuculinæ*. In the same way the *Pici* differ among themselves in possessing or being deficient of the accessory semitendinosus, *Picus* being one of the latter, whilst *Gecinus*, *Leuconerpes*, &c., are of the former.

It may be inferred from the above statements that in the families of birds, though there may be myological differences amongst the genera, these differences are never more considerable than such as consist of the absence of one muscle from the typical arrangement of the family, or, in other words, from the modification of one element of the typical formula. When, therefore, it is found that under any accepted arrangement there are subfamilies differing from one another by more than a single muscular peculiarity, there is reason to expect that these subfamilies would be further separated in a natural arrangement. The *Accipitres* furnish an example; the myological formulæ of its subdivisions are subjoined, + and – indicating the presence or absence of the ambiens muscle:—

Falconidæ A +
Vulturidæ A +
Cathartidæ A. X Y + or X Y +
Strigidæ A –
Serpentariidæ B. X Y +.

This table makes it evident that the *Falconidæ* and *Vulturidæ* are widely separated from the *Cathartidæ* and the *Serpentariidæ*, and that it is perfectly impossible to unite in any intimate way these two latter families with the two former, or with one another. In fact the *Accipitres*, as generally defined, are not a natural group at all; and the *Cathartidæ* are not the least more nearly related to the *Vulturidæ* than to the *Falconidæ*. Page 114.

Respecting families it may therefore be said that myological peculiarities which do not involve more than a single structural change from the typical arrangement of the family are frequent, and that further differences indicate a more distinct relationship

The various opinions held by different ornithologists as to the correct division of the Orders of the Class Aves are so numerous that they make it impossible in this stage of the inquiry to discuss the myological features which they present. An inspection of Plate 5 (XVII.) is sufficient to show that the formula of a bird is not of direct value in estimating ordinal characters.

Looking at the whole subject from another point of view, it may now be asked, What does the arrangement in the muscles above described teach as to the major divisions of the Class Aves? The remainder of this communication will be an attempt to answer this question.

A mere glance at Plate 5 (XVII.) is sufficient to show that the facts disclosed by a study of the myology of birds do not, without extraneous assistance, place the different families in their true relationship to one another. Because the same muscles are present in two families of birds, it cannot therefore be said that their kinship is extremely close, or the reverse; if such were the case we should have to put the *Ardeidæ* with the Passeres, and to separate the Auks from the Gulls, both of which results would be strongly in opposition to the teaching of osteology. It is therefore necessary to look around to find, if possible, myological characters which have some definite relations to equally well-marked pterylographic, visceral, or osteological peculiarities.

Before going further it will be necessary to clearly understand a principle which is of much assistance in working out the details of classification from a large number of unarranged facts. It is this: when any certain structure is found to exist in an unmodified form in several clearly separable members of any well-marked larger division of the Animal Kingdom, that structure must be considered typical of the division; in other words, that structure, or the potentiality for producing it, must have existed in the common ancestor of the division under consideration; and those of its members who are wanting in the particular structure are so because they have lost it in process of time, not because the others have separately acquired it; for the probability, if it were only a matter of probability, is very little that several distinct and different species should separately acquire a single identical structure; whilst it is infinitely more likely that several distinct species should all lose a common character. That all Mammalia should acquire branched horns is improbable; but that many which possess branched horns should have them broken off whilst rushing through a wood, whatever species they belong to, is much more to be expected.

Employing this argument with regard to the facts under discussion, Page 115. the ambiens muscle is present in many not closely related birds. It is found in genera so distant as *Struthio*, *Gallus*, *Musophaga*, *Cuculus*, *Anser*, *Aquila*, *Ciconia*, and *Thalassidroma*. This muscle must therefore be considered typical in birds; it, or the full potentiality for acquiring it in time, must have existed in the ancestral bird. Consequently those birds in which it is absent may be set down as having possessed the muscle in their ancestral form, as having lost it, and, what is more, as having lost all power ever to recover it—because the probability that exactly the same structure should be reproduced as the result of the influence of forces different from those by which it first originated, especially when acting on the body modified upon its previous condition, is infinitely little. I find no tendency to atavism in any structure once fully specialized. The modification of the tarso-metatarse of the Penguin cannot be included in the same category. The bird is hatched, as are others, with an incipient potentiality to develop separate metatarsals; a modification of its early nutrition, together with peculiarities in its habits of life, prevent the metatarsals from blending into a cylindrical bone, and so they take on a semi-ancestral form. Therefore, and nevertheless, the Penguin is no nearer the Reptilia than any other bird. It is a true bird, derived from the Avian ancestor only, which is the same thing as saying that it has no special Reptilian affinities, although its terrestrial and aquatic habits may have caused it to be acted on by forces somewhat similar, and therefore to appear, but only to appear, to have a somewhat similar conformation. The same argument applies to all the members of the class. The Ostrich and Tinamou are no nearer to reptiles than is the Sparrow or the Parrot; they are birds, and therefore they cannot be any thing else. However similar any individuals of two families which separated off two centuries ago and have never intermarried may be, no one thinks of claiming any nearer relationship for the similar individuals than for the other members of the families. Why then should it be said that some birds are Reptilian and others not? Reptiles and birds can never have interbred, therefore there can be no relationship between them.

To return to the subject. There are some families of birds, such as the *Columbæ* and the *Psittaci*, in which different genera vary in possessing or not having the ambiens muscle developed. Those in which it is absent must, from previous considerations, have lost it since the families differentiated off; and therefore those families may be classed with the others in which the ambiens is present. The *Columbæ* are further complicated in the same way with regard to the cæca of the intestine; some have cæca, others have not; they must evidently be classed with birds possessing cæca. And generally, if exceptions to a rule are found, when they are in the direction of the loss of any given structural peculiarity, such exceptions are not of much detriment to an argument if other conditions are favourable. But positive exceptions, such as the reappearance of a lost character in minor divisions in the major division of which it is supposed to be absent, are not to be allowed under any consideration whatever.

For nearly the last two years I have been on the watch for a structural character or a combination of characters to turn up which **Page 116.** would give clear indications of the most important divisions of the bird class. My search has, to my own mind, been fairly satisfactory in its results; for the classification at which I have arrived appears to have a practicability about it which is decidedly promising.

The oft-named ambiens muscle is, in my idea, the key to the whole. In some families it is present, in others absent. By combining all those in which it is found into one subclass, to be subsequently termed *Homalogonatæ* (typically kneed, because the ambiens runs in the tendon of the knee), and all those in which it is absent into a second, to be subsequently termed *Anomalogonatæ* (abnormally kneed), a primary division is the result which the following facts will in great measure justify. It may be stated at once, however, that there are a few undoubtedly homalogonatous birds in which the ambiens muscle is absent; there cannot be any anomalogonatous birds in which it is present.

The following table (Table I.) contains the names of the various most important divisions of the Class of Birds, arranged according as they are homalogonatous or anomalogonatous. Those homalogonatous divisions with an asterisk (*) against them do not possess the ambiens muscle in any of their genera; in those with a dagger (†) it is wanting in certain genera only.

TABLE I.

Class **AVES.**
- Subclass HOMALOGONATÆ.
  - Order I. GALLIFORMES.
    - Cohort (α) STRUTHIONES.
      - Family 1. STRUTHIONIDÆ.
        - Subfamily 1. *Struthioninæ.*
        - ,, 2. *Rheinæ.*
      - Family 2. CASUARIIDÆ (*).
      - ,, 3. APTERYGIDÆ.
      - ,, 4. TINAMIDÆ.
    - Cohort (β) GALLINACEÆ.
      - Family 1. PALAMEDEIDÆ.
      - ,, 2. GALLINÆ.
      - ,, 3. RALLIDÆ.
      - ,, 4. OTIDÆ.
        - Subfamily 1. *Otidinæ.*
        - ,, 2. *Phœnicopterinæ.*
      - Family 5. MUSOPHAGIDÆ.
      - ,, 6. CUCULIDÆ.
        - Subfamily 1. *Centropodinæ.*
        - ,, 2. *Cuculinæ.*
    - Cohort (γ) PSITTACI (†).
  - Order II. ANSERIFORMES.
    - Cohort (α) ANSERES.
      - Family 1. ANATIDÆ.
      - ,, 2. SPHENISCIDÆ. **Page 117.**
      - ,, 3. COLYMBIDÆ.
      - ,, 4. PODICIPIDÆ (*).
    - Cohort (β) NASUTÆ.
      - Family 1. PROCELLARIIDÆ (†).
      - ,, 2. FULMARIDÆ.

Subfamily 1. *Fulmarinæ.*
 „ 2. *Bulweriinæ.*

Order III. CICONIIFORMES.
 Cohort (α) PELARGI.
 „ (β) CATHARTIDÆ.
 „ (γ) HERODIONES (*).
 „ (δ) STEGANOPODES.
  Family 1. PHAETHONTIDÆ.
  „ 2. PELECANIDÆ.
  „ 3. PHALACROCORACIDÆ.
  „ 4. FREGATIDÆ.
 Cohort (ε) ACCIPITRES.
  Family 1. FALCONIDÆ.
  „ 2. STRIGIDÆ (*).

Order IV. CHARADRIIFORMES.
 Cohort (α) COLUMBÆ (†).
  Family 1. COLUMBIDÆ.
  „ 2. PTEROCLIDÆ.
 „ (β) LIMICOLÆ.
  Family 1. CHARADRIIDÆ.
  „ 2. GRUIDÆ.
  „ 3. LARIDÆ.
  „ 4. ALCIDÆ (*).

Subclass ANOMALOGONATÆ.
 Order I. PICIFORMES.
  Family 1. PICARIÆ.
   Subfamily 1. *Picidæ.*
   „ 2. *Ramphastidæ.*
   „ 3. *Capitonidæ.*
  Family 2. UPUPIDÆ.
  „ 3. BUCEROTIDÆ.
  „ 4. ALCEDINIDÆ.

 Order II. PASSERIFORMES.
  Family 1. PASSERES.
  „ 2. BUCCONIDÆ (?).
  „ 3. TROGONIDÆ.
  „ 4. MEROPIDÆ.
  „ 5. GALBULIDÆ.
  „ 6. CAPRIMULGIDÆ.
  „ 7. STEATORNITHIDÆ.
  „ 8. CORACIIDÆ.

Subfamily 1. *Coraciinæ.*
Page 118. ,, 2. *Momotinæ.*
,, 3. *Todinæ* (?).

Order III. CYPSELIFORMES.

Family MACROCHIRES.
Subfamily 1. *Cypselinæ.*
,, 2. *Trochilinæ.*

There are peculiarities in the arrangement of the cæca of the intestine and of the tuft of feathers on the oil-gland which are correlatable with this presence or absence of the ambiens muscle. Some birds possess cæca to the intestine at the same time that the oil-gland is tufted (1); others have cæca and a nude oil-gland (2), others a tufted oil-gland and no cæca (3), whilst a few have no cæca and a nude oil-gland (4); the genera *Didunculus*, *Goura* and *Treron*, amongst the *Columbæ*, have no cæca and no oil-gland, wherein they differ from all other birds. Now it is a curious fact that it is only amongst the homalogonatous birds that the first of the above-named conditions is found, namely a tufted oil-gland combined with cæca to the intestine; and what is more, they nearly all agree with it. The following table (II.) contains the names of those birds in which a tufted oil-gland is combined with cæca to the intestine, an asterisk indicating the families in which there are certain exceptions.

TABLE II.

*Struthiones**.
Crypturi.
*Gallinæ**.
*Otidæ**.
Phœnicopteridæ.
Palamedeidæ.
Rallidæ.
Limicolæ.
Laridæ.
Alcidæ.
Gruidæ.
Anatidæ.
Spheniscidæ.
Colymbidæ.
*Procellariidæ**.
Ciconiidæ.
Ardeidæ (one cæcum).
Steganopodes.
Falconidæ.
Vulturidæ.

Respecting the exceptions, it may be mentioned that the *Struthiones* and *Otis* have no oil-gland; but as in their nearest allies it is tufted, they may be included amongst those in which it is so also. Amongst the *Gallinæ* I have always found the oil-gland nude in the *Megapodidæ* (*Talegalla* and *Megacephalon*). The Storm-Petrels have no cæca, and the *Ardeidæ* have only one.

It is therefore evident that from the whole list of birds termed homalogonatous, only the *Musophagidæ*, *Psittaci*, *Columbæ*, *Cuculidæ*, and *Cathartidæ* are exceptions to the above-stated rule, the first two having no cæca, the next two a nude oil-gland, and the last neither cæca nor a tufted oil-gland.

Another myological fact comes in here to assist. A reference to Plate 5 (XVII.) in comparison with Table I. will show that no anomalogonatous bird has been found to possess the accessory femoro-caudal; that is, B never enters into its myological formula. Such being the case, when a bird has a formula with B in it, at the same time that either the ambiens muscle is absent, or has a nude oil-gland in combination with intestinal cæca, it is certain to be a homalogonatous bird. That the formula of the *Musophagidæ* is A B. X Y, and the ambiens is present, therefore more than counterbalance the exception presented by the arrangement of their cæca and oil-glands. The same remarks apply to the *Cuculidæ.* The *Cathartidæ* possess the ambiens, which, in conjunction with many other Ciconiine characters, leaves no doubt about their position; and the *Psittaci* cannot, from the presence of an ambiens in some of them, be placed with the Anomalogonatæ, to which they otherwise present many points of similarity.

Page 119.

Excluding the *Macrochires,* which have a nude oil-gland and no cæca, all the other anomalogonatous birds have either a nude oil-gland and cæca, or a tufted oil-gland and no cæca; and this definite set of features makes it easy to divide them up into two main orders, the Piciformes and the Passeriformes.

Piciformes, with tufted oil-gland and no cæca.	Passeriformes, with nude oil-gland and cæca.
Pici.	*Passeres.*
Capitonidæ.	*Bucconidæ* (?).
Ramphastidæ.	*Trogonidæ.*
Upupidæ.	*Meropidæ.*
Bucerotidæ.	*Caprimulgidæ.*
Alcedinidæ.	*Steatornithidæ.*
	Coraciidæ.
	Momotidæ.

The position of the Macrochires is uncertain. In so far as the mouth tends to get very broad it resembles some of the Passeriformes.

As before remarked, none of the Anomalogonatæ possess the accessory femoro-caudal muscle. In them also the posterior margin of the sternum is more perfectly formed than in the Homalogonatæ. Scansorial feet are found in both divisions; but whilst those of the Parrots and Cuckoos exhibit a similar arrangement of the tendons of the toes, the Toucans, Woodpeckers, and Jacamars follow a quite different type.

All the birds which present the palatal characters expressed by

Professor Huxley's term Schizognathous, and the nasal characters expressed by my term Schizorhinal, are homalogonatous. All non-struthious birds with a truncated vomer are anomalogonatous.

As to what appear to me to be the main divisions of the homalogonatous birds, the myology of the thigh does not give more than a certain amount of assistance. In list I. it will be seen that large brackets precede the names of the smaller divisions or families, separating them into what to me are worthy of the dignity of orders. From these it is evident that I would divide homalogonatous birds into four orders, I. Galliformes, II. Anseriformes, III. Ciconiiformes, and IV. Charadriiformes (Schizorhinæ). These must be considered separately.

The Galliformes include all the birds in which there is any approach in structure to the common Fowl. With the exception of Page 120. the *Psittaci* (which in other points also are peculiar), and the *Cuculinæ* from amongst the Cuculidæ, they all possess the accessory femoro-caudal (B) well developed. The semitendinosus (X) and the accessory semitendinosus (Y) are always present, and, except in *Casuarius*, *Dromæus*, and some *Psittaci*, the ambiens is to be found well developed.

The presence of both the accessory femoro-caudal and the accessory semitendinosus (that is, of both B and Y in their myological formula) is the most characteristic feature which they have in common, giving the formula B. X Y as typical.

The Anseriformes include most of the web-footed birds. Their most marked characteristic is the presence of the accessory femoro-caudal (except in *Bulweria*), whilst the accessory semitendinosus is absent, except in the Storm-petrels. With the exception of the *Podicipidæ*, the femoro-caudal is present; so that their formula is nearly always A B. X. Excluding *Podiceps* and a Storm-petrel in the case of one species examined, I have always found the ambiens present.

The Ciconiiformes are less easily defined than the other groups. The cæca coli are never long; the accessory femoro-caudal is never present; and the obturator externus is frequently more developed than in other birds, to replace it in action. It is in the pectoral region that these birds most closely agree. The strong short anterior costo-coracoid ligament, the bowed space between the superior margin of the second pectoral muscle and the furcula, and the frequently complicated arrangement of the great pectoral, whereby it is developed in a superficial and a deep layer (in which, by the way, the *Procellariidæ* agree with them), all point to a not far distant relationship. The *Ardeidæ* are the most aberrant of the order, the ambiens muscle being always absent in them at the same time that there is only one colic cæcum.

The Charadriiformes correspond to the Schizorhinæ, so named by me on account of a peculiarity in the structure of the nasal bones, which is sufficiently special in my estimation to justify the separation of all those birds in which it is found into a single order by themselves. There are considerable myological differences amongst its families according to their habits, the only uniform character being the presence of the femoro-caudal muscle. The ambiens is absent in the *Alcidæ* (*Alca, Uria*) and some *Columbæ.*

The minor divisions of the orders above defined must now engage our attention.

The order GALLIFORMES may be divided into three main divisions or cohorts—α. the *Struthiones*, β. the *Gallinaceæ*, and γ. the *Psittaci.*

α. The *Struthiones* are peculiar in the structure of the palate; and in them the sciatic nerve and artery always perforate the fibres of the accessory femoro-caudal in a manner not found in any other birds.

They are divisible into four families, the first three of which have no oil-gland:—

1. *Struthio* and *Rhea*, which form each the type of a separate subfamily. In common they have the formula B. X Y*, the ambiens muscle present, and long sacculated cæca coli, which in *Struthio* are situated peculiarly far from the cloaca. There is no aftershaft to the contour feathers. *Struthio* has two carotids, *Rhea* only the left. Page 121.

2. The genera *Casuarius* and *Dromæus.* They have the formula A B. X Y and B. X Y respectively. The ambiens muscle is absent, the cæca coli are short, and there is a very large aftershaft to the contour feathers. There are two carotid arteries.

3. *Apteryx*, in which there is an extra femoro-caudal muscle, the formula otherwise being A B. X Y. The ambiens is large; the cæca coli are well developed; and there is only one carotid, the left.

4. The *Crypturi*, with a formula A B. X Y. The ambiens muscle is large; the cæca coli are well developed; and an oil-gland is present, well tufted. The aftershaft may or may not be present on the contour feathers.

β. The *Gallinaceæ* all comprise B. X Y in their formula; the ambiens is present in all; and except in the *Musophagidæ* there are always cæca to the intestine.

They are divisible into six families:—

1. The *Palamedeidæ*, with formula A B. X Y, the ambiens present, cæca sacculated as in *Struthio* and *Rhea* only, two carotid arteries, no aftershaft or a very small one, and a tufted oil-gland.

2. The *Gallinæ*, with formula A B. X Y or B. X Y. The ambiens

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[* In *Struthio* there is also, as subsequently recorded by Professor Garrod in his MSS., a femoro-caudal muscle of "fair size and quite distinct from the accessorius." The proper formula therefore for this genus is A B. X Y. ED.]

is always present, as are cæca coli, an aftershaft, and a third pectoral muscle beneath the second; the oil-gland may be strongly tufted, or the tuft may be very weak; in the *Megapodidæ* it does not exist. The second pectoral is very long; and there is a characteristic shape about the sternum. In the *Megapodidæ* there is only one carotid, the left; in all the others both are present. Neither *Turnix* nor *Pterocles* are included in this family.

3. The *Rallidæ*, with formula A B. X Y, the ambiens and cæca present, two carotids, an aftershaft, a tufted oil-gland, and a characteristic sternum. *Parra* is not included.

4. The *Otidæ*, including the *Otidinæ*, *Œdicnemus*, *Serpentarius*, and *Cariama* (and perhaps the next genus, *Phœnicopterus*). The formula is B. X Y; the ambiens and cæca are present, as is the aftershaft; there are generally two carotids, though in *Otis denhami* the right only is present, and in *Tetrax* the left; the oil-gland when present, as in all but *Otis*, is tufted, except in *Cariama* and *Chunga*.

5. The *Musophagidæ*, with formula A B. X Y, an ambiens muscle, two carotids, an aftershaft, a tufted oil-gland, and no cæca.

6. The *Cuculidæ*, with an ambiens muscle, two carotids, nude oil-gland, and cæca. They form two subfamilies:—

The *Centropodinæ*, or Ground-Cuckoos, with formula A B. X Y.

The *Cuculinæ*, or true Cuckoos, with formula A. X Y.

γ. The cohort *Psittaci* presents in many points intermediate characters between the homalogonatous and the anomalogonatous birds. With a constant formula A. X Y, no cæca or gall-bladder, an oil-gland tufted or absent, the ambiens may or may not be present, and the carotids may exhibit peculiarities in their arrangement.*

The order ANSERIFORMES may be divided into two cohorts—α. the *Anseres*, β. the *Nasutæ*.

Page 122. α. The *Anseres* include four families, (1) the *Anatidæ*, (2) the *Spheniscidæ*, (3) the *Colymbidæ*, and (4) the *Podicipidæ*. With the exception of the Podicipidæ, they agree in having a formula A B. X, an ambiens muscle, cæca to the intestine (except *Mergellus*, in which there is only one small cæcum), two carotids, a very elongate great pectoral muscle, which meets its fellow of the opposite side above the symphysis furculæ in a median raphe, and a tufted oil-gland. The *Podicipidæ* have for formula B. X; the ambiens is absent, as is frequently the semimembranosus; the left carotid only is present; there are cæca coli and a tufted oil-gland.

β. The *Nasutæ*, including the Storm- and true Petrels. I have not dissected *Diomedea*. They are divisible into two subfamilies:—

1. The Storm-petrels, with formula A B. X Y, no cæca, a tufted

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* See "Proceedings of the Zoological Society," 1873, p. 465. (*Suprà*, p. 170.)

oil-gland and a peculiar sternum. The ambiens does not seem to be always developed. The great pectoral is double.

2. The *Fulmaridæ*, with formula A B. X, the ambiens muscle present, two short cæca, a tufted oil-gland, and a characteristic sternum. *Bulweria* is exceptional in having its formula A. X, and therefore quite different from that of the Storm-Petrels. The great pectoral is double.

The order CICONIIFORMES may be divided into five cohorts of somewhat different importance:—

1. The *Pelargi*, with formula A. X Y, an ambiens muscle, a tufted oil-gland, intestinal cæca, and a double great pectoral muscle.

2. The *Cathartidæ*, with formula A. X Y, an ambiens muscle, no cæca, a nude oil-gland, and a double great pectoral muscle.

3. The *Herodiones*, with formula A. X Y or X Y, no ambiens muscle, a single cæcum coli, and a tufted oil-gland.

4. The *Steganopodes*, which do not form so natural a family, in my eyes, as in those of many; for their myological formula is not the same in all, being

In *Phaethon* A. X Y,
In *Sula* and *Phalacrocorax* A. X,
In *Fregata* A,

from which it may be inferred that *Phaethon* approaches the Ciconiidæ and *Fregata* the Accipitres. They all possess the ambiens, cæca, a tufted oil-gland, and the four toes included in a web, which is but imperfectly developed in some. *Sula* and *Phalacrocorax*, with *Plotus*, form one family, *Phaethon* another, *Fregata* a third, and *Pelecanus* a fourth.

5. The *Accipitres* proper include the Falconidæ and the true Vultures (between which there is not even any subfamily structural difference), together with the Strigidæ. Their formula is A; the ambiens is present (except in the Strigidæ), as are cæca, a tuft to the oil-gland, and an aftershaft (except in *Pandion*).

The order CHARADRIIFORMES, including all the Schizorhinal birds, is a large one, and may be divided into two cohorts—α. the *Columbæ*, and β. the *Limicolæ*. They all, except *Arctica alle*, have two carotids.

α. The *Columbæ*, including the *Pteroclidæ*, have a formula A B. X Y (except in *Lopholæmus*, in which it is apparently A. X Y). The ambiens muscle is sometimes present, sometimes absent. The oil-gland, if present, is nude; cæca may or may not be present; and the pterylosis is a very diffused one. Page 123.

β. The *Limicolæ* have a tufted oil-gland and cæca; they form four families at least:—

1. The *Charadriidæ*, with formula A B. X Y and A. X Y, and an ambiens muscle.

2. The *Laridæ*, with A. X Y formula, and an ambiens muscle.

3. The *Gruidæ*, with formula A B. X Y, and ambiens muscle.

4. The *Alcidæ*, with formula A B. X, and no ambiens muscle.

The ANOMALOGONATOUS birds form three cohorts—α. the *Passeriformes*, β. the *Piciformes*, and γ. the *Cypseliformes*. They are divisible into the following families:—

α. *Passeriformes.*

1. The *Passeres*, with a formula A. X Y (except in *Dicrurus*, in which it is A. X), a characteristic palate and sternum (except in *Pteroptochus*), a left carotid only, and a characteristic *tensor patagii brevis* muscle (to be described on a future occasion).

2. The *Bucconidæ*, of which I have not dissected any example, but which most probably come here.

3. The *Trogonidæ*, with formula A. X, a left carotid only, and a very passerine pterylosis.

4. The *Meropidæ*, with a formula A. X Y, and a left carotid only.

5. The *Caprimulgidæ*, with a formula A. X Y, and two carotids.

6. The *Steatornithidæ*, with a formula X Y, and two carotids.

7. The *Coraciidæ*, in which the *Coraciinæ* and *Momotinæ* are combined, on account of their not presenting family differences. They have a formula A. X Y, and two carotids.

8. The *Galbulidæ*, with a formula A. X Y or A. X, two carotid arteries, and a scansorial foot.

β. *Piciformes.*

1. The *Picariæ*, to include the *Pici*, the *Ramphastidæ*, and *Capitonidæ*, these three not in any point presenting family differences. They may be divided into two subfamilies, the *Pici* forming the one, the *Ramphastidæ* together with the *Capitonidæ* forming another. The formula is A. X Y (except in the *Picinæ* among the *Pici*); the form of the sternum and of the tensor patagii brevis is characteristic. The foot is scansorial.

2. The *Upupidæ*, with formula A. X Y, a characteristic pterylosis, a left carotid only, and a passeriform foot.

3. The *Bucerotidæ*, with formula A. X Y, no fat found on the body, a characteristic sternum, and one or two carotids.

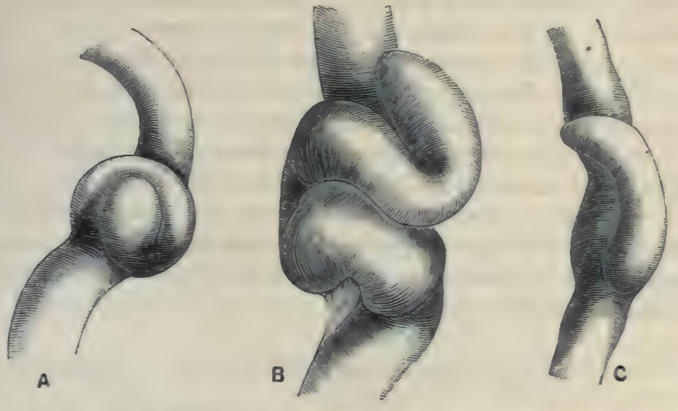
4. The *Alcedinidæ*, with formula A. X, and two carotids.

γ. *Cypseliformes*, including the *Cypselidæ* and *Trochilidæ*, between which the differences are only of subfamily importance. The formula is A; the tensor patagii brevis and the pterylosis are characteristic, as is the sternum; and there is only a left carotid (except in *Cypseloïdes*).

33. NOTE ON THE CÆCUM OF *CANIS CANCRIVORUS*.*

THE South-American *Canes* present peculiarities which have always Page 748. made it difficult to determine their exact relation to the other members of the family. This difficulty is somewhat increased by the determination of the peculiarities of their visceral anatomy; for on eviscerating a specimen of *Canis cancrivorus* I found that the cæcum differs from that of other members of the genus. Whether the observed peculiarity holds in other closely allied species, and in other individuals of the same, can only be determined by the dissection of other specimens as they come to hand.

On the authority of Professors Owen and Flower, and of the late Mr. H. N. Turner, the cæcum of all the Canidæ is uniformly cylindrical and peculiar in being folded on itself twice or three times in a serpentiform manner (Fig. B). On looking at the distended cæcum of the common Dog, with the distal or colic end downwards, the caput upwards, and the appendix itself towards the observer, it is seen to spring from the junction of the small and large intestines with an abrupt turn to the left, which is followed very shortly by an equally sudden turn to the right, causing it to stand transversely to the direction of the intestine; a third bend to the left, above the others, leads



A. Cæcum of *Canis famelicus*.
B. Cæcum of *Canis familiaris*.
C. Cæcum of *Canis cancrivorus*.
} all one half natural size.

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* "Proceedings of the Zoological Society," 1873, pp. 748–9. Read, November 18, 1873.

to the cæcal end. This condition obtains in almost all the Canidæ. In a specimen of *C. famelicus* I find the cæcum much shorter than Page 749. usual, and forming one and a quarter turn of a spiral, commencing by an upward turn to the left, and ending on the left side of the spire (Fig. A). The only other peculiarity that is generally observed is that the third fold is less developed in some than in others. But in the specimen of *C. cancrivorus* above mentioned the cæcum is much shorter than usual, being only 2 inches long in a nearly adult male animal, and almost straight, not showing any tendency to the folding on itself or otherwise typical of the genus (Fig. C). In other points of its anatomy no peculiarities were detected. In the tongue the circumvallate papillæ were insignificant, three on each side, separated by a considerable interval. The fourth lower molar characteristic of the species (or genus *Thous* of Gray) was not developed, the third being small and not above the gum. The undistended stomach presented the characteristic form found in so many of the Carnivora and figured in my account of the viscera of Binturong.* The spleen had a rudimentary third lobe. The small intestine was 5 feet, and the large intestine 6 inches, in length; and the latter seemed to bifurcate symmetrically at its proximal end into the cæcum and the small intestine, the two latter being of equal diameter and scarcely smaller than the colon. The liver presented all the characteristics of *Canis familiaris.* In the generative organs, the prostate was fairly developed, and Cowper's glands were absent; the os penis was deeply grooved, 1½ inch long, and slightly curved.

That this animal is a true *Canis* is therefore clear; but that the peculiarities of the cæcum are not certain characters to employ in classification in this case is evident, as is likewise the case with *Nandinia binotata*, which, as pointed out recently by Professor Flower,† is the only known Æluroid animal which does not possess a cæcum.

It will be interesting to observe whether the other South-American Canidæ, all of which are peculiar in that the temporal ridges only meet across the skull for a very short distance at their posterior extremity (though some other species present this peculiarity) and are considerably separated in front, agree with *Canis cancrivorus* in the simplicity and shortness of their cæca.

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* "Proceedings of the Zoological Society," 1873, p. 198. (*Suprà*, p. 154.)

† *Ibid.* 1872, p. 683.

34. ON THE VISCERAL ANATOMY OF THE GROUND-RAT (*AULACODUS SWINDERNIANUS*).*

OUR knowledge of the visceral anatomy of the Rodents is still in so Page 786. incomplete a state, and the prevalent ideas on their classification so correspondingly vague, that until the details of the structure of the most important types have been published, it will be impossible to judge of their mutual affinities.

I take the present opportunity of noting the most important points in the Ground-Rat (*Aulacodus swindernianus*) of West and South Africa, a male specimen having very recently died in the Society's Gardens.

The *tongue* is elongate and narrow, not divided into an anterior thin, and a posterior deeper portion, but of nearly uniform depth, blunt and rounded at the tip. Among the papillæ filiformes of its superior surface, papillæ fungiformes are scattered in small numbers. The circumvallate papillæ are represented by two long, narrow, elongate, circumvallate elevations, one on each side of the median line, where they nearly meet, running forwards as they diverge to form a V. The root of the tongue is covered by large, lax, and scattered conical papillæ between those last described and the hyoid bone; further back it is smooth.

The *salivary glands* present no peculiarities; the submaxillary are the largest.

The *œsophagus*, after perforating the diaphragm, runs for half an inch or more in the abdominal cavity before it joins the stomach; its epithelium, in the inverted stomach, projects beyond the cardiac orifice as a stiff puckered tube for about one-eighth of an inch.

The *stomach* is simple, proportionately slightly longer than in man, with the pyloric *cul-de-sac* also a little more developed. Its mucous membrane is smooth, except near the pyloric end, where there are a few irregular rugæ. No ridges of mucous membrane run along the Page 787. lesser curvature from the cardiac to the pyloric orifice. The pylorus is large.

In the *duodenum* the pyloric extremity is much dilated pyriformly as in many Rodents. The mucous membrane becomes velvety, with villi on the duodenal surface of the pyloric valve, and continues so along the small intestine. The whole small intestine is 5½ feet long.

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* "Proceedings of the Zoological Society," 1873, pp. 786–789. Read, Dec. 2, 1873.

The bile and pancreatic ducts open by an orifice 2 inches from the pylorus, and another a few inches further down.

In the *large intestine* the cæcum is 8 inches in length, and the intestine itself an inch over 4 feet. It is peculiar amongst the allied Rodents in that the cæcum and colon are directly continuous, no abrupt change of direction occurring at the junction with the ileum; and what is more, the sacculation on two longitudinal bands observed through the whole length of the cæcum is continued for some distance along the colon, without any marked change of character except size. However, the two longitudinal bands which sacculate the cæcum are not those which do the same to the colon; for opposite the ileo-cæcal valve, which is a simple projection of the small into the large intestine for one sixth of an inch, much like that in the horse, one of the cæcal bands splits into two, part going to join the other band, and part continuing on as an independent band. The small intestine joins the large, not, as is sometimes the case, at one of the bands, but in the middle of one of the sacculi, halfway between two of them. The diameter of the colon is less than that of the cæcum, and diminishes gradually till it becomes scarcely greater than that of the ileum. The sacculation continues, getting less and less marked, for about a foot from the ileo-cæcal valve; and the rest of the long colon is uniformly cylindrical, presenting the well-known abrupt bend near the middle of its course.

The caput of the cæcum is situated in the right lumbar region, and the base in the left lumbar, where an abrupt bend backward occurs, just before the small intestine enters. The omentum is not large, and does not cover the viscera. There is little or no fat in the abdomen.

On opening the cæcum and large intestine along its non-mesenteric longitudinal band, two strongly marked longitudinal ridges are seen to run from the ileo-cæcal valve along the colon, one on each side of the inner surface of the mesenteric longitudinal band, which is the compound one formed by one division of the bifurcate cæcal longitudinal band and the other cæcal band. These ridges diverge at first and are afterwards separated by an interval of two thirds of an inch. For the proximal diverging 2 inches they are simple; but after that they are puckered regularly in exactly the same way as M. A. Milne-Edwards has figured the *gastric* cardio-pyloric ridges in *Lophiomys*, which they also resemble in general direction and arrangement. These puckered ridges, after diverging, again approach till within one fourth of an inch of one another, after which they continue parallel for a little more than 2 feet, where, just after the sharp colic bend, they suddenly cease, joining one another just before doing so.
Page 788. The puckering, however, does not continue the whole way, it gradu-

ally diminishing a foot from the ileo-cæcal valve and ceasing altogether 4 inches further on, the ridges continuing as simple folds like railway lines.

Commencing colon of *Aulacodus swindernianus*, slit open on the non-attached border, showing the ileo-cæcal valve on the left, beyond which is the commencing cæcum; the intestine, with the two longitudinal ridges, running to the right; *a*, terminal portion of small intestine.

The *liver* possesses a gall-bladder which is short and pyriform. It presents all the typical fissures and lobes. The median fissure is slightly bridged over with hepatic tissue on the abdominal surface behind. The right and left lateral fissures very nearly separate off the lateral lobes as distinct glands; the caudate lobe is also only slightly attached. The left lateral lobe is the largest, next the right central, in which the cystic fossa and fissure are both deep. The right lateral is the smallest of the four main lobes; the caudate is smaller than any of them; and the Spigelian is only a flat flake of hepatic tissue.

The right *lung* possesses four lobes, of which the lowest is the largest, and the top one as small as the fourth, azygos one. An accessory bronchus joins the right bronchus. The left lung has two lobes, the upper the smaller, having two upper diverticula; there is no left accessory bronchus.

The *aorta* primarily branches into two trunks for the upper extremities, an innominate and a left subclavian; the left carotid soon leaves the innominate.

Page 789. The specimen being a male, those *generative organs* only can be described. The ureters enter the bladder at about one third its length from the neck. The vesiculæ seminales are two inches long, being composed of tubes with irregularly situated lateral diverticula of small size; they enter the urethra separate from the vasa deferentia, which are not swollen at their urethral ends. The testes are abdominal, being situated at the entrance of the capacious abdominal rings, with strong muscular gubernacula attached to the bottom of the would-be scrotum. The epididymis of each testis is of about one fourth its size. The prostate is, like that in most Rodents, composed of closely related but not intercommunicating bundles of glandular substance, arranged in elongated conical bundles, which can be easily separated from each other, each being about two thirds of an inch long. The membranous urethra is 3 inches long; Cowper's glands are about the size of peas, dark red and subspherical. The os penis is half-an inch long; and its free end forms part of a lip-like projection over the top of the orifice of the urethra.

There is a gland, the shape of the hearts on playing cards, fixed at its apex, which opens into the anterior wall of the termination of the rectum, just within the sphincter ani; it is white in colour, and the size of a haricot bean.

The most striking peculiarity in the above described anatomy of this animal is in the arrangement of the cæcum, which differs from that of most of the Cavies I have had the opportunity of examining in not presenting an abrupt change in the character and direction of the gut at the point of junction of the cæcum and colon. Respecting its osteology it may be mentioned that there are thirteen ribs, and that the clavicle was not developed from end to end in this not fully adult specimen, the sternal extremities being cartilaginous and joined to the free termination of a broad cartilaginous spatulate manubrium sterni. In a skeleton in the British Museum the broad bifurcate acromion is not preserved on either scapula; and they do not seem to have been broken off. In the specimen above described, this big acromion is present on both sides, but, peculiar to relate, it is *in each* only joined to the main part of the spine of the scapula by a fibro-cartilaginous ligament, and no crepitus is felt on moving the one part on the other. If this condition is not the result of injury, which it does not seem to be, it is very abnormal.

The peculiarities of the skull make me inclined to place *Aulacodus* nearest to *Lagostomus* and the American Porcupines, the former of which it very closely resembles in the arrangement of the zygomatic arch and palate, though the teeth present considerable difference. The cæcum of *Lagostomus* appears to be in many respects similar; but the liver is less complicated, possessing no cystic notch or fossa.

35. ON SOME POINTS IN THE ANATOMY OF THE *COLUMBÆ*.[*]

IN the present communication it is not my intention to describe in Page 249. detail the anatomy of any single kind of Pigeon, because that can be, most of it, learnt from the dissection of any common species: but, from the opportunities which are presented to me in the performance of my prosectorial duties, it will be my endeavour to point out those peculiarities which I have been able to recognize in the soft parts of the large number of generic forms of the Columbæ that have passed through my hands. It is my hope that those naturalists who have opportunities of examining genera and species which it has not been my good fortune to obtain, will record their observations, not omitting those points on which I shall endeavour to lay stress on the present occasion.

That there is not a perfect constancy in the pterylosis and visceral anatomy of the Pigeons has been known for some time. Nitzsch, in his work on Pterylography, incidentally mentions that in the genus *Goura* there are no cæca to the intestine, and that the gall-bladder is absent. The same facts are noted by Hunter.[†] The former naturalist also refers to the absence of the oil-gland in the same genus. Prof. Owen says[‡] that the gall-bladder is constantly deficient—a statement which, as will be seen further on, requires some qualification. The fact that all the European species of Doves belong to the genera *Columba*, *Turtur*, and *Pterocles* has caused zoologists to estimate the characters of the whole suborder more from these than from the much larger number found in extra-European countries; and the results arrived at from a more extended study tend considerably to modify the prevailing impression as to the constancy of certain characters.

The differences observable in the following structures have engaged my attention:—

1. The number of rectrices.
2. The presence or absence of the oil-gland, which is never otherwise than nude.
3. The presence or absence of cæca to the intestine, which in no

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[*] "Proceedings of the Zoological Society," 1874, pp. 249–59. Read, May 5, 1874.

[†] "Essays and Observations," vol. ii. p. 291.

[‡] "Anatomy of Vertebrates," vol. ii. p. 177.

genera, except in *Pterocles* and *Syrrhaptes*, exceed half an inch in length.

4. The presence or absence of the ambiens muscle, which does not seem as yet to have engaged the attention of naturalists, so far as this suborder of birds is concerned.

I. *The number of tail-feathers in the different genera of the* Columbæ.

Nitzsch divides the Pigeons into those with 12 and those with Page 250. 16 rectrices, and does not refer to any other numbers. Different authors have recorded the number of tail-feathers in some of the genera. Twelve, fourteen, sixteen, and twenty are the numbers which I have been able to find in the different species which I have been able to examine, though in *Calœnas* one specimen had only ten rectrices in the perfect tail, whilst most have twelve. Inspection of the following list will show that in some of the genera there are peculiarities in the number of the tail-feathers which indicate difference of more than specific importance; for instance, in *Carpophaga* fourteen is the typical number of the rectrices, but *C. novæ-zealandiæ* differs from all its congeners in possessing only twelve:—

Name of genus and species.	Number of rectrices.
Calœnas nicobarica	12
Chalcopelia puella	12
Chalcophaps chrysochlora	12
Chamæpelia talpacoti	12
Columba (all the species examined)	12
Ectopistes migratorius	12
Leptoptila jamaicensis	12
Lopholæmus antarcticus	12
Macropygia phasianella	12
Metriopelia melanoptera	12
Starnœnas cyanocephala	12
Turtur (all the species examined)	12
Tympanistria bicolor	12
Zenaida martinicana	12
Carpophaga (all species examined* except *C. novæ-zealandiæ*)	14
Didunculus strigirostris	14
Geopelia (all species examined)	14
Leucosarcia picata	14

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* Including *C. spilorrhoa*, of which I examined several examples.

Name of genus and species.	Number of rectrices.
Ocyphaps lophotes	14
Phlogœnas cruentata	14
—— *crinigera*	14
Ptilopus (all species examined except one specimen in Brit. Mus., marked *P. occipitalis* ♀, with 16)	14
Treron (all species examined)	14
Zenaidura marginata	14
Goura coronata	16
—— *victoriæ*	16
Phaps chalcoptera	16
Pterocles alchata	16
—— *arenarius*	16
Otidiphaps nobilis	20

It will be observed, as has been remarked by Prof. Baird, that, with the exception of *Zenaidura*, all the North American *Columbæ* possess 12 rectrices.

II. *The presence or absence of the oil-gland in the genera of the* Columbæ.

Page 251.

The oil-gland is present in most of the Pigeons; it is very small in the genus *Ptilopus*. It need hardly be remarked that, when present, it is never tufted.

The oil-gland is present in all the specimens examined by me of

Calœnas,
Carpophaga,
Chalcopelia,
Chalcophaps,
Chamæpelia,
Columba,
Ectopistes,
Geopelia,
Leptoptila,
Leucosarcia,
Lopholæmus,
Macropygia,
Metriopelia,
Ocyphaps,
Phaps,
Phlogœnas,
Ptilopus (? in *P. melanocephalus*),
Pterocles,
Turtur,
Tympanistria,
Zenaida,
Zenaidura.

The oil-gland is absent in all my specimens of

Didunculus,
Goura,
Starnœnas,
Treron.

III. *The presence or absence of cæca to the intestine in the genera of the* Columbæ.

My dissections lead to the result that the intestinal cæca are absent in more genera of Pigeons than they are present in, being found in only 7 out of 26. When present they never exceed a quarter of an inch in length (except in the Pteroclidæ), and are frequently not half that size. In *Turtur* they are generally shorter than in *Columba.*

Cæca are present in

Columba,
Ectopistes,
Macropygia,
Phlogœnas,
Pterocles,
Starnœnas,
Turtur.

Cæca are absent in

Calœnas,
Carpophaga,
Chalcopelia,
Chalcophaps,
Chamæpelia,
Didunculus,
Geopelia,
Goura,
Leptoptila,
Leucosarcia,
Lopholæmus,
Metriopelia,
Ocyphaps,
Phaps,
Ptilopus,
Treron,
Tympanistria,
Zenaida,
Zenaidura.

Page 252. IV. *The presence or absence of the ambiens muscle in the genera of the* Columbæ.

This muscle, of which the slender tendon runs in such a peculiar manner obliquely across the knee, arising from the supero-anterior margin of the acetabulum, and inserted into the muscular fibres of the flexor perforatus of the toes, is found in the greater number of the Pigeons I have examined, being present in about three fourths of the genera.

The ambiens muscle is present in

Calœnas,
Carpophaga,
Chalcopelia,
Chalcophaps,
Chamæpelia,
Columba,
Didunculus,
Ectopistes,
Leptoptila,
Leucosarcia,
Lopholæmus,
Macropygia,
Metriopelia,
Ocyphaps,
Phaps,
Pterocles,

Turtur,
Tympanistria,
Zenaida,
Zenaidura.

The ambiens muscle is absent in

Geopelia,
Goura,
Phlogœnas,
Ptilopus,
Starnœnas,
Treron.

The combination of the above-collected facts ought to be of considerable service in any attempts at classification; for, leaving the number of rectrices out of the question for the minute, of the eight possible variations of the three remaining characters, there are seven which are found to exist; in other words there are Pigeons known—

(1) With an oil-gland, cæca, and an ambiens muscle, viz. *Columba*, *Ectopistes*, *Macropygia*, *Pterocles*, and *Turtur*.

(2) With an oil-gland, no cæca, and an ambiens muscle, viz. *Calœnas*, *Carpophaga*, *Chalcopelia*, *Chalcophaps*, *Chamæpelia*, *Leptoptila*, *Leucosarcia*, *Lopholæmus*, *Metriopelia*, *Ocyphaps*, *Phaps*, *Tympanistria*, *Zenaida*, and *Zenaidura*.

(3) With no oil-gland, no cæca, and an ambiens muscle, viz. *Didunculus*.

(4) With an oil-gland, cæca, and no ambiens muscle, viz. *Phlogœnas*.

(5) With no oil-gland, cæca, and no ambiens muscle, viz. *Starnœnas*.

(6) With an oil-gland, no cæca, and no ambiens muscle, viz. *Geopelia*, *Ptilopus*.

(7) With no oil-gland, no cæca, and no ambiens muscle, viz. *Treron*, *Goura*.

The only combination not found being that (8) in which, of the three structures concerned, the oil-gland only is wanting.

The relative value of these different structural peculiarities is the point on which their value in classification evidently hinges. The number of rectrices being the most variable of them, its importance is most probably the least. Next, with regard to the oil-gland, it is Page 253. evident that genera such as *Treron* and *Ptilopus* are not very far separated, notwithstanding that there are important differences between them; yet the former wants the oil-gland and the latter possesses it, though but feebly developed in *P. jambu* and *P. mariæ*, and absent (apparently) in *P. melanocephalus*. It is also known that among the Psittaci this structure may or may not be developed. These considerations lead me to think that less stress should be laid on the oil-gland than on the two following characters.

The constancy of the cæca, as a point of more than family importance in all other birds, would lead me to consider their presence or absence as more significant than that of the oil-gland.

In my last communication to this Society* I gave reasons to show that the presence or absence of the ambiens muscle was a very significant fact in the classification of birds generally. This would lead me to lay considerable stress on the same point in any order or suborder in which it is found to vary.

Assuming then, as in my last paper, for reasons there stated, that the ancestral Pigeon possessed the ambiens muscle, and, on the same grounds, that it had cæca coli and an oil-gland, it is evident that the Pteroclidæ, together with *Columba*, *Turtur*, *Macropygia*, and *Ectopistes* have departed least from the ancestral type. The Pteroclidæ have branched off in another direction, as will be subsequently shown; and therefore *Columba*, *Turtur*, *Ectopistes*, and *Macropygia* (together with those undissected genera unmistakably allied to them) may be considered to be the least modified, and therefore most typical of the Columbæ.

From these, if the peculiarities of the ambiens muscle have the importance which I assign them, a branch sprang, in which the ambiens was undeveloped. This includes at the present day *Starnœnas*, *Phlogœnas*, *Geopelia*, *Ptilopus*, *Treron*, and *Goura*, most of which possess 14 rectrices, and are confined to the Malay archipelago. This Treronine division, as it may be termed, seems to be preserved in its primitive form in *Phlogœnas*, in which no further structures are lost. *Starnœnas*, which, notwithstanding its peculiar distribution, must be considered as a member of it, loses the oil-gland, and *Geopelia*, as well as *Ptilopus*, the cæca, whilst *Treron* and *Goura* are deficient in both.

The main stem seems to have shortly given off a second branch, in which the cæca coli were alone wanting. This Phapine branch is now represented, without further complication, by *Calœnas*, *Carpophaga*, *Chalcopelia*, *Chalcophaps*, *Chamæpelia*, *Leptoptila*, *Leucosarcia*, *Metriopelia*, *Ocyphaps*, *Phaps*, *Tympanistria*, and *Zenaida;* whilst from it has sprung *Didunculus*, without any oil-gland and with its quaint beak and remarkably long intestinal canal, which would indicate that its diet was usually one of fish, or more probably mollusca.†

Page 254. Respecting *Lopholæmus*, it may be mentioned that the only opportunity I have had of dissecting it has been through the kindness of Mr. Edward Gerrard, who lent me two specimens, not well preserved, in spirit.‡ In these I could not find the least trace of the accessory

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* "Proceedings of the Zoological Society," 1874, p. 111. (*Suprà*, p. 208.)

† It is through the kindness of Prof. Newton that I have had the opportunity of dissecting a specimen of this rare bird.

‡ An additional specimen has come into my hands since the above was written, by which the accuracy of my previous dissections of the species is confirmed. No

femoro-caudal muscle, which is well developed in all other Pigeons. This peculiarity, when taken in connection with the fact that, like *Carpophaga* only amongst the Phapinæ, it possesses a gall-bladder, makes me disposed to make it an independent minor branch from the Carpophagine stem.

Most ornithologists seem to be very unwilling to place the Pteroclidæ along with the true Pigeons in a single group, notwithstanding the evidence brought forward by Nitzsch, and the statement of M. Blanchard. My own observations tend to show that the two families are most intimately related, and that they must be most certainly included in the same suborder, though forming two quite independent families.

Commencing with the osteological evidence on this point, which has been very fully discussed by Mr. Parker and Prof. Huxley, the skull presents strong Columbine features. The pterygoid bones are peculiarly curved, in a manner seen nowhere else but among the Pigeons; and as in them, and not in the Fowls, the basipterygoid facets are situated midway between their two extremities. The nasal bones are, no doubt, peculiar; they are not at all typically schizorhinal, but present the extreme degree of modification of that type, probably the result of the shortness and breadth of the beak. There is, however, a nasal turbinal bone, partly occluding the osseous external nares, as in the Pigeons, whilst the premaxillary process of the nasal bone is also of considerable length. The palatine bones are perfectly Columbine in some species (e.g. *Pterocles arenarius*), and are not much modified in others, never so much so as are those of *Didunculus*. In the lower jaw there is no produced and upturned angle, like that in the Gallinæ. The cranial articular end of the quadrate bone is also strongly bifurcate. The whole skull seems to be that of a Pigeon modified by the effects of a Grouse-like life.

The furcula has no median symphysial plate or hypocleidium. The sternum is perfectly Columbine, the similarity extending to the direction taken by the costal processes and the non-development of any true manubrial rostrum, in both which points the Gallinæ are so different.

The head of the humerus presents an important character. From any number of birds' humeri those of the Columbæ may be identified, if those of the Psittaci are excluded, because the pectoral lamina or the ridge for the insertion of the great pectoral muscle is peculiar. In most birds the second pectoral muscle is inserted into the proximal Page 255.

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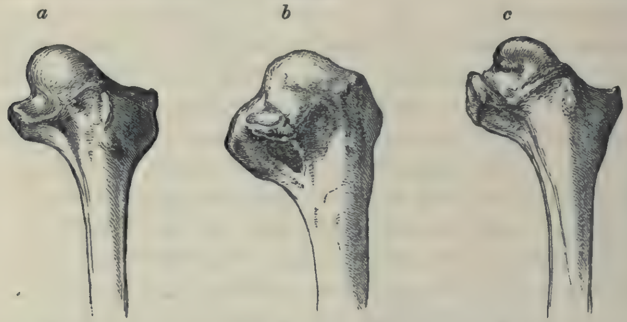
accessory femoro-caudal was present; there were no cæca coli; there was a large elongated gall-bladder and a small oil-gland. The gizzard was remarkably small, with irregular pads, one of which somewhat resembled that of *Ptilopus*.

end of this ridge, or into a prolongation of it. In the Columbæ, Psittaci, and Alcidæ this is not the case; for in them it has quite an independent place of insertion into the general surface of the head of the bone at some distance from the pectoral ridge. An oval roughness indicates the spot. It is at the angle formed by the pectoral ridge and the main part of the bone in the Gallinæ, but nearer the other side of the bone in the Columbæ. A glance at the bone itself or the accompanying drawing of it (fig. 1) will explain the point more than any amount of description. It will also be found that the pectoral ridge in the Columbæ and some of the Psittaci ends proximally in a point, peculiar to them. The Pteroclidæ agree exactly with the Pigeons in all these points, and differ widely from all the Gallinæ.

Fig. 1.



Heads of right humerus of:—*a. Pterocles arenarius; b. Gallus bankiva; c. Columba livia.*

In all important features the pelvis of the Pteroclidæ differs with the Columbæ from the Gallinæ, as in having no strongly marked fossa on the inner surface of the ischium; but in the slight development of the transverse processes of some of the sacral vertebræ it is peculiar.

The general proportions of the muscles in the Pteroclidæ are perfectly Columbine. The pectoral muscles are similarly disposed, and the crop rests on the proximal surface of the great pectoral in a similar manner. In the leg the same resemblance maintains. Among muscles the ambiens, the femoro-caudal (A), the accessory femoro-caudal (B), the semitendinosus (X), and the accessory semitendinosus (Y) are all present in Columbæ and in Gallinæ, which prevents any difference in myological formula* from assisting in distinguishing them. In the obturator internus muscle a well-marked contrast

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* See "Proceedings of the Zoological Society," 1874, p. 111. (*Suprà*, p. 208.)

between the Pigeons and Fowls is observed, which also shows that *Pterocles* is one of the former. In *Columba* and the whole suborder this muscle is small, narrow, and elliptical; but in *Gallus* and all its allies it is triangular and very large at its base. The similar number of carotid arteries in the Columbidæ, Pteroclidæ, and Gallinæ prevents any inference being drawn from them; and the same may be said of the œsophageal crop. Page 256.

In the cæca of the intestine in the Pteroclidæ there is, no doubt, a strong likeness to the Gallinæ; for whilst, as above shown, they are very short or absent in the Columbæ, they are voluminous and long in the Sand-Grouse and Fowls, being in the former between 4 and 5 inches from end to end. As in all the Gallinæ and some Columbæ (*Carpophaga* and *Ptilopus*), the Pteroclidæ possess a gall-bladder.

The following Table gives the length of the intestine, from the gizzard to the cloaca, in the species named. The most peculiar point to be noticed is its excessive length in *Didunculus*:—

Name of bird.	Length of intestine.	
	ft.	in.
*Carpophaga sp. inc.**	1	10
—— *ænea*	1	6
Chalcopelia chalcospilos	1	6
Chalcophaps chrysochlora	1	8½
Columba maculosa	2	8
Didunculus strigirostris	7	0
Ectopistes migratorius	2	6
Geopelia cuneata	0	8½
—— *humilis*	1	6
—— *placida*	1	1
—— *striata*	0	11½
Goura coronata	5	1
—— *victoriæ*	4	0
Lopholæmus antarcticus	1	4½
Macropygia phasianella	2	8
Metriopelia melanoptera	2	0
Ocyphaps lophotes	2	3
Phaps chalcoptera	2	6
Pterocles alchata	1	6
—— *arenarius*	2	1
Ptilopus jambu	1	0

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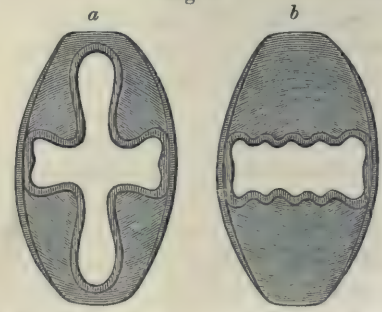
* [Called, probably by mistake, *C. aurora* in the original. Cf. Salvadori, "Monografia del Sottogenere *Globicera*," p. 16. Turin, 1878. Ed.]

Name of bird.	Length of intestine. ft.	in.
Ptilopus mariæ	0	11
—— *melanocephalus*	0	9
Starnœnas cyanocephala	2	10
Treron calva	2	4½
Turtur aldabranus	1	8
—— *chinensis*	1	6
Zenaida martinicana	1	11
Zenaidura carolinensis	2	0

In nearly all Pigeons the gizzard is well-developed after the ordinary type; in some the pad on which the food is triturated is longitudinally grooved or plicated, whilst in others it is smooth; its Page 257. ossification in the Nicobar Pigeon (*Calœnas nicobarica*) has already attracted attention.* In *Carpophaga* the stomach is very feebly muscular, not being more powerful than in strictly fruit-eating birds, such as the Hornbills. It is in the genus *Ptilopus* that a form of gizzard is developed *such as is not found in any other bird.* In *P. mariæ*, *P. melanocephalus*, and *P. jambu* it is exactly the same, being composed of four pads instead of two. A horizontal section of an ordinary gizzard presents the well-known section represented in fig. 2, *b*, it being composed of two muscular masses, which push the two pads together in a manner which I have explained elsewhere.† But in *Ptilopus* the section is much more elaborate, in a direction to which no other gizzard is known to approach; so that by the gizzard alone the genus whence it came could be determined with certainty. The accompanying figure (*a*) represents the section made exactly in

Fig. 2.



Horizontal section of the gizzard of :—*a. Ptilonopus jambu ; b. Treron calva.*

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* See Prof. Flower's observations, "Proceedings of the Zoological Society," 1860, p. 333, and Mr. Bartlett's note, *ib.* p. 99.

† "Proceedings of the Zoological Society," 1872, p. 525. (*Suprà*, p. 105.)

the same direction as in the former case; and from it the four longitudinal muscular masses, which are here seen cut across, are well displayed, leaving a cruciform cavity between them, through which the food passes whilst being triturated. This gizzard is small in proportion to the size of the bird. No approach to a like condition is to be observed in *Treron*, the section of the gizzard in that genus being quite of the ordinary form figured above.

It is generally said that the gall-bladder is absent in the Columbæ; and this is so in most of them; but besides being developed in the Pteroclidæ, it is found in all the species of *Ptilopus*, *Lopholæmus*, and *Carpophaga*. In this point also *Ptilopus* therefore differs from *Treron*.

The following Table contains the names of the different genera of the Columbæ arranged in the manner suggested above. As a classification of the suborder it is not at all my desire to put it forward as an ultimate one, but simply as the expression of the known facts of their structure. A more extended series of observations may indicate Page 258.
reasons for modifying the stress laid on some of the points; but it cannot, if my dissections are correct, change the facts themselves. As an instance of the direction in which alterations may be shown to be required, the case of the relation of *Ptilopus* and *Treron* may be taken; for, notwithstanding their general similarity in structure, these two genera present important points of difference. In the possession of a gall-bladder by the former, it resembles *Carpophaga;* and it is quite possible that the similarity of the two genera under consideration is the result of similarity in habit only, and that whilst the latter (*Treron*) sprang from the Treronine stem direct, the former (*Ptilopus*) may have descended from the Phapine stock. This appearance of the gall-bladder in these genera is very difficult to explain, except on the supposition that in those in which it is absent it has been lost very lately, or that *Carpophaga* and *Ptilopus* are very intimately related forms. The uncertainty of its appearance in closely related genera of Mammalia reduces its value as a character of classificational importance among them; but its very general absence in the Columbæ makes it almost impossible not to lay considerable stress, in classification, on its presence. In the accompanying Table *Ptilopus* is placed in the same division with *Treron* because of their similarity in the points there laid stress on; but it requires a very inconsiderable amount more evidence to necessitate its being removed from there into close proximity with *Carpophaga* and *Lopholæmus*. The fact that two forms in many respects so similar should differ so much in others is of itself a strong argument in favour of their separation; for the probability that forces which tend to produce marked external resemblances should simultaneously develop internal differences is, to say the least, extremely small.

Suborder COLUMBÆ. Schizorhinal birds with a characteristic pterylosis, humerus-head, and sternum; with the fourth gluteal muscle, which in other schizorhinal birds covers the femur-head, undeveloped; with the oil-gland nude, when present, and with the gall-bladder generally absent.

Family Columbidæ. Columbæ in which the intestinal cæca never exceed half an inch in length.

Subfamily Columbinæ. Columbidæ possessing the ambiens muscle, intestinal cæca, an oil-gland, no gall-bladder, and 12 rectrices.

Genus *Columba.*
,, *Turtur.*
,, *Macropygia.*
,, *Ectopistes.*

Subfamily Phapinæ. Columbidæ possessing the ambiens muscle and *no* intestinal cæca.

Page 259. Division *α*. The oil-gland present, no gall-bladder.

Genus *Chamæpelia.*	American.
,, *Metriopelia.*	
,, *Zenaida.*	
,, *Zenaidura.*	
,, *Calœnas.*	Old-World.
,, *Chalcopelia.*	
,, *Tympanistria.*	
,, *Ocyphaps.*	
,, *Leucosarcia.*	
,, *Phaps.*	

Division *β*. The oil-gland and gall-bladder present.
Genus *Carpophaga.*

Division *γ*. The accessory femoro-caudal muscle absent (it being present in all other Columbæ); the oil-gland and gall-bladder present.
Genus *Lopholæmus.*

Division *δ*. The oil-gland and gall-bladder absent.
Genus *Didunculus.*

Subfamily Treroninæ. Columbidæ wanting the ambiens muscle.

Division *α*. With intestinal cæca and an oil-gland; no gall-bladder.

Genus *Phlogœnas.*

Division β. With intestinal cæca, no gall-bladder, and no oil-gland.
Genus *Starnœnas.*

Division γ. With an oil-gland, no gall-bladder, and no intestinal cæca.
Genus *Geopelia.*

Division δ. With no intestinal cæca, no oil-gland (or a very small one), and scutellated tarsi.
Genus *Treron.*
,, *Ptilopus.*

Division ϵ. With no intestinal cæca, no oil-gland, no gall-bladder, and tarsi reticulate.
Genus *Goura.*

Family PTEROCLIDÆ. Columbæ in which the intestinal cæca considerably exceed half an inch in length.

Subfamily PTEROCLINÆ. Pteroclidæ possessing the ambiens muscle, a gall-bladder, and an oil-gland.
Genus *Pterocles.*
,, *Syrrhaptes.*

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36. NOTES ON TWO PIGEONS, *IANTHŒNAS LEUCOLÆMA* AND *ERYTHRŒNAS PULCHERRIMA.*[*]

SINCE my communication to the Society "On some Points in the Anatomy of the *Columbæ*,"[*] specimens of two species of this group have died in the Gardens, which deserve a passing note. Page 367.

Ianthœnas leucolæma.—The genus to which this bird belongs has been, by different authors, placed sometimes in the Columbine and at others in the Carpophagine section of the family—the number of the rectrices (12, and not 14) having made its position uncertain, as its general appearance tends to that of the Fruit-eaters.

From the paper above referred to, the definition of the Columbinæ, containing the genus *Columba*, may be thus stated:— Page 368.

COLUMBINÆ. Columbidæ possessing an ambiens muscle, intestinal cæca, an oil-gland, 12 rectrices, and no gall-bladder.

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[*] "Proceedings of the Zoological Society," 1875, pp. 367, 8. Read, May 4, 1875.

[†] "Proceedings of the Zoological Society," 1874, p. 249 *et seqq.*

Whereas *Carpophaga* possesses the ambiens muscle, an oil-gland, a gall-bladder, and no intestinal cæca.

In *Ianthœnas leucolœma* the ambiens muscle and the oil-gland are present, as are the intestinal cæca.* The gall-bladder is absent. This bird must therefore, together with *Columba*, *Turtur*, *Macropygia*, and *Ectopistes*, be placed in the Columbine and not in the Carpophagine division. The intestines are 47 inches in length, of average diameter; and the gizzard is typical in structure, having simple plicated pads.

Erythrœnas pulcherrima.—This species is truly Ptilopine in all its characters. As in *Ptilopus*, the ambiens muscle is wanting, as are the cæca to the intestine. The gall-bladder is present; and the oil-gland is very small. The gizzard presents the peculiarities of that genus, although the four pads are not so regularly constructed, minor plications existing. There are 14 rectrices; and the intestines (which are capacious, as in all fruit-eating birds) are 16 inches in length.

37. ON THE "SHOWING-OFF" OF THE AUSTRALIAN BUSTARD (*EUPODOTIS AUSTRALIS*).†

Page 471. WHETHER the account of the production of great distention of the neck in the male Australian Bustard which follows will in any way simplify the question of the presence or absence of a gular pouch in Bustards generally, is doubtful. At all events it will rectify an accepted error, and add a fresh fact to the considerable literature of the subject.

In the "Proceedings" of this Society for 1868 (p. 471 *et seq.*), Dr. Murie pictures the sexual "show off" in a specimen of *Eupodotis australis* which was presented to the Society in April 1866, by the Acclimatization Society of Sydney, and infers, from its appearance, that, as an undoubted fact, the gular pouch is present in this specimen of the species at least.

In 1873, during one of the months in which it was "showing off," namely in May, I examined the mouth of this identical bird while

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* These are extremely slender, and require special precautions to be taken for their demonstration.

† "Proceedings of the Zoological Society," 1874, pp. 471-3. Read, June 16, 1874.

Page 472.

alive, and could find no trace of a sublingual orifice, and, what is more, felt and saw a median frænum linguæ quite distinctly. This made me doubt the correctness of Dr. Murie's inference, that, because the neck of *Eupodotis australis* becomes distended much during the sexual season, *therefore* there is a gular pouch.

This individual bird, which formed the subject of Dr. Murie's plate (" Proceedings of the Zoological Society," 1868, pl. xxxvi.), died on May 11, 1874, having shown off in its wonted manner during the few preceding weeks. An excellent opportunity was thus afforded for the decision of the question whether or not this specimen had a gular pouch.

Fig. 1.

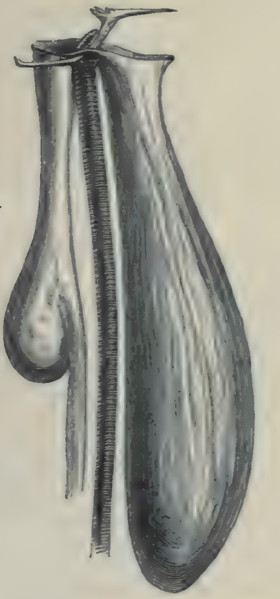

Fig. 2.

Fig. 1. The œsophagus, trachea, and gular pouch of a specimen of *Otis tarda*, seen from the side. The crop is here drawn as in the actual preparation, projecting backwards, and not forwards as usual.

Fig. 2. The œsophagus and trachea of the specimen of *Eupodotis australis* here described. The œsophagus is much dilated, and, like that of the Pouter Pigeon, can be distended with air by the living bird. No trace of a pouch or crop is to be seen.

There was no gular pouch. There was no sublingual orifice. The frænum linguæ was well developed, it being necessarily quite absent in the adult male of *Otis tarda*. How unsafe therefore is it to infer that, because the neck distends and depends during the " show-off," there must be a sublingual pouch. It is quite possible that two effects, Page 473. very similar in appearance, in closely allied birds, may be the result of different mechanisms. In the feet of the *Cuculidæ* and the *Picidæ* the scansorial arrangement of the toes is the result of entirely different dispositions of the tendons which move them; and in *Otis tarda* and *Eupodotis australis* the same reasoning holds.

In both these birds there is, during the show-off, a distention with air of a well differentiated bag, which is in both cases lined with a true mucous membrane. But in *Otis tarda* this sac is a special structure in front of the windpipe, opening under the tongue; whilst in *Eupodotis australis* (in the specimen under consideration at least), it is simply a highly dilated œsophagus.

Through the kindness of Lord Lilford I am in the possession of an excellent Spanish specimen of the gular pouch of *Otis tarda* (see fig. 1, p. 243), with the whole of the œsophagus, the tongue, and part of the trachea attached. In it the gular pouch, opening sublingually, is capacious, and, when distended, egg-shaped with no constriction in any part. The œsophagus is uniformly cylindrical for its upper two thirds, and not at all enlarged. Lower down there is a well-developed globular crop.

In the specimen of *Eupodotis australis* which died on May 11, as previously mentioned, there is no trace of a gular pouch. The œsophagus is enormously dilated from its commencement (see fig. 2, p. 243), and gives no indication whatever of any division into tube and crop. Its greatest circumference, when fairly inflated, is 14 inches, and the length of the distended portion of the tube is $17\frac{1}{2}$ inches. Before dissection, by filling its cavity with air, the lower portion of the dilated œsophagus protruded downwards considerably in front of the *symphysis furculæ*, and formed the depending portion of the sac which was so conspicuous in the living animal. The trachea descended *in front* of this sac; and when the latter was undistended, the former, on account of the diminished distance between the points it had to reach, was zigzagged from side to side in the part opposite the pendant portion. The keeper, J. Church, tells me that, when handling the sac in the living bird, he always felt a hard cord running down in front of it, which was evidently the windpipe. The dilated œsophagus was, as might have been expected, covered with two coats of muscular tissue, the outer longitudinal—and the inner transverse. The mucous lining presented no peculiarities. The skin in front of the neck was lax, with a considerable amount of coarse fat in its deeper layer; it was engorged with blood, tortuous vessels running through it in all directions.

I may mention as an anatomical peculiarity of interest that *Eupodotis australis* and *E. denhami* possess but one carotid artery, the *right*

—a condition I have not seen in any other bird; *Otis tarda* and *O. macqueeni* have *two*, and *Tetrax campestris* the *left* only. Most probably the presence of a right carotid only is characteristic of the genus *Eupodotis*.

38. FURTHER NOTE ON THE MECHANISM OF THE "SHOW-OFF" IN BUSTARDS.*

It is the uncertainty with which my material comes to hand which Page 673. must be my excuse for having so soon to present a further note on the "show-off" in the Bustards.

A young male specimen of the Great Bustard (*Otis tarda*) has recently died in the Society's Gardens; and one or two observations which I was able to make on its gular arrangements have done much to clear up, in my mind, the difficulties connected with that somewhat involved subject. My previous communication on this point ("Proceedings of the Zoological Society," 1874, p. 471)† contains a drawing of the œsophagus, trachea, and gular pouch of a Spanish specimen of *Otis tarda*, kindly given me by Lord Lilford. In the description appended to the woodcut it is remarked that the crop is peculiar, in that it springs from the posterior instead of the anterior wall of the œsophagus; and I may mention that it is further peculiar in not being quite median, as would have been expected.

I do not know the age of the young male bird above referred to, which I have recently examined. It seemed of nearly full size, had been in the possession of the Society between three and four months, Page 674. had never shown off, and had no lateral tuft of feathers from the sides of the lower jaw.

In it the œsophagus was uniformly cylindrical, with no trace of a crop, and there was no gular pouch. On looking under the tongue, however, it was evident that the arrangement of the sublingual structures was quite peculiar. In the male of *Eupodotis australis*, as I have previously remarked,‡ the frænum linguæ is well developed in the normal manner as a median vertical fold; and, what is more, it is situated as far forward as in most animals, not behind the level of the

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* "Proceedings of the Zoological Society," 1874, pp. 673, 4. Read, Dec. 1, 1874.

† (*Suprà*, p. 242.)

‡ "Proceedings of the Zoological Society," 1874, p. 472. (*Opp.*)

basihyal apparatus. In the young and pouchless male of *Otis tarda* the condition is very different. In it the frænum linguæ does not exist as such, but as two slight lateral vertical folds, with a median interval between them, a quarter of an inch across; so that the pouchless sublingual region of the young male *Otis tarda* is very like the excellent drawing of that of the pouched adult male in Dr. Murie's paper on the bird ("Proceedings of the Zoological Society," 1869, p. 141), except that what is there represented as an aperture to a pouch must be considered for the time being as only a slight depression. The tongue is also free for a considerably further distance along its under surface than in *Eupodotis australis.*

In a specimen of the head of *Otis tarda* in the Museum of the College of Surgeons* the frænum linguæ is median and normal in all respects. The sex is not mentioned; but from the fact of its differing so much from that of my young male specimen, I cannot help inferring that it is that of a female. If such is the case, until more examples are obtainable, the certainty as to the correctness of my surmise is not absolute.

The two sublingual fræna, with a membrane between them, make it seem almost certain to me that in the adolescent male bird, and not in the female, there is every opportunity for the development of a pouch, and that the habit of inflating the air-passages during the sexual season distends the membrane between the fræna linguæ, it being comparatively weak, and causes it to develop into a pouch from continued stretching. In favour of the here assumed existence of considerable pressure is the existence of the abnormally situated diverticulum in the specimen figured in my previous paper on the subject; for, from the absence of any trace of a crop in the young bird, it may be inferred that such an organ does not pertain to the species; therefore it must be the result of some superadded force, brought into action in the adult, the distention of the pharynx during the "show-off" being quite sufficient to account for it.

The specimen figured in my earlier communication and that described in the present may all be seen in the Museum of the College of Surgeons.

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* No. 772 Q.

39. ON SOME POINTS IN THE ANATOMY OF THE PARROTS WHICH BEAR ON THE CLASSIFICATION OF THE SUBORDER.*

(Plates VI & VII.)

In a former communication†, a review of certain of the most variable Page 586. characters found amongst the *Columbæ* enabled me to give hints with regard to the mutual relationships of the different genera of that considerable family, which I hope will be found of service. On the present occasion it is my desire to follow out a similar method, taking the *Psittaci*, a suborder quite as, and perhaps even more, difficult to arrange by external features only.

The unequalled collection of living Parrots in the Society's Gardens, Page 587. and the liberality of friends, have placed at my disposal specimens of the large number of 82 species, in all of which I have been able to note the characters laid stress on in this paper. To save repetition a list is here given of the species examined by me; and on all future occasions when a genus only is mentioned, it refers to those species of it which are contained in this list.

Names of Species examined.

Agapornis roseicapilla.
Aprosmictus erythropterus.
—— *scapulatus.*
Ara ambigua.
—— *ararauna.*
—— *macao.*
—— *maracana.*
Bolborhynchus monachus.
Brotogerys tiriacula.
—— *tovi.*
—— *pyrrhopterus.*
—— *virescens.*
Cacatua cristata.
—— *galerita.*
—— *leadbeateri.*
—— *sulphurea.*
Caïca melanocephala.
Calopsitta novæ-hollandiæ.
Calyptorhynchus banksii.
Chrysotis agilis.
—— *collaria.*
—— *festiva.*
—— *levaillantii.*
—— *ochrocephala.*
Conurus æruginosus.
—— *aureus.*
—— *aztec.*
—— *hæmatorrhous.*
—— *holochlorus.*
—— *jendaya.*
—— *monachus.*
—— *nanday.*

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[*] "Proceedings of the Zoological Society," 1874, pp. 586–98. Pls. LXX and LXXI.

[†] "Proceedings of the Zoological Society," 1874, p. 249. (*Suprà*, p. 229.)

Conurus pavua.
—— *petzii.*
—— *xantholæmus.*
Coracopsis barklyi.
Cyanorhamphus auriceps.
—— *novæ-zealandiæ.*
Eclectus polychlorus.
Eolophus roseicapillus.
Eos cardinalis.
—— *indica.*
—— *riciniata.*
Euphema aurantia.
—— *bourkii.*
—— *pulchella.*
—— *splendida.*
Geopsittacus occidentalis.
Lathamus discolor.
Licmetis pastinator.
Loriculus asiaticus.
—— *chrysonotus.*
—— *galgulus.*
Lorius lori.
—— *tricolor.*
Melopsittacus undulatus.
Nestor meridionalis.
Nestor notabilis.
Palæornis alexandri.
—— *erythrogenys.*
—— *longicauda.*
—— *torquata.*
Pionus menstruus.
—— *sordidus.*
Platycercus eximius.
—— *pallidiceps.*
—— *zonarius.*
Pæocephalus fuscicapillus.
—— *senegalensis.*
Prioniturus, sp.
Psephotus hæmatogaster.
—— *pulcherrimus.*
Psittacus erithacus.
Psittacula passerina.
Psittinus malaccensis.
Pyrrhulopsis splendens.
Pyrrhura leucotis.
—— *vittata.*
Stringops habroptilus.
Tanygnathus muelleri.
Trichoglossus concinnus.
—— *novæ-hollandiæ.*

Page 588. The points to which my attention has been directed, on account of the variations observed, are :—

1. The arrangement of the carotid arteries;
2. The presence or absence of the ambiens muscle;
3. The presence or absence of the furcula;
4. The presence or absence of the oil-gland;

and others of minor importance, such as the complete encirclement of the orbit by bone, and the peculiarities of the atlas vertebra. These will be considered separately.

I. *The arrangement of the carotid arteries among the Parrots.*

In my paper on the carotid arteries of birds, the peculiarities of these vessels in the Parrots are described, it being shown that three different arrangements of these vessels obtain, and perhaps a fourth. Either the two carotids may run normally, independent, and side by side up the front of the neck, in the hypapophysial canal; or the right, as usual, traverses that canal, whilst the left runs superficially along the side of the neck in company with the left pneumogastric nerve and the jugular vein; or the left carotid may alone be developed, as in the Passeres and many other birds. It has been stated that Meckel found a fourth arrangement in *Cacatua sulphurea;* but in a specimen of that species recently dissected by me, the left only was present, as in *C. cristata*, *C. leadbeateri*, and *C. galerita*.

To make this paper complete in itself, and to incorporate those dissections performed since the other was published, a list of all the Parrots which I have examined, together with the condition observed in them is given.

1. The two carotids are present, running normally, side by side, in

Agapornis,
Aprosmictus,
Calopsitta,
Calyptorhynchus,
Eclectus,
Eolophus,
Eos,
Euphema,
Geopsittacus,
Licmetis,
Loriculus,
Lorius,
Melopsittacus,
Palæornis,
Prioniturus,
Psittinus,
Stringops,
Tanygnathus,
Trichoglossus.

2. The left carotid only is present in

Cacatua.

3. The two carotids are present, the right having its normal course, the left running superficially along with the left pneumogastric nerve in

Ara,
Bolborhynchus,
Brotogerys,
Caïca,
Chrysotis,
Conurus,
Coracopsis,
Cyanorhamphus,
Lathamus,
Nestor,
Pionus,
Platycercus,
Pœocephalus,
Psephotus,
Psittacus,
Psittacula,
Pyrrhulopsis,
Pyrrhura.

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It may be observed that the only other well-defined groups of birds in which the carotids vary are the Cypselidæ, Gallinæ, Struthiones, and Otidæ.

II. *The presence or absence of the ambiens muscle.*

The ambiens muscle, the tendon of which crosses the front of the knee-capsule obliquely from above downwards and outwards, and ultimately forms part of the flexor perforans digitorum, is present in the following genera—

Ara,
Bolborhynchus,
Caïca,
Conurus,
Nestor,
Pæocephalus,
Psittacus,
Stringops.

It is absent in

Agapornis,
Aprosmictus,
Brotogerys,
Cacatua,
Calopsitta,
Calyptorhynchus,
Chrysotis,
Coracopsis,
Cyanorhamphus,
Eclectus,
Eolophus,
Eos,
Euphema,
Geopsittacus,
Lathamus,
Licmetis,
Loriculus,
Lorius,
Melopsittacus,
Palæornis,
Pionus,
Platycercus,
Prioniturus,
Psephotus,
Psittacula,
Psittinus,
Pyrrhulopsis,
Pyrrhura,
Tanygnathus,
Trichoglossus.

The only other well-defined groups of birds in which the ambiens muscle is known to vary are the Columbæ and the Struthiones.

III. *The presence or absence of the furcula.*

By this expression is meant the presence or absence of the furcula as a complete bone; for in those Parrots in which it is said to be absent, the scapular ends of the two parts of which it is composed are frequently to be found, being of considerable length in *Stringops* and some of its allies.

The furcula is complete in

Aprosmictus,
Ara,
Bolborhynchus,
Brotogerys,
Cacatua,
Caïca,
Page 590. *Calopsitta,*
Calyptorhynchus,
Chrysotis,
Conurus,
Coracopsis,
Eclectus,
Eolophus,
Eos,
Lathamus,
Licmetis,
Loriculus,
Lorius,
Nestor,
Palæornis,

Pionus,
Pœocephalus,
Prioniturus,
Psittacus,
Psittinus,
Pyrrhulopsis,
Pyrrhura,
Tanygnathus,
Trichoglossus.

The furcula is but partially developed or absent in

Agapornis,
Cyanorhamphus,
Euphema,
Geopsittacus,
Melopsittacus,
Platycercus,
Psephotus,
Psittacula,
Stringops.

Dr. Finsch, in his monograph on the Parrots*, has given a list of those species in which the condition of the furcula has been recorded, which is very complete, embracing most of the above genera.

IV. *The presence or absence of the oil-gland.*

When present the oil-gland is always tufted in the Parrots. Nitzsch, in his work on pterylosis†, has recorded its absence in some of the genera.

It is present in the following genera:—

Agapornis,
Aprosmictus,
Ara,
Bolborhynchus,
Caïca,
Calopsitta,
Calyptorhynchus,
Conurus,
Coracopsis,
Cyanorhamphus,
Eclectus,
Eolophus,
Eos,
Euphema,
Geopsittacus,
Lathamus,
Licmetis,
Loriculus,
Lorius,
Melopsittacus,
Nestor,
Palæornis,
Platycercus,
Pœocephalus,
Prioniturus,
Psephotus,
Psittacula,
Psittacus,
Psittinus,
Pyrrhulopsis,
Pyrrhura,
Stringops,
Tanygnathus,
Trichoglossus.

It is absent in

Brotogerys, *Chrysotis,* *Pionus.*

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* "Die Papageien," Bd. i. p. 197.

† "Pterylography," English edition, p. 98 *et seq.*

Page 591. In *Cacatua galerita* and *C. leadbeateri* it is present; but it is generally wanting in *C. cristata*, and has not been found in *C. sulphurea.*

The above facts may be tabulated in a form which makes their significance more readily apparent, by placing those together in which a similar arrangement is observable. Thus there are:—

1. Parrots in which there are two normally situated carotids, no ambiens muscle, a furcula, and an oil-gland—namely

Aprosmictus,
Calopsitta,
Calyptorhynchus,
Eclectus,
Eolophus,
Eos,
Licmetis,
Loriculus,
Lorius,
Palæornis,
Prioniturus,
Psittinus,
Tanygnathus,
Trichoglossus.

2. Parrots in which there are two normally situated carotids, no ambiens muscle, no furcula, and an oil-gland—namely

Agapornis,
Euphema,
Geopsittacus,
Melopsittacus.

3. Parrots with a left carotid only, no ambiens muscle, a furcula, and generally an oil-gland—namely

Cacatua.

4. Parrots with two carotids (the left being superficial), an ambiens muscle, a furcula, and an oil-gland—namely

Ara,
Bolborhynchus,
Caïca,
Conurus,
Nestor,
Pœocephalus,
Psittacus.

5. Parrots with two carotids (the left being superficial), no ambiens muscle, a furcula, and an oil-gland—namely

Coracopsis,
Lathamus,
Pyrrhulopsis,
Pyrrhura.

6. Parrots with two carotids (the left being superficial), no ambiens muscle, a furcula, and no oil-gland—namely

Brotogerys,
Chrysotis,
Pionus.

7. Parrots with two carotids (the left being superficial), no ambiens muscle, no furcula, and an oil-gland—namely

Cyanorhamphus,
Platycercus,
Psephotus,
Psittacula.

The true significance of these facts next requires attention; and the principle upon which all attempts at the formation of a satisfactory genealogy or classification of the suborder can be arrived at must be born in mind throughout. It is the following:—An anatomical character is so much the more or less certain to have been an element of the original type or ancestor whence sprang the class, order, family, or genus under consideration as it is more or less frequently found in the less intimately related minor divisions of the groups under observation. An example will make this more clear:—Two large arteries (the carotids), one on each side, run up to supply the head in most Pulmonate Vertebrata, as far as I know. In all Mammalia such is certainly the case. In many Birds there are, similarly, two carotids, though some have only one. It is therefore more than probable that the ancestral bird had two carotids, those in which one is absent having lost it subsequently. Many Parrots have two carotids; the genus *Cacatua* is characterised by the left only being present: it, therefore, has in this respect departed most from the ancestral type. Again, other Vertebrata and other Birds with both carotid arteries present have them symmetrically placed; many Parrots have symmetrical carotids; but in some the left (and the left only) is abnormal in being superficial: therefore, from the same considerations, these last have differentiated off from the parent stem, and, what is more, this peculiarity can hardly have occurred on more than one occasion, as it is otherwise unique and therefore peculiar and exceptional in origin. **Page 592.**

There is another principle to be remembered, which is that there is no such thing as reversion to lost ancestral anatomical characters. The genus *Cacatua* has lost its right carotid, as have the whole family of the Passeres and many others. There is not a tittle of evidence in favour of the assumption that they or their descendants could ever regain that vessel. Its arrested development is a positive act, the result of extra forces coming into play in early embryonic life, to remove which would require the introduction of a certain definite series of counterbalancing forces superadded to those already in action; whilst in the ancestral bird, the persistence of the two arteries resulted from the absence of any impediment to their development. The probability that the ancestral form should be reverted to cannot be greater than that an entirely new arrangement should be effected. That some domestic excentric varieties should tend in some cases to revert to the wild type can have no more bearing on the general subject than the similar tendency to exaggeration which is not apparent in the feral forms.

Upon these principles many deductions can be made as to the mutual relations of the several genera of the Psittacine suborder. For instance, it must be inferred that the ancestral Parrot possessed two carotids, running symmetrically in front of the neck, and that the ambiens muscle was present, as was the furcula and the tufted oil-gland. The intestinal cæca and gall-bladder must have been absent or lost very early, as must the postacetabular portion of the tensor fasciæ muscle;* for they are none of them to be found in any existing species; whilst the beak, tongue, crop, and rectrices must have possessed the characteristic features, which are not found to vary to Page 593. any important extent. The pterylosis of the suborder forms a considerable but much involved field for work, which has only been entered upon by the illustrious Nitzsch.

Referring back to the characterising features of the existing species whose internal structure has been noted, it will be seen that none has as yet been found with a conformation exactly similar to that of the above-described ancestral bird; in other words, no existing Parrot has been seen with two normal carotids, an ambiens muscle, a furcula, and an oil-gland. By more than a single way, however, this condition, with only one exceptional character, is found to exist. For instance, the fourth combination above given, in which the ambiens, furcula, and oil-gland are present at the same time that the carotids are abnormal (the left being superficial), agrees with the type except in one point—the disposition of the carotid arteries. Again, in the first of the combinations the only deviation from the type consists in the absence of the ambiens muscle.

These two different directions of variation must therefore have formed the secondary stems from which the more specialized genera subsequently sprang. In other words, the main stem must have given rise to two, in one of which the carotids remained normal, whilst in the other the left became superficial. The following are the genera as they will thus appear:—

Genera in which the left carotid has remained normal.	Genera in which the left carotid has become superficial.
(PALÆORNITHIDÆ.)	(PSITTACIDÆ.)
Agapornis.	*Ara.*
Aprosmictus.	*Bolborhynchus.*
Cacatua.	*Brotogerys.*
Calopsitta.	*Caïca.*
Calyptorhynchus.	*Chrysotis.*
Eclectus.	*Conurus.*
Eolophus.	*Coracopsis.*
Eos.	*Cyanorhamphus.*
Euphema.	*Lathamus.*

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* *Vide* "Proceedings of the Zoological Society," 1873, p. 628. (*Suprà*, p. 189.)

Genera in which the left carotid has remained normal.	Genera in which the left carotid has become superficial.
(Palæornithidæ)	(Psittacidæ.)
Geopsittacus.	*Nestor.*
Loriculus.	*Pionus.*
Lorius.	*Platycercus.*
Melopsittacus.	*Pœocephalus.*
Palæornis.	*Psephotus.*
Prioniturus.	*Psittacus.*
Psittinus.	*Psittacula.*
Stringops.	*Pyrrhulopsis.*
Tanygnathus.	*Pyrrhura.*
Trichoglossus.	

Each of these secondary types must have then become a centre for variation in itself. From the 4th combination, in which only the carotids are peculiar, sprang the 5th, 6th, and 7th, with the ambiens deficient, just in the same way that the 1st, 2nd, and 3rd combinations originated from the ancestral form by the same process of reduction. The loss of the furcula and of the oil-gland (though never, as it Page 594. happens, both together) have further aided in the formation of tertiary and further subdivisions, which, upon the dissections above given, would lead to the arrangement of the family which is depicted in Plate LXX [6.].

This may be represented in the tabular form as follows:—

Suborder (or Cohort) PSITTACI.

Family I. Palæornithidæ. (Left carotid normal.)

The ambiens muscle absent. Carotids two, except in the genus *Cacatua.*

Subfamily (1) Palæornithinæ. No further deviation.

Palæornis.
Eclectus.
Aprosmictus.
Tanygnathus.
Prioniturus.
Psittinus.
Loriculus.
Trichoglossus.
Lorius.
Eos.

Subfamily (2) Cacatuinæ. Orbital ring completely ossified, and characteristic in that it develops a process bridging the temporal fossa (*vide* Plate LXXI [7.]).

Calopsitta.
Calyptorhynchus.
{ *Licmetis.*
{ *Eolophus.*
{ *Cacatua.*

Subfamily (3) STRINGOPINÆ. The furcula lost.*
Stringops.
{ *Euphema.*
{ *Geopsittacus.*
{ *Melopsittacus.*
Agapornis.

Family II. PSITTACIDÆ. (Left carotid superficial.)

Division 1. The ambiens muscle present.

Subfamily (4) ARINÆ. No further deviation.
{ *Ara.*
{ *Conurus.*
{ *Bolborhynchus.*
{ *Caïca.*
Psittacus.
Pœocephalus.
Nestor.

Page 595. Division 2. The ambiens muscle wanting.

Subfamily (5) PYRRHURINÆ. No further deviation.
Pyrrhura.
Lathamus.
Coracopsis.
Pyrrhulopsis.

Subfamily (6) PLATYCERCINÆ. Furcula lost.
{ *Platycercus.*
{ *Psephotus.*
{ *Cyanorhamphus.*
Psittacula.

Subfamily (7) CHRYSOTINÆ. Oil-gland lost.
{ *Chrysotis.*
{ *Pionus.*
Brotogerys.

In phyllogenetic language this arrangement would be expressed thus:—The original stem, in which the carotids were normally dis-

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* See the special remarks on this group in the postscript to this paper.

posed, gave off a branch characterised by their abnormal arrangement. The continuation of the main stem, as well as the branch, shortly lost the ambiens muscle—the latter (and not the former), however, being represented at the present day in its unmodified form by the Arinæ. Each of the two secondary branches persists as the Palæornithinæ and the Pyrrhurinæ respectively, they both branching dichotomously in an exactly similar manner, the former giving rise to the Stringopinæ and the specially modified *Cacatua cristata* and *C. sulphurea*, the other to the similarly modified Platycercinæ and Chrysotinæ.

A method of formulation will assist in making this more readily intelligible. If the presence of two carotids, normally disposed, is represented by the figure 2, the abnormal arrangement may be represented by 2. Then, if the presence or absence of the varying structures be represented by + or –, the following table will express the characteristics of the different subfamilies :—

	Carotids.	Ambiens.	Furcula.	Oil-gland.
Palæornithinæ	2	–	+	+
Cacatuinæ	2	–	+	+
	L	–	+	–
Stringopinæ	2	–	–	+
Arinæ	2	+	+	+
Pyrrhurinæ	2	–	+	+
Platycercinæ.......	2	–	–	+
Chrysotinæ........	2	–	+	–
Type form	2	+	+	+

The Palæornithinæ will thus be represented by the formula 2, –, +, + ; the Arinæ by 2, +, +, + ; and so on. Plate [7] LXXI. will represent these facts in a more self-evident manner.

Through the kindness of Prof. Flower and also from the death of the specimen presented by Mr. Murdoch to the Society, I have twice had the opportunity of dissecting *Stringops habroptilus*. As a Parrot it is not so strikingly peculiar as many seem to think. Its wings are useless, and the carina sterni is correspondingly reduced, it is true ; but as points of classificational importance, I regard these as insignificant. The points of special anatomical interest which it does possess, however, are particularly instructive. The proximal ends of the incomplete furcula are well developed, so much so that it might at first sight seem that their symphysial ends are only lost in correlation with the excessive reduction of the powers of flight; though this is probably not the case, because the allied similarly modified genera *Euphema* &c. do not keep to the ground. Page 596.

Further, in the Society's specimen above mentioned, though the ambiens muscle did not cross the knee, yet its fleshy belly was well differentiated on both sides, its thin tendon being lost over the capsule of the joint. In the College of Surgeons' specimen, however, this muscle was entirely absent in the only knee which was in a fit state for dissection, the other being much shot. It is only in the genus *Œdicnemus* that I have elsewhere found a similar partial loss of the ambiens.* The partial development of this muscle in this particular instance shows that the tendency to lose it is not of great antiquity; and it is to be noted that there is no other Parrot with normal carotids in which any trace of an ambiens is to be found. These considerations suggest, what may perhaps be the case, as is suggested by the peculiarities of their geographical distribution, that *Agapornis* may be the representative among the normal-carotid Parrots of the Platycercine branch from the Arinæ, whilst the Stringopinæ proper (including *Geopsittacus*, *Melopsittacus*, and *Euphema*) are more direct continuations of the main stem, as indicated by the dotted portions of the diagrams (Plates [6] LXX. and [7] LXXI.), *Stringops* itself being the nearest living representative of the common ancestor of the whole suborder.

Further, it may be worth while taking a glance at some of the most important changes which my classification would necessitate. Taking Mr. Sclater's "Revised List of Vertebrated Animals in the Society's Gardens" as a good representative of current opinion, the Order PSITTACI is there divided into two families and seven subfamilies, thus:—

Order PSITTACI.
  Family I. STRINGOPIDÆ.
  Family II. PSITTACIDÆ.
    Subfamily 1. CACATUINÆ.
    ,, 2. ARINÆ.
    ,, 3. PLATYCERCINÆ.
    ,, 4. PSITTACINÆ.
    ,, 5. LORIINÆ.
    ,, 6. NESTORINÆ.

Page 597. As far as the major division is concerned, the facts brought forward in the present communication suggest a different arrangement, as shown above, which would approximately distribute these subfamilies thus:—

Family I.	Family II.
Stringopidæ.	*Arinæ.*
Loriinæ.	*Platycercinæ* (in part).

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* *Vide* "Proceedings of the Zoological Society," 1873, p. 640. (*Suprà*, p. 202.)

Family I.	**Family II.**
Cacatuinæ.	*Psittacinæ* (in part).
Platycercinæ (in part).	*Nestorinæ.*
Psittacinæ (in part).	

The generally received families Platycercinæ and Psittacinæ are avowedly rather incongruous mixtures. Mr. Gould, with acute perception, was able to differentiate *Aprosmictus* from *Platycercus*, chiefly by its habits of life; and anatomical considerations show that Dr. Finsch's attempt to reabsorb it in the older genus is a retrograde step. If Dr. Meyer is right in stating that the sexes in *Eclectus* are of different colours, its relations to *Aprosmictus* may be very intimate.

It may at first sight seem very heretical to remove *Lathamus* from the Loriinæ, the brush-tongue being considered characteristic of that subfamily. To the unbiased student, however, the brush-tongue is a character not more important than several of those that have been above considered. It is only an excessive development of the papillæ which are always present on the lingual surface, and is seen in a slightly different form in the Lion and other Felidæ. The character of the papillæ is somewhat different in *Lathamus* from what it is in *Lorius*, they being blunter and shorter in the former genus than in the latter.

The totally different geographical distribution of *Palæornis* and the true Arinæ is quite opposed to Dr. Finsch's proposition that *Conurus* and *Brotogerys* should be the neighbours of the Palæogæan genus.

Brotogerys entirely agrees in structure with *Chrysotis* and *Pionus*, differing greatly from *Conurus;* whilst in itself *Conurus*, as generally received, embodies the red-tailed species, with the fourth primary not acuminate, and the green-tailed species, with an accuminate fourth primary. In the former section (*Pyrrhura*) the ambiens muscle is quite lost, whilst in the latter (*Conurus*) it is always well developed.

Prof. Huxley is not the only naturalist who has been puzzled by the geographical distribution of *Psittacula*. This genus in its wide sense, however, is broken up into far separated genera—the Old-World *Psittinus* and *Agapornis* differing entirely from the New-World *Psittacula*, *Agapornis* being the homologue, as it may be termed, in the normal-carotid Parrots of *Psittacula* in the other group, whilst *Psittinus* is a less differentiated genus of the former division.

Nestor no doubt stands rather isolated; but possessing the ambiens muscle, as well as all the other characters of *Psittacus* and the true Arinæ, it must be classed with them.

My subfamily Pyrrhurinæ seems a mixture; and all I can say in its favour is that the combination of anatomical characters is exactly the same in all its genera, which have a very scattered distribution. Page 598.

It will be noticed that no Parrots with normal carotids occur in the New World: and, as far as I know, none but members of that group have red beaks.

P.S. (December 8th, 1874).—On the 25th of last month, from the death of one of the specimens of *Stringops habroptilus*, recently purchased by the Society, I have had an opportunity of dissecting a third individual of the species. In it the ambiens muscle is complete, of fair size, at the same time that it crosses the knee as in *Psittacus*. This makes me feel more convinced that the arrangement indicated by the dotted portions of the diagram plates accompanying this communication is the correct one, and that the main stem has given rise to three instead of two branches—the Stringopinæ being the nearest representatives of the ancestral form, some of its members (*Geopsittacus*, *Melopsittacus*, *Euphema*, and *Cyanorhamphus*) having quite recently lost, whilst *Stringops* itself is just now on the point of losing the ambiens muscle. It is, however, quite possible, if external resemblances and geographical distribution are left out of consideration, that *Stringops* must stand as the sole representative of the Stringopinæ, thus conforming with generally received ideas; and that *Geopsittacus*, together with *Melopsittacus*, *Euphema*, and *Cyanorhamphus*, must be placed with *Agapornis* as part of the family Agapornithinæ, in which the formula is 2, —, —, +. The close external resemblance between *Stringops* and *Geopsittacus* nevertheless makes me indisposed to adopt this view.

40. NOTES ON THE ANATOMY OF CERTAIN PARROTS.*

SINCE the publication of my paper "On some points in the Anatomy of the Parrots," in the "Proceedings" of the Society (1874, p. 586), I have had the opportunity of dissecting several species, some of which, from their peculiarities, deserve special note. They are the following:— Page 691.

1. *Dasyptilus pecqueti.* It is through the great kindness of Dr. A. B. Meyer that I have had the advantage of being able to dissect this extremely rare bird. Dr. Meyer obtained the specimen in New Guinea, and has preserved it in spirit, entire. He has most liberally allowed me to determine those anatomical points to which I have drawn attention in the paper above referred to.

There are two carotid arteries; the left, however, runs superficially as in the Psittacidæ (as defined by me). The oil-gland is large, subglobose and possesses a well-developed tuft of shortish feathers around its orifices. The rectrices are twelve in number.

In its myology and osteology it agrees with the Pyrrhurinæ in entirely wanting the ambiens muscle, and in having a furcula, which bone is not large or powerful, nor so slender as in the Lories.

The orbital ring is incomplete, the eye not being encircled by bone. The femoro-caudal muscle is large; and the semitendinosus with its accessory head are well developed,—in which arrangements it agrees with all the Psittaci.

The intestines are 17¼ inches long, there being no trace of cæca. The liver-lobes are somewhat unequal in size, the left being the smaller. The stomach is small and much like that in the Fruit-eating Parrots generally. The proventriculus forms a dilated sac, of which the walls, instead of being, as is usually the case, thick and glandular, are strikingly thin, at the same time that no glands are visible.

Dr. Meyer has already† given a short description of the peculiarities of the tongue, and, in writing to me, tells me that he has further observations to make on the same.

As in nearly all birds, the main artery of the thigh is the sciatic, whilst the vein is the femoral. Page 692.

There is a fenestra near the posterior margin of the sternum, on each side.

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[*] "Proceedings of the Zoological Society," 1876, pp. 691–2. Read, June 20, 1876.

[†] "Mittheil. aus dem k. zoologischen Museum zu Dresden," 1875, p. 14.

2. *Deroptyus accipitrinus.* A Brazilian specimen of this rather peculiar genus from the Society's collection has the two carotids arranged as in *Dasyptilus*, the left being superficial. The furcula is of fair size, the orbital ring incomplete, the oil-gland well tufted, the ambiens muscle absent.

3. *Polyteles barrabandi* possesses two carotids, normally situated—in other words, side by side in the hypapophysial canal. The furcula is small and slender. The oil-gland is decidedly large, and well tufted. There is no ambiens muscle. The intestines measured 40 inches.

4. *Chalcopsitta scintillata* has the two carotids normally situated, a small furcula, a small tuft to the large oil-gland, and no ambiens muscle. The intestines measured 37 inches.

5. *Coriphilus fringillaceus* has the two carotids normal, the furcula small and slender, no ambiens muscle, and a well-tufted oil-gland. This specimen was kindly given me by Canon Tristram, carbolized and dry.

Of genera which have already passed through my hands I have had the following additional species:—

Ara militaris.
Cacatua moluccensis.
—— *philippinarum.*
Eclectus grandis.
Eos reticulata.
Licmetis tenuirostris.
Lorius domicella.
Pæocephalus meyeri.
Tanygnathus albirostris.

They all agree with those species previously dissected, except *Licmetis tenuirostris*, which has only one carotid, the left, whereas *L. pastinator* has two. It will be interesting to verify this difference between the South-Australian species and its more western ally; for the uncertainty of the disposition of these vessels in the Cacatuinæ is rendered more striking if it is correct.

In the specimen dissected, of *Cacatua philippinarum*, a gall-bladder was present. This is the only case in which I have seen this viscus in any Parrot.

Formulating the varying characters of the above newly dissected genera upon the principle adopted in my earlier paper and there explained, the formulæ run thus:—

(1) *Dasyptilus* 2.—.+.+.
(2) *Deroptyus* 2.—.+.+.
(3) *Polyteles* 2.—.+.+.
(4) *Chalcopsitta* 2.—.+.+.
(5) *Coriphilus* 2.—.+.+.

Such being the case, *Dasyptilus* and *Deroptyus* fall into my subfamily Pyrrhurinæ, whilst the other three must be placed with the Palæornithinæ. It is interesting to notice that *Deroptyus* agrees with *Pyrrhura*, and not with *Conurus*.

41. NOTE ON THE ABSENCE OR PRESENCE OF A GALL-BLADDER IN THE FAMILY OF THE PARROTS.*

In a former communication† I had the opportunity of showing that the generalization, founded upon the dissection of an insufficient number of genera, that the gall-bladder is wanting in the Columbæ, does not apply to *Carpophaga*, *Lopholæmus*, or *Ptilopus*. On the present occasion I have to correct a similar error with reference to the Psittaci, because I have found a well-developed gall-bladder in specimens of *Cacatua philippinarum*, *Cacatua goffini*, *Cacatua moluccensis*, and *Calopsitta novæ-hollandiæ*, in which last-named species it is small and easily overlooked. Page 793.

In my earlier dissections I have not recorded the presence of a gall-bladder in any species of Parrot. That, no doubt, is because, it being absent in so many, I did not expect to find it.

From the above facts it is highly probable that the presence of a gall-bladder in the Cacatuinæ will have to be included among the characteristic peculiarities of this subfamily. At the same time its persistence in them is in favour of the view that the Palæornithinæ, as restricted by me,‡ are but little different from the ancestral Parrots, and the Cacatuinæ still less so. The primitive Parrots must have possessed a gall-bladder—because we know that this organ is present in the Cacatuinæ, and consequently was not absent in the primitive species, as the probability that it should have been independently developed a second time is infinitely little.

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* "Proceedings of the Zoological Society," 1877, p. 793. Read, Nov. 20, 1877.

† "Proceedings of the Zoological Society," p. 257. (*Suprà*, p. 239.)

‡ "Proceedings of the Zoological Society," p. 594. (*Suprà*, p. 255.)

42. ON THE KANGAROO CALLED *HALMATURUS LUCTUOSUS* BY D'ALBERTIS, AND ITS AFFINITIES.*

(Plates VIII–X.)

Page 48. DURING the time that H.M.S. "Basilisk" was cruising in the region of the south-east of New Guinea one of the sailors acquired a specimen of a small Kangaroo, which Signor L. M. D'Albertis, C.M.Z.S., obtained from him at Sydney. In a letter addressed to Mr. Sclater, dated Sydney, N.S.W., December 1, 1873, Signor D'Albertis described this specimen, under the name of *Halmaturus luctuosus*, as follows†:—"Length from the nose to the occiput 4½ inches; length of the ears 1¾ inch; length of the thigh 5¾ inches; length of the tarsus, including the nail, 4¾ inches; length of the tail 11½ inches. Total length, from the nose to the tip of the tail, 2 feet 5 inches. Its weight is 7½ pounds.

"The fur is short, its general colour dark ashy brown with a silvery tinge, white at the roots; chin, throat, and chest white, with two horizontal ashy stripes under the pouch; on the top of the head a silvery whitish spot; the thighs more grey; feet dark, almost black; the arm white inside; the hand black. The tail moderately strong, of a similar colour to the body, but white and bare of hairs for about an inch at the extremity. The lips are barely covered with fur; the eyelids are puffed, almost naked, and provided with eyelashes so fine as not to be readily seen at first sight."

Hab. "S.E. of New Guinea."

On April 17, 1874, this Kangaroo was deposited by Signor D'Albertis in the Society's Gardens; and at the Meeting for Scientific Business on May 5th following, Mr. Sclater, in reporting on the additions to the Society's Menagerie,‡ exhibited a drawing of it, and referred to it as the "typical example of *Halmaturus luctuosus* of D'Albertis." It is this specimen, a female, which forms the subject of the present communication. It died, Nov. 24, 1874, with congested lungs, after a severe frost, the first of the commencing winter.

An examination of the dead body, and especially of the mouth, which it was impossible to observe in the living animal, made it

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* "Proceedings of the Zoological Society," 1875, pp. 48–59. Pls. VII–IX. Read, Feb. 2, 1875.

† "Proceedings of the Zoological Society," 1874, p. 110.

‡ "Proceedings of the Zoological Society," 1874, p. 247, Pl. XLII.

evident that the species could not be rightly included in the genus *Macropus* or *Halmaturus*. Further comparison made it clear that it was intimately related to the genus *Dendrolagus*, and also to the species described in Waterhouse's "Mammalia"[*] as *Macropus brunii*. Page 49.

Mr. Waterhouse bases his description of this last-named species on a skin so labelled in the British Museum, and on Müller's account of the same animal in his elaborate work,[†] in the letterpress of which it is termed *Dorcopsis brunii*. The priority of the generic name being undisputed, any fresh species which can be shown to be generically related to the above-determined species is evidently a species of the genus *Dorcopsis*.

This last remark is called for because the subject is rendered somewhat involved by an oversight of the illustrious Müller. In his description of his *Dorcopsis brunii* he evidently has no doubt that the specimen or specimens he is considering, is or are identical with the "Philander" described by Bruyn[‡] as having been seen by him in the garden of the Governor of Batavia, upon which the name *brunii* was originally based. Prof. Schlegel,[§] however, has most convincingly shown the unjustifiableness of this assumption, and has proved beyond a doubt that the species to which the name Philander can alone be applied is that found only in the islands of Aru and the Ké group, whilst the species which forms the subject of Müller's memoir is a denizen of New Guinea itself. Prof. Schlegel therefore retains the name *Macropus brunii* for the Philander of Aru, and of the New-Guinea animal forms the new species *Macropus muelleri*. As to me it is evident that *M. muelleri* is generically distinct from *Macropus* in its widest sense, and from all its minor divisions, it is also evident that *Dorcopsis muelleri* must be the name applied to the *Dorcopsis brunii* of Müller. The species which forms the subject of the present communication, belonging (as I hope to prove) to the same genus as *Dorcopsis muelleri* (Schlegel), must therefore stand as *Dorcopsis luctuosa* (D'Albertis).

The material at my disposal is the following:—the skin and skeleton of the type specimen of *Dorcopsis luctuosa;* the skins of an adult male and female, as well as of a young male, of *Dorcopsis muelleri* in the British Museum, collected by Mr. Wallace; a skull from the skin of the above-mentioned female of *Dorcopsis muelleri;* the much-discoloured skin of the male of the same species in the British Museum, from New Guinea, described by Mr. Waterhouse[||] as *Macro-*

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[*] Vol i. "Marsupiata," p. 180.

[†] "Zoogdieren van den Indischen Archipel," pt. 4, Pl. XXI.

[‡] "Reizen over Moskovie," p. 374, Pl. 213 (1713).

[§] "Nederlandsch Tijdschrift voor de Dierkunde," 1866, p. 350 *et seq.*

[||] "Mammalia," vol. i., p. 180.

pus brunii; two skeletons of *Dendrolagus inustus*, one in the British Museum and the other in the Museum of the College of Surgeons; as well as a pair of skins and an imperfect skull of *Macropus brunii* from Aru, kindly lent me by Mr. Edward Gerrard.

So far as I know, the visceral anatomy of *Dorcopsis muelleri* has not been described. That of *Dendrolagus inustus* is fully given by Prof. Owen in the "Proceedings" of the Society;[*] and some of the actual specimens on which this description is based are preserved in the Museum of the College of Surgeons. The internal anatomy of *Macropus brunii* is not known.

Page 50. The following Table gives the most important measurements of the skin of the female *Dorcopsis luctuosa*, compared with specimens of the same sex of *Dorcopsis muelleri* and *Macropus brunii*:—

Lengths, &c.	*Dorcopsis luctuosa* ♀.	*Dorcopsis muelleri* ♀.	*Macropus brunii* ♀.
	in.	in.	in.
From tip of nose to base of tail.............	24	20·25	21·0
Tail....................................	13·25	15·4	11·75
From tip of nose to occiput................	5·0	5·0	4·0
Fore limb...............................	5·75	6·75	4·75
Hind limb	10·75	12·55	10·5
From heel to end of nail of fourth toe........	4·75	4·75	5·0
Length of ear...........................	1·4	1·25	1·75
Circumference of base of tail	4·25	..	2·0
From knee to knee over the back............	14·0	..	17·0

The general contour of the body is quite Macropine; the breadth at the hips, however, is somewhat small. The hair is soft, short, and of a nearly uniform length all over the skin.

The head is elongate and conical, the muffle naked, the eyes large and antilopine. The colour of the upper surface and sides of the head[†] and back is uniformly blackish with a silvery gloss, each hair being whitish at its base for two fifths of its length, black for the next two fifths, and white at the tip. On the ventral surface a broad longitudinal white band extends from the line joining the angles of the mouth, backwards along the neck and belly as far as the pouch, behind and from the sides of which it continues towards the tail of a true slate-colour as far as the cloacal orifice, between which spot and

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[*] "Proceedings of the Zoological Society," 1852, p. 103 *et seq.*

[†] The silvery white spot on the top of the head, mentioned in D'Albertis' description, is not produced by the presence of white hair, but results from the fact that the spot where it is *sometimes* seen is the anterior junction of the forward-directed hair of the neck with the backward-directed hair of the frontal region. Its existence depends entirely on the way in which the hair is brushed; and it is not visible except after the natural disposition has been disturbed.

the base of the tail it is again white. This white band occupies the whole of the region between the angles of the jaw, and continues down the neck over the abdomen of a slightly greater width. It only encroaches on the sides of the body by sending an expansion into each axilla, which is visible laterally just behind the elbow. There is no lateral transverse white stripe across the front of the thigh, like that so strongly marked in *M. brunii;* and, unlike this last named species, the light grey, nearly white stripe above and parallel to the lip is very insignificant, and does not extend backwards under the eye.

The ear is rounded, black inside and out, with a slight white line formed by the similarly coloured roots of the there exposed hairs bounding the auditory meatus anteriorly.

The non-exposed surfaces of both the arm proper and the thigh are of a pale grey. The other parts of both the fore and hind limbs are black. The nails of both the fore and hind limbs are short and Macropine.

The peculiarity in the direction of the hair of the neck, which Page 51. elsewhere occurs only in *Dorcopsis muelleri*, *Dendrolagus ursinus*, and *Dendrolagus inustus*, is as strongly marked as in those species—all the hair covering the space bounded in front by a line running transversely across the parietal region, and behind by two lines joining in the middle line between the shoulders to form a right angle seven inches behind the occiput, and extending forward and outward to the shoulder-joint, being directed forward, whilst the general body-covering of hair is directed normally backwards.

The lips are nearly naked, as is the skin covering the subsymphysial portion of the mandible, just behind which are four large and conspicuous glandular hair-follicles in the middle line, arranged in pairs to form a square (Plate [9] VIII.). A collection of glands of a similar nature is found on the upper eyelid, situated a little nearer the inner than the outer canthus. These are shown in Müller's drawing of *Dorcopsis muelleri.*[*] A few long hairs are to be found on the sides of the upper lip.

The eyelids are somewhat puffed, almost naked, with the eyelashes scarcely apparent.

The tail is peculiar in being of considerable diameter to near its extremity, and in being uniformly thickly covered, for all but its termination, with soft, not very short, black hair. The *skin* of the distal end of the tail is *black*, except for its terminal $1\frac{1}{2}$ inch, where it is nearly white. On the upper part of this white portion there are a few white hairs; elsewhere it is naked and scaly. The scales are also distinctly seen extending forward for a short space over the

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[*] *Loc. cit.* Pl. XXII.

inferior surface of the black skin, from the absence of hair in that part. The characteristic manner in which the animal employs its tail as a method of support (well shown in "Proceedings of the Zoological Society," 1874, pl. xlii.), might have almost been predicted from the above-described distribution of the hair; for it is evident that only a part at the extreme end could have habitually come into contact with the ground.

The only brown hair on the body is that in the pouch, which is rufous. There are four mammæ.

There is not the least difficulty in distinguishing *Dorcopsis luctuosa* from *D. muelleri*. The general colour of the head, back, and tail in the specimens of the latter species from Mysol, above referred to, is a mouse-chocolate, which becomes duller over the thighs, and of a pale grey on the outside of the fore limb. In *D. muelleri* the general white of the abdominal surface expands slightly opposite the orifice of the pouch, just above the knees; it, however, does not develop into a band over the flank as in *Macropus brunii:* the white of the throat also extends on to the angle of the jaw, and continues forward to join the dim white stripe along the upper lip; and there is a second insignificant white line under each eye, also (as mentioned by Prof. Schlegel) not nearly so marked as in *M. brunii.* In the male of *D. muelleri* the white tip to the tail is as much as three inches in length.

The skull of *Dorcopsis luctuosa* (Plate [8] VII.) very closely
Page 52. resembles that of *D. muelleri*, the following being the two most important measurements in adult specimens of the same sex (female) :—

	D. luctuosa. in.	*D. muelleri.* in.
Length of skull.................	4·1	4·55
Greatest breadth, from zygoma to zygoma	2·2	2·05

In some minor details there are slight differences. In *D. muelleri*, as in most species of *Macropus*, the premaxillary region is bent downwards in such a way that the line formed by the trenchant edges of the molar teeth, if projected onwards to the nose, is quite above the incisor teeth. In *D. luctuosa* this bending downwards of the snout is not so marked, as will be seen by comparing the side view of the skull (Plate [8] VII. fig. 3) and the similar one of *D. muelleri* in Prof. Müller's elaborate work above referred to.

The palatine foramina, one large one on each side, together with several much smaller ones behind each, in *D. muelleri* end behind the transverse palato-maxillary sutures, whilst in *D. luctuosa* their anterior margins are formed by the palatine plates of the maxillary bones, into which they encroach a short distance. In *D. luctuosa* the upper of the lacrymal foramina in each lacrymal bone has an ossific ridge behind it, which causes it to be completely exserted, or situated on the face outside the orbit; whilst in *D. muelleri* the absence of this bony ridge causes it to be situated in a recess on the margin of the orbit. In *D. luctuosa* the apex of the angular process which is developed downwards from the inferior margin of the maxillary portion of the zygoma, is opposite the anterior cusp of the third molar tooth, whilst in *D. muelleri* it corresponds to the posterior cusp of the second molar.

With regard to the teeth themselves, the canines in *D. muelleri* are quite the size of or even slightly larger than the most lateral incisor; in *D. luctuosa*, however, they are much smaller, being nothing more than slightly curved dentine cylinders about $\frac{1}{35}$ of an inch in diameter, as in the subgenus *Lagorchestes*, and directed downwards and forwards. In both the species the third incisor has an inflection on its labial surface, as in all the species of *Macropus:* in *D. muelleri* this fold is a little in front of the middle of the tooth; and in *D. luctuosa* it is decidedly nearer the posterior border. In the last-named species there is a similar distinct inflection on the second incisor; in *D. muelleri* this is not apparent. In *D. muelleri* the inferior incisor is directed more immediately forward than in *D. luctuosa*, in which it turns slightly upwards; this peculiarity is correlated with the difference in the obliquity of the premaxillary region (*vide* Plate [10] IX.).

In the enormous premolars there is a slight difference—those of *D. muelleri* being a little the larger, in the upper jaw having a breadth of 0·55 inch against 0·475 inch for the same teeth in *D. luctuosa*. In *D. muelleri* the bony septum between the two fangs of each premolar, especially of the lower jaw, is particularly conspicuous in the undisturbed **Page 53.** tooth, even projecting slightly beyond the osseous alveolar margin. In *D. luctuosa* this septum is scarcely visible.

The most important characters of the skull of *Dorcopsis*, as a genus, which distinguishes it from *Dendrolagus*, are the following:—In *Dendrolagus* the head is proportionally much shorter, the effect of which on the lower jaw is that, as the dental series is not correspondingly reduced, the ramus and the body of each lateral moiety meet at a right instead of an obtuse angle; there are no palatine foramina; the zygoma is considerably deeper; the exoccipital processes are longer, though not much so; the lower incisors are considerably broader, at the same time that the upper lateral incisors are larger and more cylindrical, with superficial grooves which can scarcely be termed inflections; the premolars are not so broad, and their outer posterior tubercles are more distinctly developed.

The molar teeth of *Dorcopsis* and *Dendrolagus* are almost identical (*vide* Plate [10] IX.).

The cranial characters which distinguish *Dorcopsis*, as a genus, from *Macropus*, are not very significant. Looking at the base of the skull the arrangement of the teeth deserves attention. In *Dorcopsis* the premolar with the molars on both sides form straight lines, which are exactly parallel one to the other; whilst in *Macropus* the molar-premolar series form slight curves, convex outwards, converging behind as well as in front.

In *Dorcopsis* the zygomata are not so powerful or deep from above downwards, as in the similar-sized species of *Macropus*. A peculiarity also presents itself in the lateral occipital region, the exoccipitals descending considerably below the free extremities of the paramastoids in *Macropus*, whilst in *Dorcopsis* they reach downwards scarcely any further distance.

Respecting the teeth, *Dorcopsis* differs from *Macropus* in the much diminished size of the superior lateral incisors. The central incisors are not so broad, but nearly as long. The second incisor is very much smaller; and though presenting a slight inflection in *D. luctuosa*, as mentioned above, this inflection is not, as in *Macropus*, posterior and internal, at the line of contact with the anterior margin of its more lateral neighbour. The third incisor is also very much smaller. The inflection on its labial or outer surface presents the same differences in the two species of *Dorcopsis* that are found in the various species of *Macropus*: in *D. luctuosa*, as in *M. brunii* and *M. thetidis*, it is very near its posterior border; whilst in *D. muelleri*, as in *M. major* and most of the other species, it is far forward.

The inferior incisors in *Dorcopsis* are proportionally narrower than in *Macropus*, in which peculiarity *Dendrolagus* resembles the latter genus: they, however, wear down in a similar manner, namely at the anterior end of the supero-lateral margin, differently from that in the Hypsiprymniform Macropodidæ, in which they wear in a rodent-like fashion.

The presence of the superior canines in *Dorcopsis* distinguishes it
Page 54. from most of the species of *Macropus*, although they are almost as well developed in the subgenus *Lagorchestes* as in *D. luctuosa*, and in that one only.

The premolars of *Dorcopsis* are particularly interesting, presenting characteristic features which are more suggestive of its affinities than any other skeletal point. As to those in the upper jaw, their breadth from before backwards is very nearly or quite as great as that of the first and second molar, together with the anterior of the two cusps of the third. The crown of the tooth on each side is prismatic in shape, with one of the angles forming the cutting-edge, the opposite side the base. A tubercle on the inner surface of the posterior end of the tooth disturbs the uniformity of the prismatic shape; it is continued forward along the margin of the lingual surface as a feebly developed ridge or cingulum. Opposite it on the labial surface, a small tubercle is also to be found, larger in *Dendrolagus*, with a similar, slighter cingular expansion.

From the thus somewhat swollen neck or cingulum several ridges with intervening depressions run at right angles, to end at the trenchant edge. These ridges differ considerably from those observed in the corresponding tooth of the genus *Bettongia*, in other points than their degree of obliquity: they are less numerous, and therefore further apart, because the tooth is considerably broader; and they are continued as what look like tumefactions of their basal ends, into both the inner and outer cingulum. It may be here mentioned that the premolars of *Hypsiprymnus* proper (*H. murinus*, *H. gilberti*, and *H. platyops*) agree much more closely with *Dorcopsis* and *Dendrolagus* in the characters in which those genera differ from *Bettongia*.

The mandibular premolars are much like those in the maxilla. They are not so broad, equalling only the two succeeding molars. They present a tumefaction or cingulum at the base of the crown; but the posterior internal and external tubercles are not developed.

In *Macropus* there is never anything like the size of the premolars of *Dorcopsis* or *Dendrolagus*, although there is a considerable range of difference in different sections of the genus, which in *Macropus* proper appears to me to be correlated with the length of ear rather than with any other character. In *M. major* their size and permanency is but slight; and in most of the long-eared species they are not so broad as the first true molar. In *M. billardieri* and *M. brunii* they attain their maximum size proportionally; and they are nearly as large in the subgenera *Petrogale* and *Lagorchestes*. In *M. billardieri* and *M. brunii* they are almost exact miniatures of those in *Dorcopsis*, except that the number of perpendicular ridges is fewer.

Respecting the molars of *Dorcopsis* and *Dendrolagus*, they may be termed macropodiform, because, though much resembling those of the type genus, they present special characters. The two transverse prismatic ridges, with the small connecting bridge between them, are present, although the last-named structure is less conspicuous and narrower. The anterior minor ridge is also to be seen; it is, however, Page 55. much smaller and narrower than in *Macropus;* as in that genus, it is more marked in the mandibular than in the maxillary molars. The peculiar twist in the molar-premolar series of the lower jaw (the anterior teeth turning outwards and the posterior inwards), by which the trenchant edges are rendered parallel, as in the upper jaw, at the same time that the rami of the mandible converge is, as might be expected from the previously mentioned greater parallelism in the maxillary series of *Dorcopsis*, more marked in that genus than in

Macropus. It may be mentioned that the molar teeth in *Dorcopsis* and *Dendrolagus* do not exhibit any characters intermediate between *Macropus* and *Hypsiprymnus.*

The remaining bones of the skeleton do not present features of special interest. The typical number of precaudal vertebræ are present, namely, C. 7, D. 13, L. 6, and S. 2; there are 19 caudal vertebræ, with well developed chevron bones between the proximal ones. The anterior arch of the atlas presents no gap, the two moieties meeting with a linear junction. The anticlinal vertebræ are the 10th, 11th, and 12th dorsal. The clavicles are fairly developed; and the first ribs are very broad. There is a supracondyloid foramen to the humerus; and the fibula is not ossified to the tibia. The following are the lengths of some of the most important long bones:—Humerus, 2·75 inches, radius 3·2, femur 5·1, tibia 6·2, fourth metatarsal 1·8, pubic symphysis 1·7.

Respecting the soft parts, the tongue has three small circumvallate papillæ at its base, arranged in the ordinary V-shaped manner. The palate presents several strongly marked transverse ridges. The submaxillary and sublingual glands are small, the former ellipsoid in shape. The parotids are large, flat, and triangular, with their bases directed towards the root of the neck, and their apices to the masseter muscle. Their position is indicated by the dotted lines in Plate [9] VIII.

The left lung is formed of a single lobe, with a slight fissure on the ventral margin, near the apex, opposite the broadest part of the heart. The right lung consists of two lobes, the main portion and the azygos lobe. The lobe proper presents two fissures—one near the apex, running vertebrally and diaphragmatically, separating an apical lobule, the other running vertebro-apically, and marking off the median lobule.* This median lobule partly embraces the base of the heart, as in many animals. There is no third bronchus.

The heart is quite Macropine, there being two superior venæ cavæ. The right ventricle also spirally wraps round the much stronger left, as in *Macropus.*

The stomach is perfectly Macropine; that is, it is elongated, sacculated, with the œsophagus entering it much nearer the cæcal than Page 56. the pyloric extremity, with the walls of the pyloric end smooth and much thickened. The cardiac cæcal extremity, like that in *Dendrolagus* as described by Prof. Owen, consists of a single *cul-de-sac*, not a bifid one like that in *Macropus giganteus.*

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* The method of description here adopted is an attempt to avoid the employment of terms, which necessitate any assumption with respect to the position of the animal. Supposing the animal to have its vertebral column horizontal, and its four limbs on the ground, then the above description might be thus read:—"The lobe proper presents two fissures—one near the apex, running upwards and backwards, the other running forwards and upwards."

In the subgenus *Petrogale* the stomach is not bifid at its cardiac extremity, in which respect it resembles *Dorcopsis*. In other respects, however, it presents considerable differences; it is more capacious opposite the œsophageal orifice, and the cardiac portion is bent on the rest nearly at right angles, which is not the case in *Macropus giganteus* and *Dorcopsis*.

The character of the mucous membrane also deserves attention.* In *Macropus giganteus*, as is well known, the squamous epithelium of the œsophagus spreads over most of the stomach also, the pyloric extremity, and one of the two cardiac cæca (which is itself bifid) being alone lined with a columnar coating. In *Petrogale* this latter is absent, the digestive mucous membrane being confined to the pyloric region. Of *Dendrolagus inustus* Prof. Owen remarks,† "the epithelium is continued from the œsophagus, for a breadth of 2 inches down the posterior surface of the stomach, and of 1½ inches down the anterior surface, and thence is continued, slightly diminished in breadth, 3 inches towards the pyloric end of the stomach, and 2½ inches towards the cardiac end. The rest of the cavity is lined with the usual gastric vascular membrane, the surface of which is diversified by patches of follicular apertures along the upper curvature of the stomach, which patches increase in breadth as they approach the true digestive portion." A very similar condition maintains in *Dorcopsis luctuosa*, the only difference being that the squamous lining covering the whole of the cardiac *cul-de-sac* is also found to spread from the œsophageal orifice along the lesser curvature for a short distance towards the pylorus. As in *Dendrolagus inustus*, two strong parallel longitudinal folds run from the œsophageal opening, in this squamous-covered mucous membrane, for some distance on the way to the pyloric compartment, gradually disappearing before they reach it.

The small intestine is 97 inches in length, with numerous oblong Peyer's patches distributed throughout its whole distance, averaging 1½ inch long, by ⅓ inch across. The cæcum and large intestine are not sacculated; the former has a length of 2½ inches, and its circumference is the same; the latter is 32 inches long, being one-third the length of the small intestine, which is the same proportion that Prof. Owen‡ observed between the same-named viscera of *Dendrolagus inustus*. The equally short cæcum in the *Hypsiprymni* differs in having two lateral longitudinal bands which scarcely sacculate it.

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* [See, for a full description of this, the paper by Messrs. E. A. Schäfer and D. J. Williams "On the Structure of the Mucous Membrane of the Stomach in the Kangaroos," which was communicated to the Zoological Society by Prof. Garrod, "Proceedings of the Zoological Society," 1876, pp. 165–177.—Ed.]

† "Proceedings of the Zoological Society," 1852, p. 105.

‡ *Loc. cit.* p. 106.

The spleen is perfectly Macropine, being narrow and elongate, with a well-developed third lobule.

The liver very closely resembles that of the different species of *Macropus*. In comparing the livers of different animals it is my habit to estimate by sight, and therefore only approximately, the bulk of the
Page 57. different lobes, and to write down the results in the form of a formula. Employing the divisions, so evidently natural, proposed by Prof. Flower, I commence by writing down the name of the largest lobe, after which the others in the order of their bulk, with symbols between each to indicate their relative size. Taking the liver-formula of *Dorcopsis luctuosa* as an example, it may be thus written,

$$\text{L.L. } 2 > \text{C. } \tfrac{1}{2} > \text{R.C. } \tfrac{1}{2} > \text{Sp.} > \text{R.L. } 2 > \text{L.C.};$$

and it reads as follows:—The left lateral lobe (L.L.) is the largest; it is twice the size of the caudate (C.), which is half as large again as the right central (R.C.), which is half as large again as the Spigelian (Sp.), which is larger (very little) than the right lateral (R.L.), which is twice the size of the left central (L.C.).

The similarly constructed formula of *Macropus melanops* is

$$\text{L.L.} = \text{C. } 2 > \text{R.C. } \tfrac{1}{2} > \text{R.L. } \tfrac{1}{2} > \text{Sp. } 3 > \text{L.C.},$$

and of *Halmaturus derbianus*

$$\text{L.L. } 1\tfrac{3}{4} > \text{C} = \text{R.C. } \tfrac{1}{2} > \text{Sp. } \tfrac{1}{2} > \text{R.L. } 2 > \text{L.C.}:$$

they show how great a similarity there is between the different members of the family Macropodidæ.

The gall-bladder is situated in the deep cystic fossa; and the umbilical fissure is not deep. The Spigelian lobe has its apex directed vertebrally and resting on the left lateral lobe, as in *Macropus;* no secondary lobules are connected with it.

There is a peculiarity in the liver of the specimen of *Dorcopsis luctuosa* under consideration, which may be individual, or it may be characteristic of the species, genus, or subfamily; at all events, I have not seen it in any other mammalian animal. Looking at the diaphragmatic surface of any multilobate liver, the lateral margins of the mass formed by the right and left central lobes are always seen to overlap, to a greater or less extent, the lateral lobes in an imbricate manner. Similarly the right lateral lobe overlaps or covers the caudate. In the livers of *Macropus* and *Halmaturus* which I have by me, this conformation is strictly maintained. But in *Dorcopsis luctuosa* the caudate lobe overlaps the right lateral lobe (instead of being situated on its abdominal surface), in such a way that the last-named lobe is only seen between the right free edge of the right central lobe and the left *free* edge of the caudate. This condition is not brought about by any *post mortem* change in the position of the lobes, because the right lateral fissure is not so deep as to separate them at their vertebral extremity.

The uterus is perfectly Macropine, as are the vaginæ. No direct communication could be found between the uterine pouch of the vaginæ and the common vaginal canal.

A gland, as usual, about the size of an almond, with a slender duct, opens on each side of the narrow cavity included between the sphincter ani and the external common sphincter.

In conclusion, the comparison of the various organs and structures of the Macropodidæ which have come before me in my study of *Dorcopsis luctuosa* would lead me to divide up the family in the following manner:— Page 58.

Family MACROPODIDÆ. Diprotodont Marsupialia wanting the hallux, the second and third digits of the pes being much reduced and included in the skin as far as the ungual phalanges, which at the same time have the claws so formed that the inner is convex inwards and the outer convex outwards, at the same time that their contiguous surfaces are flattened. The stomach is elongated and sacculated.

Subfamily MACROPODINÆ. Macropodidæ in which the œsophagus enters the stomach near the cardiac end; with a Spigelian lobe to the liver; with no lateral longitudinal bands to the colic cæcum when it is short, and with radius of normal form.

Section 1. MACROPUS. With the premolars never much larger than the first molar; with a characteristic molar-tooth-pattern; with the stomach but slightly lined with digestive epithelium (?) and with the hair on the nape of the neck directed backwards. *Hab.* Australia, Tasmania, Aru, and the Ké Islands.

Genera or subgenera. *Macropus*, *Halmaturus*, *Petrogale*, *Lagorchestes*.

Section 2. DORCOPSIS. With the premolars strikingly large, with a characteristic molar-tooth-pattern, slightly modified upon that of *Macropus;* with the stomach mostly lined with digestive epithelium, and with the hair of the nape of the neck directed forwards. *Hab.* New Guinea and Mysol.

Genus 1. *Dorcopsis.* Limbs Macropine in their proportions.

Genus 2. *Dendrolagus*, *Protemnodon**, *Sthenurus**. Fore limbs much longer than in *Macropus.*

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* An inspection of the plates in Prof. Owen's paper on these new genera ("Phil. Trans.," 1873, p. 245), makes it evident that they are scarcely distinguishable from *Dendrolagus*, and must be included in the DORCOPSIS section of the family.

Subfamily Hypsiprymninæ. Macropodidæ in which the œsophagus enters the stomach near the pyloric end; with no special Spigelian lobe to the liver; with lateral longitudinal bands to the short colic cæcum; with a much-flattened and expanded radius, with a characteristic molar-tooth-pattern, and with the incisors worn down much as in Rodent animals. *Hab.* Australia and Tasmania.

Genus *Hypsiprymnus* (including *H. murinus*, *H. gilberti*, and *H. platyops*). Auditory bulla somewhat inflated; palatine foramina, one large one on each side; ridges on premolars few and perpendicular. Face elongate.

Page 59. Genus *Bettongia* (including all the others of the group except *B. rufescens*). Auditory bulla much inflated; palatine foramina as in *Hypsiprymnus;* ridges on premolars numerous and oblique; head short.

Genus *Æpyprymnus** (including only *Bettongia rufescens* of Gould). Auditory bulla not inflated; palatine foramina absent; head short; tarsus considerably longer than in the two other genera.

It should be mentioned that the visceral anatomy of *Æpyprymnus rufescens* has not been published, and that Mr. Waterhouse divides the genus *Hypsiprymnus* into three subgenera corresponding exactly with the three genera here defined.

My best thanks are due both to Mr. Sclater and Dr. Günther for the very kind way in which both these gentlemen have assisted me in my study of this subject.

EXPLANATION OF THE PLATES.

Plate 8. (VII.)

Lateral superior and inferior views of the skull of *Dorcopsis luctuosa*, natural size.

Plate 9. (VIII.)

View of the inferior surface of the neck of *Dorcopsis luctuosa*, showing the median gland with four orifices situated in the hyoid region. The positions of the large parotid and small submaxillary glands are indicated by dotted lines.

Plate 10. (IX.)

Teeth, twice the natural size, of (figs. 1–5) *Dorcopsis luctuosa*, (figs. 6–10) *Dorcopsis mülleri*, and (figs. 11–15) *Macropus brunii*. The upper two rows represent the left upper premolar, the third and fourth rows the upper and lower third left molar, and the bottom row the incisors.

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* This term I propose for Mr. Waterhouse's first section of *Hypsiprymnus*, which he has left without any Latin name.

43. ON A POINT IN THE MECHANISM OF THE BIRD'S WING.*

THE beautiful investigations of Borelli, together with those of M. Marey, make it certain that in any organ which is employed as a flapping wing there must be a stiff or rigid anterior margin. In the insect the stout anterior nervure performs this function; in the bird the bones of the arm, forearm, and manus do the same. How, in the latter, this necessary rigidity is developed, considering the presence of the elbow- and wrist-joints, must be, at first sight, a matter of surprise. It depends on the mechanical arrangement by which, when, in the wing, the arm is bent on the forearm, the manus is always similarly bent on the forearm; and when extension of the forearm is made, extension of the manus equally certainly follows. This occurs when all the muscles and tendons are removed, and the ligaments binding the bones together are alone left. Page 82.

The explanation of this mechanism is not difficult. The arm consists of one bone only, the humerus; the forearm of two, the ulna and radius; the manus of the two carpals together with the metacarpals and phalanges. The mutual relations of these two bones are such that the radius and ulna move one above another like the two limbs of a pair of drawing-parallels, each being fixed proximally to the humerus and distally to the carpus. The plane common to the radius and ulna is the same as that in which flexion and extension of the elbow is performed, so that one of the two bones of the forearm, the radius, articulates with the humerus at a point nearer the shoulder, or further from the elbow, than its companion, the ulna. At the wrist the radius is consequently superior, articulating with the carpal bone on the pollex side: whilst the ulna articulates with the other element of the carpus. This condition maintaining the parallel movements of the radius on the ulna must necessarily be attended by a parallel movement of the humerus on the manus. When the humerus bends upon the ulna, the manus therefore similarly bends upon the forearm; and the triceps muscle is able, unassisted, to maintain the whole limb in a rigid state during extension.

In making a wooden model of these bones to illustrate the above described mechanism, one or two points of mechanical detail suggested a reference to the shape of the distal end of the humerus. The wing

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* "Proceedings of the Zoological Society," 1875, pp. 82, 3. Read, Feb. 16, 1875.

Page 83. in the living bird, when at rest, is completely folded; and when fully extended forms but a slightly angular rod. To allow of this considerable range of movement of the bones of the forearm on the humerus, and of their being completely folded up, it is necessary to attach a very projecting hinge at the portion of the model of the humerus which represents the humero-ulnar articulation, otherwise, when fully flexed, the model radius would not be able to be included between the then parallel humerus and ulna; especially as the radius, to get in its fully flexed position, must rotate on a hinge which itself projects its semidiameter at least beyond the humerus.

These requirements explain the characteristic shape of the distal end of the humerus in birds. It is curved towards its flexor side, and sharply so at its extremity where it comes in contact with the ulna. At the same time the radius articulates with it on a well-developed knob, situated above the similar surface for the ulna, and to its outer side (which allows of a less extensive joint). The similar arrangement required at the wrist-joint is arrived at by the interpolation of the carpal bones between the forearm and consolidated metacarpus.

In some wings, when all the muscles are removed, this movement is not so manifest as in others, there being a certain amount of independent power of movement in the manus in all positions. This is much reduced in the living bird by the tendon of the *tensor patagii longus* muscle, which runs from the shoulder, along the free margin of the patagium, to the wrist, where, in being attached to the metacarpal mass on the pollex side, it aids the extension of the manus during the extension of the forearm.

The mechanism above described is stated by Dr. Alix* to have been first indicated by Bergmann, as far as the anatomical arrangement is concerned, although Strauss-Dürckheim, in his 'Théologie de la Nature' was the first to explain it fully. Dr. Alix himself has also† entered into the detail of the movement "of elongation" of the radius, which is well explained in his large work above referred to.‡ My object in bringing the subject before the Society is to draw special attention to so important a point, and to illustrate its action by a wooden model, which demonstrates its accuracy in a very striking manner.

It may be here mentioned that the movement of the general plane of the wing during both the up and down stroke, which by Borelli and his followers is ascribed to the elastic yielding of the feathers in birds,

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* "Essai sur l'appareil locomoteur des Oiseaux," Paris, 1874, p. 230.

† "Bulletin de la Société Philomathique," 1864.

‡ *Loc. cit.* p. 330 *et seq.*

and of the wing-membrane in insects, appears to me rather to be dependent on the torsion of the bones or main nervure of the wing, the power of lateral flexion in which is proved by M. Marey's discovery of the figure-of-8 action in the insect. A thin wooden lath employed as a nervure to an artificial wing, if set with its narrow section vertical and fixed to a non-yielding horizontal wing, gives a vertical figure-of-8 when moved up and down, the plane changing exactly as it is described by M. Marey in the insect.

44. ON THE FORM OF THE LOWER LARYNX IN CERTAIN SPECIES OF DUCKS.*

THE present communication contains descriptions of the condition of the lower larynx in some rare members of the *Anatidæ*, which are not referred to in the works of either Mr. Eyton or Mr. Yarrell. Page 151.

1. SARCIDIORNIS MELANONOTA (Gm.): Sclater, Rev. Cat. Vert. p. 241. Page 152.

To Mr. Eyton, who established the genus to which this peculiar bird belongs, the visceral anatomy was unknown; and I am not aware of any subsequent description of it having been published. A pair were purchased by the Society on the 18th of September, 1867, the female of which died on the 10th of March, and the male on the 18th of October last year; these are the specimens which I have examined. In both sexes the diameter of the trachea diminishes slightly at its lower extremity before it again expands a little to end in the syrinx. As in birds generally, the tracheal rings are complete and notched in the middle line before and behind, in such a way that where they meet the two halves overlap and are overlapped respectively by the rings above and below them. The lower tracheal rings, however, in both sexes are much thinned in front, as is the case in the male of *Harelda glacialis*;[†] they are not ossified together.

In the male *Sarcidiornis melanonota* (fig. 1) there are 20 anterior, membrane-covered fenestræ, formed in the intervals between these thinned rings; in the female (fig. 2) there are only 12 of the same. Page 153. In the latter there is no lateral diverticulum from the syrinx; but in the former, from the left side, as usual, one is developed, entirely

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[*] "Proceedings of the Zoological Society," 1875, pp. 151–6. Read, March 2, 1875.

[†] *Vide* figs. Eyton's "Anatidæ," plate opposite p. 65; Yarrell's "Brit. Birds," vol. iii. p. 261.

osseous, irregularly compressed, and very small, not having a diameter in any part greater than that of the trachea itself (*vide* figs. 1 and 2).

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1. Lower part of trachea of *Sarcidiornis melanonota* ♂.
Fig. 2. Ditto of *Sarcidiornis melanonota* ♀.
Fig. 3. Ditto of *Rhodonessa caryophyllacea* ♀.

In the male specimen the cæca are 3 and 2¼ inches long; in the female not quite 2 inches. Their diameter is inconsiderable, not exceeding ⅙ of an inch. The whole intestinal canal measures between 4½ and 5 feet; and the gizzard is decidedly small, not being bigger than that of a common Duck (*Anas boscas*).

2. Rhodonessa caryophyllacea (Lath.).

Anas caryophyllacea, Scl. "Proceedings of the Zoological Society," 1874, p. 110.

This rare Duck is generally placed in the genus *Anas;* by Mr. Eyton, however, it is considered to belong to the *Fuligulinæ;* and that ornithologist puts it, along with *Fuligula rufina*, in the genus *Callichen*. A pair purchased by the Society on the 12th January last year, died, the female on the 11th and the male on the 15th of March, 1874. From these two specimens I was able to remove the windpipes for examination. The structure of the syrinx of the male is in favour of the Fuliguline affinities of the genus; and the trachea presents points Page 154. of superficial similarity to that of the last-described bird, *Sarcidiornis melanonota*, as will be seen by a comparison of the accompanying drawings (figs. 1–5) of the lower portion of the windpipes in the two. In the female (fig. 3) there is no lateral diverticulum, the syrinx being simple. The lower end of the trachea is hardly contracted at all. There is, however, a slight thinning of the anterior portions of some of the inferior tracheal rings, as in the female of *Sarcidiornis melanonota*, though to a less extent—a small, transverse, anterior fenestra being the result. In the *Rhodonessa* the syrinx proper is nevertheless differently constructed, the last five or six tracheal rings being consolidated together, the fenestration being situated higher up; whilst in the *Sarcidiornis* the fenestration of the unanchylosed rings continues as low down as the bronchial bifurcation (*vide* figs. 3, 4, and 5).

Fig. 4.

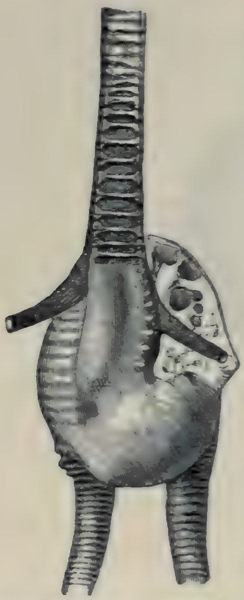


Fig. 5.

Fig. 4. Lower part of trachea of *Rhodonessa caryophyllacea* ♂ (front view).
Fig. 5. Ditto (side view).

In the male *Rhodonessa caryophyllacea* (figs. 4 and 5) the lower portion of the trachea is less capacious than a little higher up, where a slight fusiform dilatation occurs. Above the large syringeal box there are in front 15 transverse fenestræ formed between the thinned tracheal rings, as in the *Sarcidiornis* and *Harelda*. Below them the syrinx is formed by a considerable dilatation in two directions—one to

Page 155.

Fig. 6.

Trachea of *Metopiana peposaca* ♂ (front view).

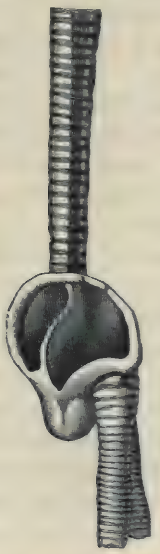
the left, which is the larger and has semimembranous walls; the other slightly to the right, inferior in position to the former. This latter is simply osseous, no fenestræ being present in it; it intrudes upon the right side as well as the left in front. The last 12 or so tracheal rings are considerably dilated and co-ossified, the two above-mentioned compartments being connected with the cavity formed by their fusion through a single left-sided orifice, the left bronchus springing from the membraniform cavity.

The cæca are not quite equal in size, being $2\frac{1}{8}$ and $1\frac{3}{4}$ inches long; the whole intestine measured 4 feet.

3. Metopiana peposaca (Vieill.): Sclater, Rev. Cat. Vert. p. 255.

Of this bird Mr. Sclater mentions* that "it has a large bulbous expansion in the windpipe." This I have found in all the male specimens which I have examined. Its distance above the bifurcation of the bronchi is best estimated from the accompanying sketch (fig. 6, p. 282) which is of the natural size. A similar tracheal dilatation is to be observed in the male of *Melanitta fusca*, that in *Clangula histrionica* being much less considerable. In a male, purchased on the 6th of July, 1870, which died on the 7th of January last, the syringeal

Fig. 7.



Lower part of trachea of *Metopiana peposaca* ♂ (side view).

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* "Proceedings of the Zoological Society," 1868, p. 146.

box (see figs. 6 and 7) is constructed on the same type as in *Fuligula rufina* and *F. ferina*, being mostly composed of membrane, with an intersecting, oblique, simple osseous bar running across near the upper margin of its outer side. There is also some dilatation of the consolidated rings which go to form the lower portion of the trachea; this is to be observed on both the right and left sides, the box being connected with the latter only. In the female no box is developed. The trachea narrows slightly above the syringeal box.

Page 156. The cæca in this specimen were 5½ and 6 inches in length, the whole intestinal canal measuring 4½ feet.

45. ON THE FORM OF THE TRACHEA IN CERTAIN SPECIES OF STORKS AND SPOONBILLS.*

Page 297. No account of the peculiarities of the windpipe in *Tantalus ibis* and in *Platalea ajaja* has yet, to the best of my knowledge, appeared in print. They cannot but interest ornithologists; I therefore append descriptions of them from specimens which have passed through my hands as Prosector to the Society.

In the Transactions of the Linnean Society† there is a paper by Mr. Joshua Brookes, F.R.S., "On the remarkable Formation of the Trachea in the Egyptian *Tantalus*." The author does not mention the sex of his specimen, and does not refer to the existence of any intrathoracic or any other loops; he draws attention only to the existence of a lateral compression of the portion of the trachea which is contained within the thorax; and he incidentally refers to the similarity of the arrangement of the windpipe in the Spoonbill and *Tantalus ibis*, but does not hint at the points in which they agree.

In most species of Ciconiidæ the only peculiarity of the windpipe is that the bronchi are longer than in other birds, the bifurcation of the trachea occurring at, or even a little above, the superior aperture of the thorax. This condition I have observed in the female *Ciconia boyciana* which died on January 15th, 1874, as well as in examples of *C. maguari* and *C. alba*. In the male of *C. nigra* the bronchi are known to be peculiarly long,‡ and to form an ∞-shaped curve enter-

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* "Proceedings of the Zoological Society," 1875, pp. 297–301. Read, April 6, 1875.

† Vol. xvi. p. 499.

‡ "Naumann's Naturgeschichte der Vögel Deutschlands," vol. ix. p. 229.

ing the lungs. No other peculiarities have been described among these birds.

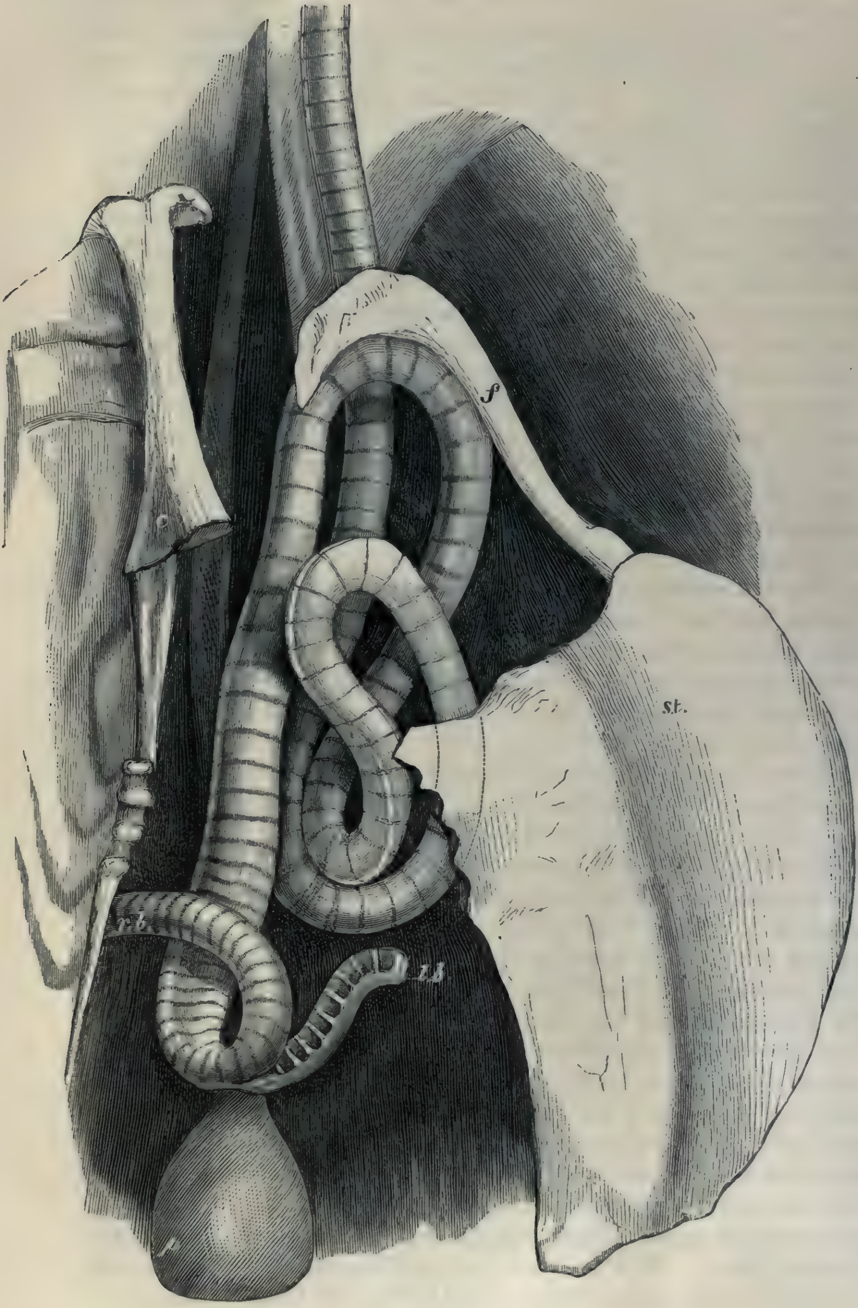
A specimen of *Tantalus ibis* was purchased by the Society on the 26th of May, 1873, which died on the 12th of March, 1875. It proved to be a male. The following is the arrangement of the convolutions of its trachea (see figure, p. 286). The windpipe descends the neck in front of the œsophagus without any peculiarities being observable, the rings which go to compose it being exactly like those of other allied birds, circular, complete, elastic, notched in the middle line before and behind, and of ordinary depth. Directly it reaches the superior aperture of the thorax, between the two rami of the furcula, a sudden change occurs. The succeeding rings are inelastic, from being ossified; and they are ossified together in pairs, so that their apparent depth is more than double that of the cervical rings, the intermediate membrane being included in the double rings. The depth of the unmodified rings is hardly more than $\frac{1}{12}$ of an inch, that of the intrathoracic modified ones being as much as $\frac{1}{4}$ of an inch. The diameter of both is about $\frac{1}{3}$ of an inch; those in the chest are further peculiar in developing a slight median longitudinal ridge along their *posterior* surface.

The two *musculi depressores tracheæ*, after running down the wind- Page 299.
pipe as long as it is in the neck, leave it together as it enters the chest to run to their insertions behind the sternal articular ends of the second complete ribs, the left one crossing in front of the upper of the two loops described below. There are no special lateral muscles running to the syrinx.

The trachea, modified in the manner above described, continues its normal course downwards as far as a horizontal plane cutting the base of the heart, when it makes a fairly gradual turn through half a circle, directly forward, to consequently ascend with the posterior keel above mentioned, running along the middle of its convex surface. On reaching the level of the symphysis furculæ it makes a second semicircular turn to the right, to again descend nearly as far as on the former occasion, and making a third similar turn to the left whilst in the fold of the first loop, ascends a third time as high as the line joining the two sides of the furcula—in other words, to the very top of the thoracic cavity. Here it turns backwards to descend again, in contact with the first part of the intrathoracic tube, to its right side, as far as the level of the apex of the heart and the commencement of the proventriculus; where, making a short very abrupt turn forwards, it bifurcates into the two bronchi, which therefore, uniquely, run from their origins upwards and outwards to their respective lungs. In this third and last descending portion of the windpipe, which has a length of 5½ inches, the lower 3 inches are

Page 298.

Fig. 1.



Intrathoracic convolutions of the trachea in *Tantalus ibis*.
c, coracoid; *f*, furcula; *p*, proventriculus; *r.b*, right bronchus; *l.b* left bronchus; *st*, sternum.

considerably flattened in what would be the lateral direction, which through the convolutions it has been called upon to make, is twisted, so that the flattening appears to be nearly antero-posterior, the median ridge, developed posteriorly, being placed considerably on the right side.

About an inch above this flexure, in which the bronchi bifurcate, the previously deep double rings suddenly cease to be developed as such, and return to their normal condition just before the peculiarly situated and simple syrinx is reached.

There are altogether 82 of the ossified double rings in the modified portion of the windpipe.

The earlier bronchial rings are peculiar in being deep, the fibro-cartilaginous rings being ossified and thickened above and below for a certain portion (the external) of their circumference.

Platalea ajaja.—The peculiar convolution, within the thorax, of the trachea in *Platalea leucorodia* is well figured by Mr. Yarrell.[*] The arrangement in *Platalea ajaja* is, however, quite different. A pair of these birds was purchased by the Society on the 13th of August, 1870. The female dying on the 27th of July, and the male on the 13th of October, 1873, have given me the opportunity of examining the windpipe in both sexes. The trachea is simple, straight, of uniform calibre, and peculiarly short, extending only two-thirds down the length of the neck, where the uncomplicated syrinx is situated and the bifurcation of the bronchi occurs. The usual pair of muscles, one on each side, runs to this syrinx from above, and ceases there. The bronchi are fusiformly dilated at their commencement, where the rings which encircle them are not complete, a membrane taking their place in that portion of each tube which is contiguous to its opposite neighbour. Each bronchus, lower down, is composed of complete cartilaginous rings (*vide* fig. 2, p. 288). Page 301.

By many ornithologists *Tantalus* is arranged along with *Platalea* and *Ibis*, instead of with the Storks. Nitzsch, in his "Pterylography," places it with *Ciconia* in his group PELARGI, separating off *Platalea* and *Ibis* to form the HEMIGLOTTIDES. In the "Revised List" of the Animals in the Society's Gardens, Mr. Sclater adopts the same arrangement. In my paper "On the Nasal Bones of Birds,"[†] it is mentioned that *Platalea* and *Ibis* are schizorhinal—that is, have the external osseous nares split up in a manner there described, in which point they differ from the rest of Prof. Huxley's Pelargomorphæ, and therefore from *Tantalus*.

There are many other structural peculiarities which make it per-

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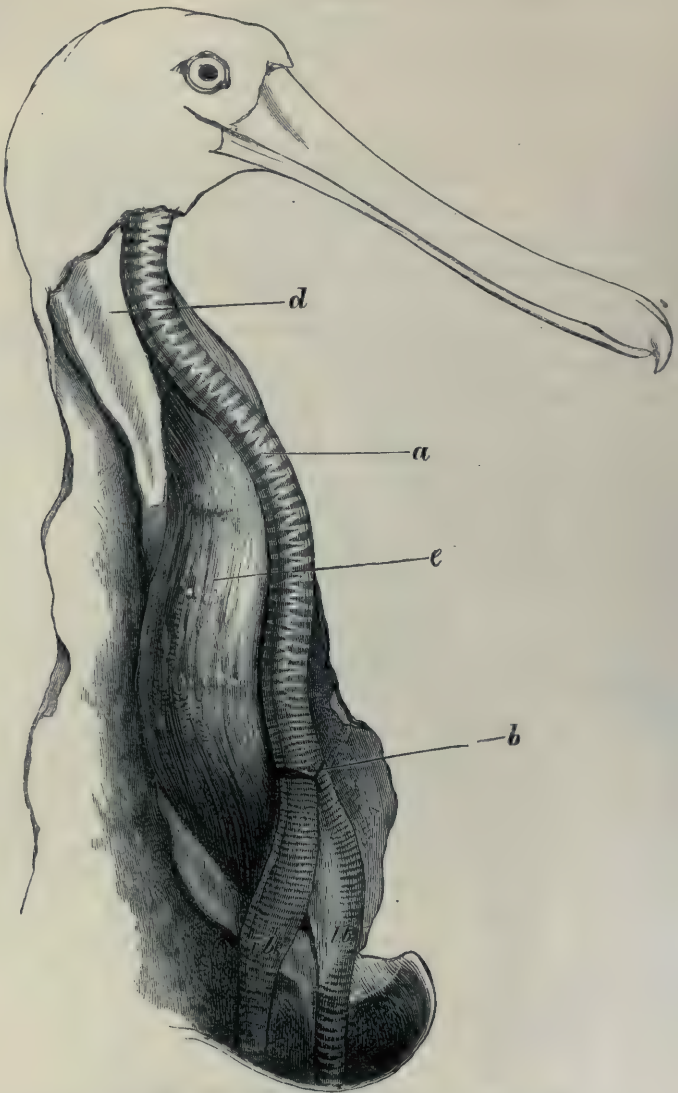
[*] "British Birds," vol. ii. p. 504.

[†] "Proceedings of the Zoological Society," 1873, p. 33. (*Suprà*, p. 124.)

Page 300. Fig. 2.



Cervical bifurcation of the bronchi in *Platalea ajaja.*

a, trachea; *b*, syrinx; *d*, œsophagus; *e*, cervical muscles and vertebræ; *r.b*, right bronchus; *l.b*, left bronchus.

fectly certain that *Tantalus* is a member of the Ciconiidæ, and not an aberrant one either. Some of the most important it will not be out of place to mention here. They will be most easily appreciated in a tabular form, as thus represented:—

In *Ibis* and *Platalea*.	In *Ciconia* and *Tantalus*.
The skull is schizorhinal.	The skull is holorhinal.
The angle of the mandible is produced and recurved.	The angle of the mandible is truncated.
The *pectoralis major* muscle is simple, not being separable into distinct layers.	The *pectoralis major* muscle is in two layers, a superficial and a deep, easily separable one from the other.
The *accessory femoro-caudal* muscle is well developed.	The *accessory femoro-caudal* muscle is absent.
The *semitendinosus* muscle is muscular throughout.	The *semitendinosus* muscle is tendinous for its distal half.
A small muscular belly is sent from the *biceps cubiti* to the tendon of the *tensor patagii longus* muscle.	No slip leaves the *biceps cubiti* muscle to join the *tensor patagii longus.*

46. ON THE DISPOSITION OF THE DEEP PLANTAR TENDONS IN DIFFERENT BIRDS.*

THE arrangement of the tendons in the palm of the hand and the Page 339.
sole of the foot among the Mammalia is a subject of great intricacy, as
may be inferred from the comparison of the dissections of different Page 340.
animals whose anatomy has been sufficiently investigated. Among
birds peculiarities in the disposition of the plantar tendons has already
attracted the attention of Professor C. J. Sundevall, who, as is well
known, divides the Passeres off from all other orders, and includes
Upupa with them, because in them, and in them only, the tendon of
the *flexor longus hallucis* muscle is quite independent of that of the
flexor perforans digitorum; whilst in other birds the former joins the
latter, so preventing the two from being quite independent in their
action. All other descriptions which I have seen of special dissections
have been confirmatory of this view; and my own observations, with
but a slight exception in the case of *Botaurus*, to be mentioned below,
support Professor Sundevall's separation off of the Passeres together
with *Upupa* on this particular character. My dissections, however,
have shown me that there is still more to be learnt from the plantar
tendons, and that the large mass of birds which all agree in that the
two above-mentioned deep flexors blend together, present among

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* "Proceedings of the Zoological Society," 1875, pp. 339–48. Read, April 20, 1875.

themselves peculiarities as important as that which so definitely characterizes the Passeres. To describe and to endeavour to show the bearing of these differences are the objects of the present paper.

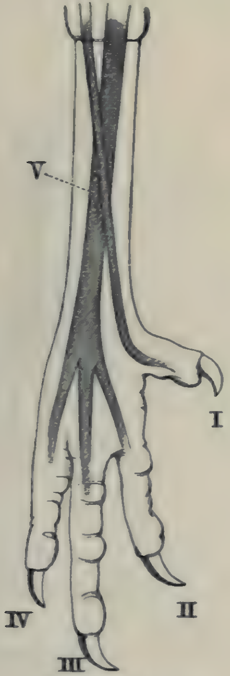
In birds generally, whatever the number of their toes, there are two muscles whose fleshy bellies are situated in the leg proper (that is, between the knee and the ankle), deep, and just behind the tibia. These muscles arise, one from almost the whole of the posterior surface of the tibia and from the fibula, in a bipenniform manner, and the other from the inferior surface of the horizontal femur, just behind the outer genual articular condyle. The former is termed the *flexor perforans digitorum pedis*, because its terminal tendons perforate those of the more superficial flexors on their way to the ungual phalanges of their respective toes; and the latter is termed the *flexor longus hallucis*, because there is generally a shorter muscle to the same digit.

These two muscles descend to the ankle (the joint between the tibio-tarsus and the tarso-metatarsus) side by side; they run behind it, in the fibro-cartilaginous or osseous mass which, in birds, is always found at the posterior part of the upper end of the tarso-metatarse, in two canals, deeper than any of the other flexor tendons; and in these canals there is always a definite relation between them. Sometimes the tendons are side by side; and then it is always that of the *flexor longus hallucis* which is the external of the two, the osseous vertical ridge, which is nearly always seen in the dry bone, separating them. Sometimes, however, one is superficial or, in other words, posterior to the other. When this is the case it is always the *flexor perforans digitorum* which is the deeper. In the Swifts, for instance, the *flexor longus hallucis* quite covers the *flexor perforans digitorum;* but in most Parrots, as may be seen by the disposition of the osseous canals in the dry tarso-metatarse, that for the former muscle is external as well as superficial, only partially covering it.

These relations are constant, and must be always borne in mind
Page 341. in all attempts to identify the muscles. From these it can be inferred, as is verified by dissection, that the tendon of the *flexor longus hallucis* crosses its companion superficially on its way from the ankle to its insertion in the hallux.

Just before, or just at the commencement of, the sole of the bird's foot (near the joint between the metatarsus and the phalanges), these two tendons generally split up to supply the toes. By far the majority of the families of birds agree in the distribution of the terminal tendons, conforming to one common type. This typical arrangement must be first described. The common Fowl (*Gallus bankiva*) is a very good example. The accompanying diagram (fig. 1) will assist in explaining it. The tendon of the *flexor longus hallucis* descending on the outer side of the tendon of the *flexor perforans digitorum*, crosses it

Fig. 1.



Gallus bankiva.

Fig. 2.

Apteryx mantelli.

superficially in its downward and inward course to the lower surface of the base of the hallux, whence it traverses the flexor surface of that digit to the base of the ungual phalanx at which spot it is inserted. The *flexor perforans digitorum* continues down to the sole of the foot as a single tendon, where it immediately splits into three parts, one to the ungual phalanx of each of the three anteriorly directed digits. Opposite the lower part of the tarso-metatarse the Page 342. *flexor longus hallucis* sends downwards a fibrous vinculum (V) which joins the *flexor perforans digitorum* tendon just before it commences to trifurcate. In all cases this vinculum is always directed downwards from the hallux-muscle to the digits-muscle, so that, when the tendon of the *flexor perforans digitorum* alone is pulled upon, the three anterior digits alone are flexed; but when the *flexor longus hallucis* is put in action, the digits as well as the hallux are simultaneously flexed.

The proportion borne by this vinculum to the main tendon of the *flexor longus hallucis* varies considerably. In some birds it is comparatively feeble and insignificant; whilst in others, with but a small hallux, it is much larger than the hallucial moiety, and seems to be the main continuation outwards of the insertion of the muscle into that of the *flexor perforans digitorum*, the slip to the great toe being but small compared with it. In the Dorking Fowl the *flexor longus hallucis* tendon splits into two (after it has given off the vinculum to the *flexor perforans*), one resulting portion going to the normal hallux and the other to the supplementary toe, which is therefore a hallux also, as is generally supposed.

Fig. 3.

Tinnunculus alaudarius.

Fig. 4.

Buceros rhinoceros.

This manner of distribution of the deep plantar tendons, which is that found in a great number of birds, may be summarized as follows :—The *flexor perforans digitorum* splits opposite the meta-
Page 343. tarso-phalangeal joint into three tendons, one running to the ungual phalanx of each of the three anteriorly directed toes. The *flexor longus hallucis* is inserted into the ungual phalanx of the hallux, but it sends downwards near the middle of the tarso-metatarsus a vinculum to join the tendon of the *flexor perforans digitorum* just before the trifurcation of that muscle (figs. 1 and 7).

This condition is found in the following birds which I have examined :—

Gallus bankiva.
Megacephalon maleo.
Fulica atra.
Musophaga violacea.
Schizorhis africana.
Crotophaga sulcirostris.

Phœnicophaës, sp.?
Eudynamis orientalis.
Cuculus canorus.
Nestor notabilis.
Chrysotis festiva.
—— *ochrocephala.*
Ara chloroptera.
Baza lophotes.
Syrnium aluco (vinculum very broad).
Leptoptilus argala.
Ardea sumatrana (vinculum very slender).
—— *cinerea* (vinculum scarcely exists).
Cancroma cochlearia.
Geopelia cuneata.
Ibis rubra.
Platalea ajaja.
Eurypyga helias.

In *Ardea cinerea* and in *A. sumatrana*, here mentioned, the vinculum is stated to be extremely feeble. In *Botaurus stellaris* this condition is carried a step further, the vinculum being quite wanting. Prof. Sundevall states that such is the case only in the Passeres and in *Upupa*; here, however, is a slight exception to that generalization.

Frequently the vinculum above referred to is so considerable in strength that it makes the *flexor longus hallucis* appear to fuse with the *flexor perforans digitorum*, and only to send a slip before doing so to the hallux. This condition is evidently but an inconsiderable modification upon the previously described typical arrangement (fig. 2, p. 291). It is, however, a stepping-stone to others, which it assists in explaining. It is found in the following birds, which I have dissected (it will be noticed that they have the hallux comparatively insignificant):—

Apteryx mantelli.
Nothura maculosa.
Chenalopex ægyptiacus.
Cygnus nigricollis.
Podiceps minor.
Phalacrocorax carbo.

In many of the Accipitres Diurnæ a slight modification of this arrangement is observed. The *flexor longus hallucis* divides into two moieties opposite the lower end of the tarso-metatarse, one of which runs to the hallux. The other part is the representative of the vinculum of the above-mentioned birds; it is peculiar, however, in that, instead of joining the tendon of the *flexor perforans digitorum* before it is distributed to the anterior toes, it mostly runs down to blend with the slip which is associated with the inner of these (digit 2) only (fig. 3). This condition I have observed in

Haliaëtus albicilla,
Tinnunculus alaudarius.

In *Geranoaëtus aguia* and in *Polyborus brasiliensis*, besides the special tendon from the hallux-muscle to the second digit, there is a broad thin vinculum present, as in *Gallus*. In the Accipitres Diurnæ the arrangement of the tendons therefore differs in different groups—

Page 344.

in *Baza* their distribution being quite normal, that is as in the first-described manner; in *Polyborus*, *Haliaëtus*, *Tinnunculus*, and *Geranoëtus* this condition is combined with a special extra tendon to the second digit, which greatly increases its power of flexion. The arrangement observed in the Cathartidæ is in no way allied to any of these, and adds another important point to the many now known to separate them off entirely from the Accipitres veræ.

The next arrangement to be described is a very different one. The two deep flexors descend beyond the ankle-joint independently, as usual; after passing which, generally about one-third down the tarso-metatarse, they blend completely, *before* any slip has been given off. From the conjoined tendon thus formed the tendons of distribution spring, four in number, one to the hallux and others to each of the three anteriorly directed toes (fig. 4, p. 292), that to the former being generally separated off before any of the others.

Among Homalogonatous birds the only group in which I have observed this condition is that of the Cathartidæ—both *Cathartes atratus* and *Sarcorhamphus gryphus* possessing it, and so differing entirely from their supposed allies the diurnal Accipitres. Among Anomalogonatous birds the arrangement is very commonly found; I have seen it in

Coracias garrula,
Buceros rhinoceros,
Steatornis caripensis,
Podargus cuvieri,
Caprimulgus europæus,
Cypselus alpinus.

On looking at the plantar tendons thus arranged, without further dissection, the slip to the hallux from the conjoined deep flexor tendon seems to spring from its inner (that is, hallucial) side); whereas, from what has been said above, the long flexor of the hallux is situated external to the common flexor, at the ankle-joint.

Further, in these birds, on straining upon the distal hallux slip with one hand, at the same time that the distal slips to the remaining toes are held in the other, the two elements of the conjoined tendons tend to divide up in the direction of the ultimate fibres; and in doing so the line of rupture always develops in such a way that it leaves the thus further-separated hallux slip still on the inner side in connexion with the main *flexor perforans* tendon.

A natural condition, like this thus artificially produced one, is found in some birds closely allied to those in which the last described arrangement obtains. It is found in *Momotus lessoni*, *Dacelo gigantea*, and *Merops apiaster*. In them the tendons of the *flexor longus hallucis* and of the *flexor perforans digitorum* pass down beyond the ankle-joint in the typical manner, the former external to the latter as usual. Opposite the upper end of the tarso-metatarse the *flexor perforans digi-*

torum gives off from its *inner* side the flexor slip which supplies the hallux, the majority of the tendon descending as usual towards the foot. Opposite the middle of the tarso-metatarse it is joined by the Page 345. tendon of the *flexor longus hallucis* on its outer side, whereupon the conjoined tendon splits into three divisions to supply the three anterior toes (*vide* fig. 5).

The peculiar conformation in the foot of the *Trogonidæ* is associated with an equally abnormal arrangement of the plantar tendons, which I have found in *Trogon puella* and in *Pharomacrus mocinno*. In these birds the tendon of the *flexor longus hallucis* is situated, as it ought to be, external to the *flexor perforans digitorum*; it also crosses it superficially, opposite about the middle of the tarso-metatarse, sending down a slender vinculum in the normal manner. The peculiarity is in the ultimate destination of the tendons, the *flexor longus hallucis* and the *flexor perforans digitorum* each dividing into two near the metatarso-phalangeal articulation, the two portions of the former tendon running to the hallux and digit 2, the two of the latter to digits 3 and 4 (*vide* fig. 6). This arrangement is not found in any other group of birds, as far as my experience goes.

Fig. 5.

Momotus lessoni.

Fig. 6.

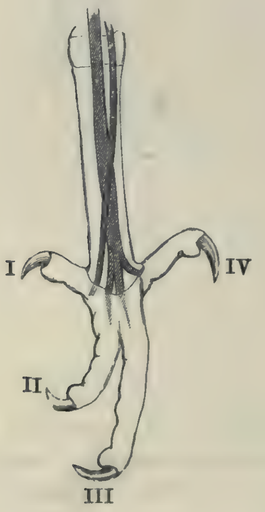
Trogon puella.

Besides the three last peculiar arrangements of the tendons, which I have not found elsewhere described, there is another still more peculiar and unexpected. I have observed it in all the Anomalogonatous
Page 346. birds with scansorial feet which I have examined, and in them only, it being present in

Ramphastos ariel,
Megalæma asiatica,
Gecinus viridis,
Tiga javanensis,
Galbula albirostris,
Urogalba paradisea.

It is represented in fig. 8. The two tendons descend behind the ankle as usual, having their origins typical. There is nothing peculiar till they have descended two-thirds down the tarso-metatarse. About opposite the middle of that bone the *flexor longus hallucis* sends a vinculum downwards as in the Fowl, to join the tendon of the *flexor perforans digitorum.* Just above the metatarso-phalangeal articulation the tendons become arranged for distribution in a most uncommon manner. The tendon of the *flexor perforans digitorum* does not split up, but runs to one digit only, namely the third toe, which is the outer of the two that are directed forward. It is covered superficially by the *flexor perforans digitorum*, just as that latter muscle is splitting up to be distributed to the hallux as well as to digits 2 and 4. In these

Fig. 7.



Crotophaga sulcirostris.

Fig. 8.

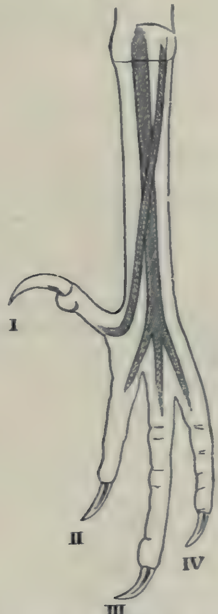
Megalæma asiatica.

birds we have, therefore, the *flexor longus hallucis* arising from the lower surface of the femur only, running through the ankle at the outer side of the other deep tendon, and sending a vinculum downwards—all of which are special characters of that muscle only, it being Page 347. distributed to three toes, whilst the *flexor perforans digitorum* only supplies one.

The birds with scansorial feet thus fall into two divisions, according to the arrangement of their plantar tendons, these being normal in the *Psittaci* and *Cuculidæ*, whilst they are extremely peculiar in the *Picidæ*, *Ramphastidæ*, *Capitonidæ*, and *Galbulidæ*. In my paper on the Classification of Birds,* the presence or absence of the *ambiens* muscle made me feel justified in placing the *Psittaci* and *Cuculidæ* among my HOMALOGONATÆ, at the same time that the *Pici*, *Ramphastidæ*, *Capitonidæ*, and *Galbulidæ* are arranged among the ANOMALOGONATÆ. These new observations are therefore strongly in favour of the naturalness of the classification proposed.

There is only one other point to be considered on the present occasion, as far as this question is concerned. It is the distribution of

Fig. 9.



A typical Passerine Foot.

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* "Proceedings of the Zoological Society," 1873, p. 626, and 1874, p. 111 *et seq.* (*Suprà*, p. 187, *et seq.*)

these tendons in birds which do not possess the hallux, or in which there is no long flexor tendon to that digit when it is present. In all these cases both the *flexor longus hallucis* and the *flexor perforans digitorum* muscles are present and well developed, only they blend completely opposite the upper part of the tarso-metatarse to form a single common tendon to be distributed, on its splitting up, to the anterior Page 348. toes—to the two of *Struthio*, the three of *Rhea*, *Otis*, &c. Dr. Alix[*] has described how that, in the common Swan (*Cygnus olor*), there is no long flexor tendon to the small hallux. I have not examined that species; but there is undoubtedly a small one in *C. nigricollis*, *C. atratus*, and in all the other Anserine birds I have examined, as above mentioned. However I have found this tendon to the hallux wanting in

Parra africana,	*Pygosceles papua*,
Chauna derbiana,	*Podiceps minor*.

Professor C. Sundevall has shown[†] that in the Passeres and in *Upupa epops* the tendons of the *flexor longus hallucis* and the *flexor perforans digitorum* are quite free from one another, not being united by any vinculum. In all the Passeres which I have examined my observations agree with these generalizations. However, the same condition maintains in *Botaurus stellaris* and almost in *Ardea cinerea*, where the vinculum is scarcely more than a single fibre (*vide* fig. 9).

DESCRIPTION OF THE FIGURES.

In all the figures the numbering refers to the digits I, II, III, IV, representing the hallux, second, third, and fourth digits respectively. In all, the deep plantar tendons are alone represented, and these from their plantar aspect, the hallucial tendon being the outer of the two at the heel-joint.

Fig. 1. Left foot of *Gallus bankiva;* V, vinculum running downwards from the outer hallucial tendon to the inner digital common tendon.
2. Right foot of *Apteryx mantelli.*
3. Right foot of *Tinnunculus alaudarius.*
4. Right foot of *Buceros rhinoceros.*
5. Right foot of *Momotus lessoni.*
6. Arrangement of the tendons in the left foot of *Trogon puella.*
7. Right foot of *Crotophaga sulcirostris.*
8. Right foot of *Megalæma asiatica.*
9. Right foot of a Passerine bird.

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[*] "Essai sur l'appareil locomoteur des Oiseaux." Paris, 1874, p. 464.

[†] "Methodi naturalis avium disponendarum tentamen" (Stockholm, 1872), and elsewhere.

47. ON THE HYOID BONE OF THE ELEPHANT.*

THE hyoid apparatus of the Indian Elephant (*Elephas indicus*) Page 365. present peculiarities which a study of the same in the Ungulata would tend to complicate rather than to simplify. The basihyal together with the thyrohyals form an arch (of which, by the way, I have not seen the components anchylosed even in adult specimens)—which does not present the least difficulty, a small pair of cartilaginous lesser cornua being present in the position of the lesser cornua of anthropotomy. It is the stylohyals which, as far as I can find, have not yet been correctly described. Of them Professor Owen remarks†, "From the middle of the stylohyal a slender pointed process is sent off at an Page 366. acute angle." And in Professor Flower's "Osteology" it is said that "the stylohyals are remarkable for having a long pointed process projecting downwards from near the middle of their posterior border." Professor Morrison Watson‡ enters fully into the description of the hyoid muscles, without mentioning, though evidently correctly understanding, the disposition of the bones with which they are associated.

From the above remarks it is evident that the thick short portion of each stylohyal is assumed to be the body of that bone, the pointed process being considered to be an accessory part of it. Such, however, is not the case—the slender pointed process in reality corresponding to the long body of the stylohyal in the Perrisso- and Artiodactyla, whilst the short thick process is the posterior descending process. That such is the case I have been able to prove recently in two specimens.

In the Indian Elephant the stylohyal (*s h*) is a thin bone composed, Page 367. in the adult male, of a flat portion, 4 inches long, less than $\frac{1}{4}$ inch thick, and very nearly $\frac{3}{4}$ inch broad, with parallel sides, obtusely truncated at both ends, which are capped with cartilage. In the standing animal the position of this portion of the bone is nearly vertical. Above, it is closely united to the stylo-temporal region of the skull, whilst the lower end gives origin to the digastric muscle. From the middle of the *anterior* border continues onwards the body of the bone, at an acute angle with the lower portion of the above-described

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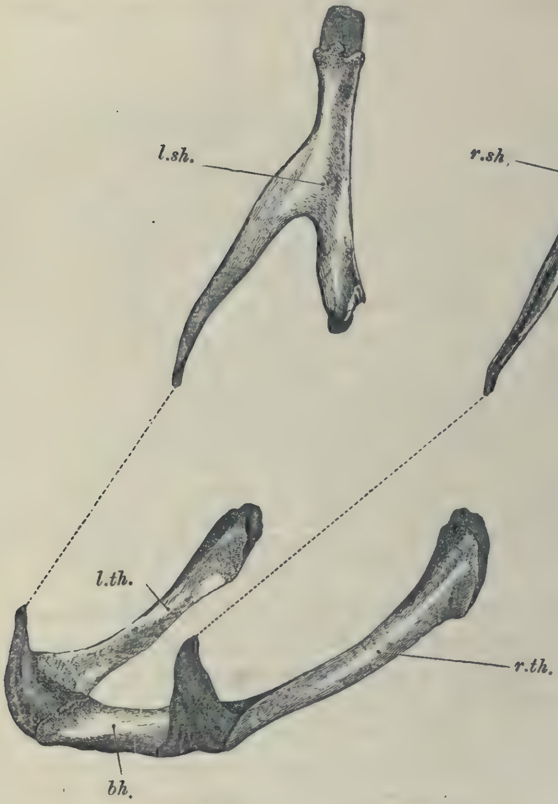
* "Proceedings of the Zoological Society," 1875, pp. 365–7. Read, May 4, 1875.

† "Anatomy of Vertebrates," vol. ii. p. 441.

‡ "Journal of Anatomy and Physiology," November 1874, p. 131.

element, downwards and forwards. This is elongately triangular in shape, 6 inches long, $\frac{3}{8}$ inch broad at its middle, and tapering to a point in front, where it gives attachment to a hardly specialized stylohyoid ligament and serves for the origin of the stylo-glossus muscle. The interval between the tip of this stylohyal and the lesser cornu (cartilaginous) of the hyoid bone is 5 inches, or a little less than the length of the process itself. As it descends in its downward and forward course, this tapering stylohyal curves slightly on itself, turning a little outwards.



Hyoid bones in Indian Elephant.

The accompanying figure will explain the condition.

The descending digastric process, as it may be termed, may be compared to the posteriorly directed process of the stylohyal in the Ungulata. It differs from it, however, in one essential particular, which is that in the latter it does not give origin to the digastric muscle, but only to the stylohyoid; whilst in the Elephant the digastric arises from its lower end only, and the stylohyoid from the angle formed at its junction with the body of the bone.

In the Elephant therefore the deficiency of the lateral intermediate elements of the hyoid apparatus permit of a much greater movement of the base of the tongue than in the Ungulata, whose nearly rigid stylohyals, epihyals, and ceratohyals can allow of little more than an antero-posterior movement of the base of the tongue, in part of the circle of which the hyo-cranial attachment is the centre.

48. REPORT ON THE INDIAN ELEPHANT WHICH DIED IN THE GARDENS JULY 7TH, 1875.*

On May 1st, 1851, the Society purchased of Mr. Batty (then of the Circus, Westminster Bridge), for £800, an adult female *Elephas indicus* with its female calf. The specimens had been deposited in the Society's Gardens on the 19th of the preceding month. In the spring of the year 1850, John Stimpson, now keeper in the Society's service, left the E.I. Company's military service, and when at Cawnpoor, on his way to Calcutta, met an animal-dealer, Mr. Wallace, who was on his way to Calcutta with the female and calf in question as well as another Elephant. Stimpson is sure that the calf was born after the female had been captured, and thinks that it was three months old when he first saw it. He assisted in taking charge of the animals till they arrived in this country: they were five months on the voyage. Page 542.

Of the two specimens purchased by the Society the mother was sold on April 28th, 1854, to the Zoological Society of Brussels, the calf continuing to suckle until that date, *i.e.*, until upwards of four years of age.

It is this calf of 1851 which died on July 7th, 1875 (25 years old). The Superintendent, the head keeper, and the Elephant-keepers are of opinion that it continued to grow until within a year of its death. Its height at the withers at the time of its death was just eight feet.

For the last four years at least the animal has lost the power of extending its trunk, from paralysis of the anterior intrinsic muscles of that organ. It has thus not been able to throw its trunk over its

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* "Proceedings of the Zoological Society," 1875, pp. 542–3. Read, Nov. 2, 1875.

Page 543. head, or even the least forwards. When it took food it flexed the trunk so as to present the orifice forwards. This symptom is one of decay.

For the last two years of its life it exhibited marked signs of rheumatism, varying in severity, very considerable at times. This was most manifest on its kneeling down to be saddled.

The animal during the last three years of its life looked preternaturally aged and worn out. It has never suffered the least from cough, and has not become strikingly thin. It carried its saddle and visitors 36 hours before its death, apparently without discomfort, and ate well on the evening of the 6th inst.

For about six months the animal did not, as it was formerly wont to do, lie down at night. On the night of the 6th of July it fell on its left side, and did not subsequently make any powerful attempt to rise. The breathing was, when down, unusually rapid (about 25 a minute); and no marked symptoms of pain manifested themselves, general discomfort being evident. It died during the night of the 7th, having at 8.30 P.M. had a large dose (over 100 grs.) of strychnia given it by the mouth. Whether the poison was the cause of death is uncertain.

With the exception of one of the lungs, all the organs, the brain included, were perfectly healthy. The lung in question was almost entirely infiltrated with tubercular deposit, not more than one-sixth being competent for the respiratory function. The tubercular infiltration was uniform or nearly so, being of a lighter colour and nearly in a condition to break up in the centre of the organ, forming a dark grey solid mass in the more recently affected portions near the margins.

It may be mentioned that the teeth just coming into wear had, in both jaws, 23, 24, or 25 plates; they were therefore the sixth molars. The epiphyses of the long bones were firmly united.

No entozoa were found.

As to the duration of the disease it is not easy to decide. It, no doubt, was of considerable standing; probably it had commenced with the first signs of decrepitude, about three years ago.

As to the cause of the tuberculosis, that was probably connected with the animal having been born and bred in captivity in a cold climate. A wild-caught animal 4 or 5 years of age would probably have thriven better.

49. NOTES ON THE MANATEE (*MANATUS AMERICANUS*) RECENTLY LIVING IN THE SOCIETY'S GARDENS.*

(Plates XI—XIII.)

UNTIL the arrival, on August the 6th of this year, of a living female Manatee in the Society's Gardens, very few Europeans had had the opportunity of seeing a live Sirenian; and those who had previously been so fortunate, had not, in most cases, been able to observe it under the favourable circumstances of position afforded by a small shallow pond approachable on all sides. In this pond it was not the least difficult to watch the creature minutely whilst it was feeding, as well as to make other notes of its habits which would necessarily be overlooked by those who meet it in its native haunts. Page 137.

Dr. Murie, in his valuable monograph on the Manatee,† justly remarks, that "in museums it is customary to see such bloated overstuffed specimens, that from them, as well as figures extant, an unfair idea of the configuration is obtained." Dr. Murie's own illustrations, with their beautiful textural details, represent the animal much more accurately. The only fault in them, if it is a fault, is rather in the opposite direction to that above indicated by him. His specimens were dead and preserved; they had evidently shrunk slightly, the living animal appearing a little more rounded, and presenting less well-marked skin-folds.

The following are the measurements of the animal which I have had the opportunity of dissecting, taken almost immediately after death:—

	Inches.
Total length	80
Circumference (3 inches in front of umbilicus)	50
Greatest breadth of tail (8 inches from end)	19
Umbilicus to anus	21
Vulva to anus	4·25
Circumference at root of tail (7 inches beyond anus)	28·75
Length of tail-flapper	19·5
Length of fore limb	14
From eye to front of snout	4·75

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* "Transactions of the Zoological Society," X. pp. 137–145. pls. XXVIII—XXX. Read, Nov. 16, 1875.

† "Transactions of the Zoological Society," VIII. p. 127.

	Inches.
Breadth of snout halfway down	5·5
Height of snout at middle line	3
From ear to ear over head	8·75
From eye to eye above head	6·4
From ear to eye on one side	5·75

Page 138. Whether in Dr. Murie's figured specimen the snout and front part of the head had been swollen during life, whether the enlargement was the result of *post mortem* change, or whether it was on account of the youth of the individual, that part of the body is represented of considerably larger proportionate size with reference to the rest of the animal than it was in the Society's living example, in which the head was more distinctly like a clean-cut truncated cone, without any well-marked transverse folds or appearance of puffiness.

It is, however, in the oral margin of the upper lip that the *deadness* of Dr. Murie's specimen is most manifest; and the fact that the peculiarity in the mechanism of that organ has not yet (so far as I am aware) been described, indicates how impossible it sometimes is to predict special functions from anatomical structure alone.

The upper lip is prehensile; in other words, the animal is able, by its unaided means, to introduce food placed before it into the mouth without the assistance of the comparatively insignificant lower lip. To understand how this is accomplished it is necessary that the structure of the labial margin should be described.

A front view of the head, Plate [11] XXVIII, fig. 2, shows that on each side of the narrow median portion of the superior labial margin of the oral orifice depends a rounded lateral lip-pad of considerable size, which gives a deeply notched appearance to the upper lip. Of these lip-pads, Dr. Murie tells us* that "at the dependent angle on each side of the muzzle is a circumscribed oval prominence half an inch in diameter, where the ridges, furrows, and bristles [found elsewhere] are specially pronounced. This spot would seem to possess most tactile delicacy; for twigs of the infraorbital and facial nerves are abundant thereto. . . . . The above disposition strongly reminds one of the moustachial apparatus of the Walrus; but their shortness and rigidity render them unequal to perform the office of a sieve, as is the case in the Pinniped: they therefore incline to the hirsute covering of the muzzle of the Hippopotamus." In another place† the same author, speaking of the lifting muzzle of the upper lip (the *levator labii superioris proprius*), remarks, "Many vessels penetrate the root and origin of this levator;

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* "Transactions of the Zoological Society," VIII, p. 133.

† *Loc. cit.* p. 149.

this, no doubt, led Vrolik* to regard 'the structure of the upper lip as plainly an erectile tissue.'" Observations on the living animal verify the correctness of Vrolik's surmise. It is a *post mortem* change which causes the thickly bristled erectile lip-pads to be directed downwards. In the living animal their erectile tissue is distended with blood on most occasions, especially whilst feeding, and the pads are by this means directed inwards, towards one another, in such a way that the deep median notch which they go to form is even deeper and the bristles meet across the median line.

Further, these pads have the power of transversely approaching towards and receding from one another simultaneously, Plate [11] XXVIII. figs. 1 and 2. When the animal is on the point of seizing, say a leaf of lettuce, the pads are diverged transversely in such a way as to **Page 139.** make the median gap of considerable breadth. Directly the leaf is within grasp the lip-pads are approximated, the leaf is firmly seized between their contiguous bristly surfaces, and then drawn inwards by a backward movement of the lower margin of the lip as a whole.

The appearance produced by the movements of this peculiar organ is very much the same as that of the mouth in the silkworm and other caterpillars whilst devouring a leaf, the mandibles in these insect larvæ diverging and converging laterally in a very similar manner during mastication.

As to the mechanism of the process, the erectile nature of the lip-pads no doubt assists in the manner above indicated. These organs, when dilated, form more satisfactory muscular origins than when flaccid. Innumerable transverse muscular fibres connect their basal portions, forming the bridge above the median lip-notch, and approximate them. They are evidently separated and diverged by the *levator labii superioris proprius*, which is almost entirely distributed, in its insertion, to the considerable amount of skin-covered fibro-elastic tissue forming the interval between the nares and the lip-margin.

With reference to the valvular mechanism for closing the nostrils during submersion, it may be mentioned that these circular orifices have each a flap valve, which forms the floor or inferior wall of the nasal tubes when the animal is breathing, but which rises and completely occludes it when closed, as represented in both the figures on Plate [11] XXVIII.

Looking at the living animal generally, the most striking peculiarity was the sluggishness of its movements. When crossing its pond there was none of the lateral movement of the body so characteristic of the Seals. All flexions were up and down, the whole trunk

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* "Mem. Zoolog. Soc. Amsterdam," 1852, p. 59.

bending a little in that direction, the base of the tail doing so freely at a clearly marked transverse fold-line in that region.

An opportunity occurred to me for seeing it out of water, when its pond was drained dry for a short time. From my observation on this occasion it is perfectly evident to me that the Manatee is purely aquatic in habits, and that it never willingly quits the water. When on land it seemed perfectly unable to advance or recede, the only movements it performed being that from its belly to its back, and *vice versâ*. In these it made use of its limbs, flexing the body and the tail at the same time. When resting on its belly it seemed extremely uncomfortable, apparently on account of difficulty in breathing, which it is easy to account for on the assumption that the weight of the body being supported on the almost ribless anterior walls of the thorax and abdomen, compressed the abdominal viscera against the lungs, and so greatly diminished the respiratory movements. It would not remain in this position for any length of time, but seemed comparatively comfortable whilst lying quietly on its back, as it did until the inflowing water had refilled the pond sufficiently to allow of its again supporting itself in the water.

Page 140. I may mention that the power of moving the slightly exserted elbow was considerable, whilst that of the wrist was small but apparent. It used its limbs much more freely than do the Seals, sometimes employing the extreme margins of the paddles to assist in introducing food into the mouth, at others employing them in progression along the bottom of the pond, during which time the swimming-tail could not be brought into play to any extent.

The Manatee came into my hands within an hour or so of its death, and one of the earliest things that seemed desirable to do was to obtain some of its blood for examination. The first cut through the skin was sufficient to prove how different an animal it is from any of the Pinniped Carnivora; for instead of the muscles being of a deep almost black-red hue, as they are in the Seals, they were of a pale pink, more like veal or pork than any other flesh known to me, much lighter than beef.

The blood-disks are circular and non-nucleated, as it was certainly known they would be. Their size, however, is their peculiarity. From the valuable investigations of Mr. Gulliver, which are incorporated in their entirety in the Society's "Proceedings" for 1875 (p. 474 *et seq.*), it is known that the largest mammalian blood-disks are found in the Elephants ($\frac{1}{2745}$ of an inch in diameter), Great Anteater ($\frac{1}{2769}$), Sloths ($\frac{1}{2865}$), Aard-vark ($\frac{1}{2769}$), and Walrus ($\frac{1}{2769}$). In the Manatee the diameter of the largest reaches $\frac{1}{2700}$ of an inch, others being considerably smaller.

If there is any stress to be laid on the size of the blood-disks in the classification of animals, as it seems almost impossible that there should not be from the comparative constancy in their size in closely allied species and genera, then the relationships of the Manatee to the Artiodactylate Ungulates must be most distant, as small size of blood-disks is a special peculiarity of those latter animals, the largest being $\frac{1}{4070}$ of an inch in diameter, namely in the European Bison (*Bison bonassus*). In the Elephant and Edentates, on the contrary, the blood-disks are particularly large.

With reference to the digestive organs there is not much for me to add to previous descriptions. In the stomach of our specimen the plications of the mucous membrane were slightly different from the figures given by Dr. Murie. Several well-marked, though not large longitudinal folds run along the lesser curvature of the first cavity from the cardiac orifice to the entrance of the second. These are bounded on the vertebral and ventral faces of the organ by a large, similarly directed fold, which imperfectly separates off the irregularly plicated portion in connection with the greater curvature from that in the region of the lesser. The mucous membrane of the second stomach is raised into rounded anfractuous folds, much like those of the human cerebral surface. The muscular parietes of the whole organ are very thick, extraordinarily so at the cardiac end. There is no pyloric dilatation of the duodenum. The intestines in their muscularity are very cat-like. A large number of vessels, forming quite a *rete mirabile*, is to be found at the ileo-cæcal valve, in the angle between the large and small intestines. As Dr. Murie states, the cæca
and the commencement of the colon are, when undisturbed, situated Page 141,
in the left diaphragmatic corner of the umbilical region of the abdomen. The following are the lengths of the intestinal viscera:—

	ft.	in.
Small intestine	31	2
Large intestine	20	3
Cæca from apices to ileo-cæcal valve	0	$3\frac{1}{2}$
Each cæcum externally	0	$1\frac{7}{8}$

The stomach was small in comparison with the size of the animal. The same may be also more certainly said of the bifid heart and of the lozenge-shaped spleen.

The liver has a very peculiar shape, resulting from the very aberrant position of the lungs, which much curtail the transverse space usually occupied by that organ. Dr. Murie remarks, "*In situ*, but still more so when removed, the entire liver has great resemblance in shape to the inflated lungs of an ordinary mammal." This accurate simile would be even more so if the organ were compared to the lungs of a mammal distended with, say, solid jelly, and then cut down by a transverse slice which removed about one fourth their bulk from their apices. The liver may also be said to form a cylinder, flattened from before backwards, transversely truncated in front, and irregularly excavated behind, or on its abdominal surface. The heart rests, with the intervention of a fibrous expansion from the diaphragm, on the truncated anterior end of the organ, which corresponds to the diaphragmatic surface as usually described. Its dorsal surface is separated entirely from the spinal column by the interpolation of the lungs between the two.

The bulk of the liver is formed by the two lateral lobes, between which, at the anterior end, are wedged the central lobes, the right of which is considerably the larger. The drawings (Plate [12] XXIX. figs. 1 and 2) will explain this better than any amount of description. The suspensory ligament is strong, and the umbilical notch small. The right lateral fissure is not deep, and does not extend up to the truncate superior surface, whilst the left lateral is considerable and does so, going quite to its vertebral border. The caudate lobe is only a slight extension of hepatic tissue along the vena cava: the Spigelian is elongate, conical, and directed backwards; it is well seen in the dorsal view.

Another peculiarity is a considerable bridge of hepatic tissue, extending, on the concave abdominal surface of the liver, from the vertebral portion of the right central lobe to the middle of the left lateral lobe. This bridge is not quite half as broad as it is long, and it is bent into a semicircle, the convexity of which is directed abdominally.

With reference to the parts connected with generation, my observations entirely agree with those of Dr. Murie so far as the mammary development is concerned. No teats were to be found, nor any decided
Page 142. indications of their whereabouts. Just internal to the ventral insertion of the limbs there were one or two slight mamilliform thickenings of the integument, which had no deeper-seated glands apparently connected with them.

The vagina is partitioned into two parts by the transverse hymen, in which two small apertures exist, each not more than $\frac{1}{8}$ inch in diameter. The one, the common urinogenital portion, is $2\frac{1}{4}$ inches long, with the median urethral orifice just in front of the hymenal openings. Between it and the short prepuce-like clitoris is a blind pocket, just large enough to admit the ungual phalanx of the thumb. The true vagina is two inches in length, with slight irregular foldings; its walls are dense and fibro-cartilaginous in texture, as is the well-developed os uteri. The uterus closely resembles that of the Dugong, its cornua being $5\frac{1}{2}$ inches long, the body being only $2\frac{1}{4}$ inches. Its lining membrane is longitudinally plicated.

The rudiment of the urachus is more preserved than usual; and from the anterior extremity of the bladder a fine tube extends along its axis for a short distance.

Dr. Murie has described and figured the brain. He, however, mentioned that the specimen he examined was not in the most fit state for investigation. I was able to remove the organ within twenty-four hours of the animal's death, when it was not in the least injured; my opportunities have therefore been more favourable, and the differences I have detected make me think it better to give fresh illustrations of its conformation. The brain does not present convolutions properly so called. The Sylvian fissure is large and bifurcates high up; it ceases some way externally to the main longitudinal fissure of the brain; it also separates sufficiently at its origin to show the situation of the *lobus opertus.* A hippocampal sulcus also gives origin to the hippocampus major. There are distinct indications of a superior frontal sulcus. The calloso-marginal sulcus is well marked, continuous, and extends far back, ceasing in front opposite the genu of the corpus callosum. Below this point the frontal lobe extends a great distance, as is clearly shown by Dr. Murie, and it presents slight indications of sulci on its antero-inferior angle (*vide* Plate [13] XXX.).

The corpus callosum is short from before backwards, and in a median longitudinal section only covers the anterior and a little of the superior border of the thalamus opticus. Between it and the fornix no septum lucidum is developed, the precommissural fibres forming a thick median longitudinal plane, extending from the corpus callosum to the fornix. The anterior white commissure is small, as in the pineal gland. The corpora quadrigemina are not large.

There is no trace of a posterior horn to the lateral ventricle. The hippocampal sulcus, however, extends so far up above the posterior portion of the thalamus opticus as to develop the basal part of the hippocampus major into a triangular lobule, partly obliterating the back of the lumen of the cavity of the lateral ventricles, and bounded along its base-line, which runs from behind and externally forwards and inwards, by the ample fringe of the choroid plexus. The anterior horn of each lateral ventricle is deep, in correlation with the great **Page 143.** extent of the lobe it excavates. The walls of the cerebral hemispheres are not at all thick, the lateral ventricles being capacious.

Professor E. R. Lankester being specially interested in the question as to the cervical nerves, dissected them out in the specimen under consideration. The following are his notes on the subject:—

"Dr. Murie, in his paper on the Manatee, states that in a specimen dissected by him there were eight pairs of cervical nerves, of which two pairs issued between the second and third cervical vertebræ.

Hence he is led to infer that the presence of only six cervical vertebræ in the Manatee's neck is to be explained by the supposition that the third vertebra is suppressed, leaving the two pairs of cervical nerves before and behind it, respectively third and fourth, unseparated by a vertebra. My attention was called to this statement by Professor Edouard Van Beneden, of Liége, who two years since dissected a Manatee in Brazil, and having especially searched for Dr. Murie's third and fourth pairs of cervical nerves, had succeeded in finding but one in the position indicated. Professor Van Beneden urged me, if opportunity should occur, to examine this point carefully in the Manatee then living in Regent's Park. I was kindly allowed to make this investigation by my friend Professor Garrod; and I have to state that the following result was obtained by making first of all a dissection of the external course of the cervical nerves, and subsequently removing the skull and first three cervical vertebræ one by one, so as to trace the nerves to their origin in the medulla. A single pair of nerves issues between the occiput and atlas, a single pair between the atlas and axis, a single pair between the axis and third cervical vertebra, a single pair between the third and fourth cervical, and a similar arrangement obtains for the fourth and fifth, fifth and sixth, sixth and first dorsal. The piece of the spinal cord, with the pair of nerves attached to it, which issues between the axis and the third cervical vertebra (hence the third pair of cervical nerves) was removed by Professor Garrod and preserved in spirit. The third pair of cervical nerves is considerably larger near its origin than is either the first or second nerve; but the most marked increase of bulk is observed in the fourth, which issues between the third and fourth cervical vertebræ. There was no trace in the specimen dissected of any additional nerve, or of any structure which could be taken for such a nerve, in the interspace between the second and third cervical vertebræ. The third cervical nerve is connected by a slip to the fourth, and furnishes through this slip the highest origin for the phrenic nerve.

"Dr. Murie does not expressly state that he followed his supposed two pairs of cervical nerves issuing between the second and third vertebræ to their origin in the medulla; and from his drawing one is justified in supposing that he drew an inference as to the existence of these two pairs of nerves from the position of two nerve trunks, which it is possible he would have found united to form a single trunk if he had pursued them to their origin.

"The fact which I am anxious to put on record is, that in two Page 144. Manatees dissected since the publication of Dr. Murie's statement as to these cervical nerves, careful search was made with the view of confirming his statement, and the condition described by him was not found to obtain; but the usual and normal arrangement of a single pair of cervical nerves between each successive pair of cervical vertebræ was in both cases ascertained with precision."

Mr. C. S. Tomes has also kindly examined the minute structure of the teeth, with the following results:—

"The teeth of the Manatee present several peculiarities of structure, and the resemblance in external form which they bear to those of the Tapir is not fully carried out in their histological characters. I am not acquainted with any one tooth which combines the characters of the tooth of the Manatee; and I believe that an examination of a microscopical section would serve, with certainty, to identify a tooth as belonging to this creature.

"The enamel which thickly coats the crown is peculiar, in that its prisms pass from the dentine to its surface in perfectly straight lines, so that there is none of that crossing of the contiguous layers (decussation of the enamel prisms) nor of that waviness of course which are supposed to lead straight to the enamel of most of the animals.

"The whole thickness of the dentine (in very thin sections) has an appearance as though made up of an immense number of globules aggregated together. This appearance is a common one in very soft, imperfectly formed human teeth, and is to be seen in the Dugong and in some Cetacea.

"The dentinal tubes of the crown of the tooth give off very many small branches, and each tube terminates in a very large elongated cavity, of irregular outline. It is common enough for dentinal tubes to terminate in the small irregular spaces which are found in the periphery of the dentine of the roots of teeth; but such a termination beneath the enamel in the crown of a tooth is very unusual.

"The dentine of the roots of the teeth is permeated by a series of channels far larger than the dentinal tubes, the so-called vascular canals. These leave the pulp-cavity at regular intervals, pursue a course towards the surface of the root similar to that of the dentinal tubes, and terminate by anastomosing with their neighbours, and so forming a network of loops beneath the cementum.

"The dentinal tubes between the vascular canals are in no respect peculiar; they are mostly cut before reaching the immediate surface of the dentine, which might be described as coarsely and roughly ossified, while its interior portions are developed with perfect regularity. The vascular canals exist in the dentine of the crown of the tooth. Of the cementum there is nothing to be said; it is thick, and its lacunæ are richly supplied with canaliculi.

"It does not appear to me that the histological characters of the tooth can be made much use of as indicative of its affinities; still it may be worth while to note resemblances to the Tapir's tooth, which, though they may be purely accidental, are remarkable. My father, in Page 145.

1851,* described the teeth of the Tapir as presenting two peculiarities—the one, that the dentinal tubes of the crown of the tooth terminated beneath the enamel in oval dilatations, a most unusual manner of termination; the other, that vascular canals were to be found in the dentine of its roots.

"The regular oval dilatations which terminate the coronal dentinal tubes of the Tapir's tooth are as nothing compared to the great cavities into which the coronal tubes of the Manatee's tooth would pass; and where there is one vascular canal in the dentine of the root of the Tapir's tooth there are fifty in that of a Manatee. Yet it is remarkable that, besides an external similarity of form, the Manatee's tooth should present what might be called an immense exaggeration of the two peculiarities which mark the dental tissues of the Tapir."

DESCRIPTION OF THE PLATES.

Plate 11. (XXVIII.)

Front view of the head of *Manatus americanus*, representing the extreme positions of the pads of the upper lip in the movements described in the letterpress.

Fig. 1. Lip-pads approximated.
Fig. 2. Lip-pads separated.
In both figures the nostrils are represented closed.

Plate 12. (XXIX.)

The liver of *Manatus americanus*.

Fig. 1. Ventral aspect.
Fig. 2. Dorsal aspect.

Plate 13. (XXX.)

The brain of *Manatus americanus*.

Fig. 1. Longitudinal section in the middle line.
Fig. 2. Lateral aspect.
Fig. 3. Superior aspect, the upper part of the right hemisphere having been removed.
Fig. 4. Inferior aspect.

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* "Proceedings of the Zoological Society," 1851, p. 121.

50. ON THE *CÆCUM COLI* OF THE CAPYBARA (*HYDROCHŒRUS CAPYBARA*).*

In no work on anatomy with which I am acquainted can I find any Page 19. reference to the peculiarities of the cæcum coli of the Capybara, which are but an extreme exaggeration of those observed in many of the allied forms.

In most of those mammals in which a cæcum is present, that organ is simply a direct continuation backwards of the colon beyond the place of junction of the small and large intestines. In some Rodents, however, this is not the case, the sacculated cæcum in them not being a direct continuation of the larger gut, but a lateral diverticulum from a true but simple cæcum.

In his account of the anatomy of *Capromys fournieri*,† Prof. Owen remarks that the arrangement at the ileo-colic junction is such that "the two orifices of the blind intestine [that into the ileum and that into the colon] are analogous to the cardia and pylorus of the stomach;" and in his "Anatomy of Vertebrates,"‡ the same illustrious author tells us, with reference to the same animal, that "the cæcum is marked Page 20. off from the colon by a valvular structure, similar to that at the end of the ileum." This is an approximation to the condition which obtains in the animal under consideration.

In the Capybara the small intestine enters the enormous sacculated cæcum at about an inch from its open extremity, and its relations to it are not in any way peculiar. The sacculated cæcum is nearly two feet long, and is traversed by four longitudinal bands. At its open end, which is an inch beyond (that is, further from the cæcal extremity than) the ileo-cæcal valve, it is constricted by a circular sphincter muscle, which forms the orifice of communication with the rest of the cylindrical large intestine. The colic surface of this sphincter is situated *in the side of* the colon, three inches from the blind extremity of a true, simple, thick-walled, slightly pyriform cæcum, which is directly continuous with the colon, and is indistinguishable from it in structure. This second cæcum is, as indicated above, three inches from the extreme end to the centre of the orifice by which it communicates with the sacculated one. Superficially its longitudinal muscular coat is strongly marked, covering it perfectly uniformly.

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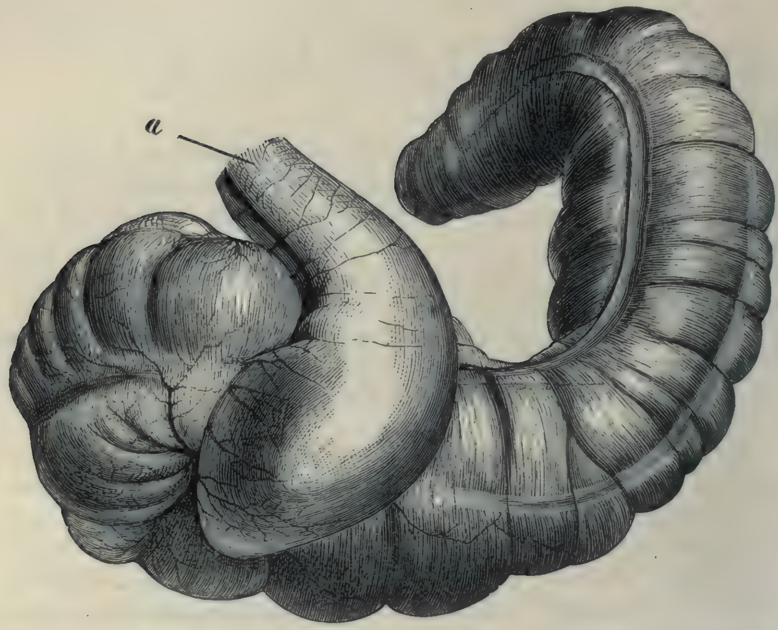
* "Proceedings of the Zoological Society," 1876, pp. 19–22. Read, Jan. 4, 1876.

† "Proceedings of the Zoological Society," 1832, p. 70.

‡ Vol. iii. p. 425.

Fig. 1.



Sacculated and simple cæca of the Capybara. The continuation of the colon is seen at *a*. The small intestine at its termination cannot be seen, being hidden in the proximal angular bend of the sacculated cæcum.

Page 21. The ileo-cæcal valve is linear and longitudinal; it projects a short distance into the sacculated cæcum from above as a tube with slightly turned lips, of which the inferior is a little the longer and larger. There are some thickened gland-patches in the sacculated cæcum, and a large one in the colon, at the margin of the sphincter which is towards the continuation of the large intestine; three or four others are situated irregularly in the walls of the true cæcum.

The disposition of the colon is peculiar and interesting. The accompanying sketch (fig. 2) will explain it best. It was taken from the view obtained of them as the animal lay on its back. As is well known, the large intestine commences in the left hypochondriac region, the true cæcum capping the end of the sacculated one anteriorly. The
Page 22. gut then, with a curve to the right, runs back to the hypogastric region, where, with a reversed figure-of-eight twist, it gets into the normal position of the ascending colon. It so reaches the right hypochondriac region, and then commences to form, in the transverse colon, coils very similar to, though on a smaller scale than those in *Indris* among the Lemurs and in the Artiodactylate Ungulata, the much-developed loop being twisted on itself to the left side. After reach-

Fig. 2.

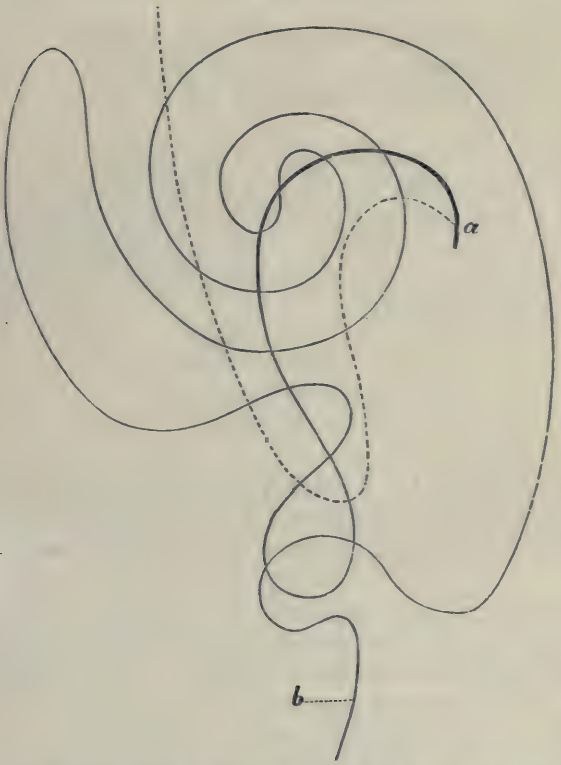


Diagram of the convolutions of the colon in the Capybara. The dotted line represents the cæcum springing from the side of the dilated end of the large intestine, and running forward to the diaphragm. *a*, ileo-cæcal valve; *b*, rectum.

ing the left hypochondrium the descending colon continues straight to the sigmoid flexure, which is strongly developed, and thence to the rectum.

The sacculated cæcum being bound to the first part of the colon by bands of equal length (about 2½ inches), follows the course of that canal, and is therefore doubled on itself, not, as Prof. Owen remarks, occupying the posterior half of the abdomen, but running forwards towards the diaphragm, above the colon, till its caput arrives in the right hypochondriac and epigastric regions, where the ruminant-like coil above referred to is strongly bound to it on its under or ventral surface.

Neither in *Cavia*, *Dolichotis*, *Capromys*, nor in any of the allied forms with which I am acquainted, does the strong sigmoid curve of the large intestine, at the commencement of the sacculated cæcum, develop into a true secondary cæcum in the manner that it does in the Capybara.

Whilst on the subject of the viscera of the Capybara, the following measurements of those of an adult male will not be out of place—small intestine 21 feet, large intestine 6 feet 7 inches, cæcum 1 foot 10 inches.

The liver is comparatively simple. The gall-bladder is pyriform, situated in a cystic fossa, not reaching the free margin of the gland. The right central lobe is slightly more bulky than the left lateral, which is more than twice the size of the left central, which, again, is somewhat larger than the caudate. The Spigelian lobe is minute, and bifid as in so many Rodents.

51. ON A PECULIARITY IN THE CAROTID ARTERIES, AND OTHER POINTS IN THE ANATOMY, OF THE GROUND-HORNBILL (*BUCORVUS ABYSSINICUS*).*

Page 60. A SPECIMEN of *Bucorvus abyssinicus* having recently died in the Society's Gardens, I have had the opportunity of examining the anatomy of that genus for the first time. In all respects, except the one to be referred to as regards its arterial system and a minor myological feature, it agrees with *Buceros*. As is the case in all the Bucerotidæ, there was not a trace of fat to be found on any part of the body of the adult bird, though it may be present in young individuals; and the air-cells extended so extensively among the muscles that on removing the skin no dissection was required to display each muscle from origin to insertion. The muscular tissue was also strikingly compact and dry, as in the Hares among mammals, in which animals also it is known that fat is never deposited. The oil-gland, as in *Buceros*, instead of being simply tufted, was also covered with a dense mat of short feathers, about a square inch in area.

In *Buceros*, as in most birds, the two carotid arteries, immediately they separate from their respective innominate arteries, converge, and meet before they have gone any considerable distance up the neck, to run together in the median hypapophysial canal on the anterior surface of the cervical vertebræ. In some Parrots the left carotid,

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* "Proceedings of the Zoological Society," 1876, pp. 60, 61. Read, Jan. 18, 1876.

instead of coursing the above-mentioned canal with its fellow, runs up along the side of the neck together with the left pneumogastric nerve to reach the head. In *Bucorvus*, in the specimen dissected by me at least,* a further extension of this peculiarity obtains; for both the carotids, instead of meeting and running together, course up the *sides* of the neck in company with the pneumogastric nerves and jugular veins of their respective sides, as they do in mammals, and in no other birds, as far as I am aware. Another peculiarity is, that these abnormally placed carotids are particularly small in calibre; and I noticed that the vertebrals were as conspicuously large, evidently to make up the blood-supply of the head.†

As to the visceral anatomy, it may be mentioned that the uniformly cylindrical crop leads, through the zonary proventriculus, to the stomach, which is much like that of *Buceros*,‡ but more muscular, and with the dense epithelial lining much more firmly attached. Page 61. The intestines are particularly capacious, being quite an inch in diameter; they are four feet in length, and have no colic cæca connected with them. The liver has a gall-bladder; and the left of the two lobes which go to form it is a little the smaller. In the syrinx there is a pair of intrinsic muscles to the first bronchial half-ring. The tongue is almost as small as it is in the Pelicans.

Myologically, of the five muscles in the thigh, which, in my estimation, are specially significant,§ the ambiens is absent, as are the femoro-caudal and the accessory femoro-caudal, the semitendinosus and the accessory semitendinosus being well represented. In this respect *Bucorvus*, therefore, differs from *Buceros* and *Toccus*, the femoro-caudal‖ muscle being present in the two latter genera. As is most probably known to many, *Bucorvus* walks, placing one foot in front of the other, whilst *Buceros* always hops, with both feet together.

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* A second specimen, since received, entirely agrees with the above description.

† [On this subject Mr. W. Ottley's paper, "A Description of the Vessels of the Neck and Head in the Ground-Hornbill" ("Proceedings of the Zoological Society," 1879, pp. 461–7), may be consulted. The author's investigation into the subject was undertaken at Garrod's suggestion.—Ed.]

‡ *Vide* "Transactions of the Zoological Society," vol. I. Plate XVIII. p. 122.

§ "Proceedings of the Zoological Society," 1873, p. 626, and 1874, p. 111. (*Suprà*, p. 187 *et seq.*).

‖ [Called, by a misprint, the *accessory* femoro-caudal in the original. The latter muscle is absent in *all* Anomalogonatous birds.—Ed.]

52. ON THE ANATOMY OF *CHAUNA DERBIANA*, AND ON THE SYSTEMATIC POSITION OF THE SCREAMERS (*PALAMEDEIDÆ*).*

(Plates XIV—XVII).

Page 189. In his memoir "on the systematic position of the Crested Screamer (*Palamedea chavaria*)," published in the "Proceedings" of this Society,† Prof. Parker has placed that bird among the Anseres, and away from the Rallidæ, with which it had been generally associated. In his "Classification of Birds,"‡ Prof. Huxley adopts the same view as Prof. Parker. Both these distinguished authorities base their opinions on anatomical considerations; it therefore behoves me to attempt to substantiate the different views expressed by me in my paper "on certain muscles of Birds, and their value in Classification,"§ as it is so considerably at variance with that of the authorities just mentioned.

The great extent to which the skeleton is permeated with air renders the features presented by the different bones of *Chauna* less distinctive than in the majority of birds. For this reason the soft parts will be first considered.

Cutaneous System. Pterylosis.—Nitzsch has described the pterylosis of *Palamedea cornuta* and *Chauna chavaria;* and, as might be expected, *C. derbiana* does not differ in any important particulars from the latter. As he remarks, the most striking point observed in the plucked bird is the extreme whiteness of the surface, which depends on the fact that the skin is almost universally emphysematous to the depth of nearly a quarter of an inch. On pressing with the finger, the characteristic crackling of a tissue filled with air is most marked, the only places in which it is absent, or nearly so, being the anterior surfaces of the upper ends of the tibia, and, to a less degree, two triangular spaces, equilateral, with their bases towards the middle line, situated one on each side over that part of each pectoral region which is near the head of the humerus, in the apex of the larger triangular surface bounded by the superior and axillary margins of the great pectoral muscle.

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* "Proceedings of the Zoological Society," 1876, pp. 189–200. Plates XII—XV. Read, Feb. 1, 1876.

† "Proceedings of the Zoological Society," 1863, p. 511.

‡ "Proceedings of the Zoological Society," 1867, p. 415.

§ "Proceedings of the Zoological Society," 1874, p. 111. (*Suprà*, p. 208.)

In the Gannet and the Pelican the skin is likewise emphysematous, but not exactly in the same way. In them the superficial surface of the cutis forms a plane surface, and the deep layer another, with the air-cells intervening between them, and the feather-quills traversing them. In *Chauna*, however, these two cutaneous layers are not definable, the whole presenting the appearance as if a non-emphysematous skin had been forcibly blown up, so as to cause its surface to be irregular and bubbled, more like an artificially distended mammalian lung than anything else. The feathers and the semiplumes do not perforate the air-cells, but cause the skin to be indented where they are situated.

The disproportionately massive appearance of the legs is also caused by the presence of air beneath the tessellated skin, which extends almost to the ungual phalanges of the toes. Page 190.

The contour-feathers, many of them, possess a very feeble aftershaft, especially in the region of the nape, as found by Nitzsch in *C. chavaria;* and there is also a slight groove along the posterior surface of the rhachis of each.

The rectrices are twelve in number.

There are twenty-six remiges in one of my specimens; Nitzsch and Sundevall find twenty-seven. Of these ten are primaries, the fourth being the largest. Of the sixteen secondaries the distal twelve are subequal, whilst the proximal four decrease in size as they approach the elbow.

The tufted oil-gland is not strikingly large; it is somewhat flat, with a single orifice on each side, surrounded by a circle of half-inch feathers which constitute the tuft.

The tibio-tarsus is nude for its distal third, being there covered, as over the tarso-metatarse and digits, with small red polygonal scales.

The plumage is uninterrupted, there being no spaces without contour-feathers, except the axillary cavities mentioned by Nitzsch, in which down-feathers only are to be found. The down-feathers are universally distributed. The nude neck-ring of *C. chavaria* is absent in *C. derbiana.* The feathers of the humeral tracts are considerably the strongest of the contour-feathers.

Looked at in its entirety, the pterylosis of the Screamers is unique, and in no way approaches that of the Anserine birds.

Alimentary Canal.—The *palate* is elongate and triangular, with three longitudinal rows of papillæ, which are conical, large, and therefore comparatively few in front, smaller and more numerous behind. They all tend somewhat backwards.

The *tongue* is just over an inch long, and $\frac{3}{8}$ of an inch broad, its sides being parallel for nearly their whole length. The tip is obtusely triangular, with a small papillary fringe at its extremity, $\frac{1}{8}$ of an inch broad. The base is straight, and is edged with spines $\frac{1}{10}$ of an inch long, and shorter, directed backwards. The surface and lateral margins are quite smooth, the whole organ being flattened, slightly grooved longitudinally down the centre, and nowhere more than $\frac{1}{8}$ of an inch thick. At its base are two lateral juxtaposed protuberances, rough on the surface, and together equal in area to one-third of its surface. There is no transverse constriction or oblique groove like that found on the surface of the tongue in some Anatidæ.

The *œsophagus* is uniform in diameter, no crop being even indicated; it is not capacious.

The *proventriculus* is peculiar. It is more than usually capacious, and is glandular only in a patch which occupies but a small portion of its surface. This patch (which is clearly shown in the representation of this portion of the alimentary canal in Plate [14] XII. fig. 1, at its upper end, where the proventricular dilatation ceases) has a Page 191. narrow zonary belt of glands. It can, however, be seen that by far the majority of the glands are aggregated into a posteriorly situated patch. The only birds with which I am acquainted in which the proventricular glands do not form a zone, or an approach to one, are *Struthio* and *Rhea*. In the Gallinæ and Anseres they form a zone.

The glandular surface occupies a subelliptical space, 2 inches by $1\frac{3}{8}$ in its long and short diameters, in the upper and back part of the canal, with the long axis in the direction of the tube. Its lower end is $2\frac{3}{4}$ inches from the upper orifice of the gizzard. The gland-tubes are simple, not racemose, and average $\frac{1}{5}$ inch in length. The remainder of the area of the proventriculus, above five-sixths of it, is covered with coarse and irregularly folded epithelium.

The *gizzard* is constructed on the usual type; it is decidedly small in proportion to the size of the bird (in the Anseres it is as conspicuously large), being much more elongate, narrow, and less muscular than in grain-feeders. Longitudinal folds plicate the triturating surfaces, which are smooth in the Geese, Ducks, and Swans.

The *spleen* is the size of a haricot bean, and of much the same shape. Its position is in no way peculiar; but, as in all birds, being placed *above* the gizzard, it tends to confirm the opinion that the latter organ is only the representative of the pyloric end of the stomach, the cardiac component of which is represented by the proventriculus.

The *liver* is composed of two simple rounded lobes, united by a narrow isthmus of hepatic tissue; the lobes are of nearly equal size; and there is a fairly voluminous gall-bladder.

The following table gives the intestinal lengths:—

	♂		♀	
	ft.	in.	ft.	in.
Small intestine	7	3	6	10
Large intestine	1	1	0	7
Cæca	0	3	0	2

The *duodenum*, with its characteristic bend round the pancreas, is more capacious than the rest of the small intestine; but it is not large, being about $\frac{1}{4}$ inch in diameter. The hepatic and pancreatic ducts enter it at the bend, $2\frac{1}{2}$ inches from the pylorus.

The pair of *cæca* present a condition unlike that found in any other bird with which I am acquainted. In that they are situated some considerable distance from the cloaca, they agree only with *Struthio* and *Rhea*. In the much larger Cassowaries the large intestine is not more than 7 inches long. In both *Apteryx* and the Tinamous, as well as in all other birds, the Anseres and Gallinæ included, the large intestine does not exceed 4 inches in length. *Chauna* in having a large intestine, the length of which is several times the diameter of the gut, agrees therefore with *Struthio* and *Rhea* only. These organs are figured in Plate [15] XIII., they being opened up in fig. 1 to show their internal structure.

Instead of being smooth externally, the cæca are sacculated on two longitudinal bands. They are peculiarly capacious for their length, and fusiform in general outline. The sacculating bands are Page 192. not lateral, but on their outer and inner borders, being continued from the longitudinal fibres of the large and the small intestine. Their mucous membrane is not plicated when they are distended. It is only, among other birds, in *Struthio* and *Rhea* that the cæca are sacculated; in these, however, there is only a spiral twist like that in the cæcum of the hares and rabbits.

Each cæcum has a well-developed special sphincter muscle guarding its aperture of communication with the intestine; and what is more peculiar still is, that they do not open into the colon proper, but into a special cavity, a continuation of the main intestinal tube, but separated off by a very constricting sphincter from the colon, as well as by the ileo-cæcal valve from the small intestine. This ileo-colic cavity is $\frac{3}{4}$ of an inch long and about $\frac{1}{2}$ an inch in diameter when undistended. Its mucous membrane is like that of the cæca, much more delicate than that of the colon. The ileo-cæcal valve is a small slit-like opening, nearly $\frac{1}{4}$ of an inch long, with its lips projecting a little way into the ileo-colic cavity. The two openings of the cæca into the same cavity are one on each side of it, a little oblique in regard to it, and considerably larger in lumen. The opening into the colon is very constricted; beyond it the mucous membrane of the large intestine is, as Dr. Crisp remarks,* transversely plicated, to produce an appearance much like coarse valvulæ conniventes.

Nothing like the above-described condition is to be observed in any other bird, not even in *Struthio* or *Rhea*, in both of which, as typically, the cæca enter the commencement of the uniformly cylindrical colon by fair-sized orifices, not surrounded by a special sphincter. This being the case, I cannot agree with Prof. Parker's remark† that "there is nothing whatever in the digestive organs, which are extremely voluminous, to separate the bird from the Geese."

Respiratory Organs.—Prof. Parker‡ remarks, "the trachea and inferior larynx are truly anserine; for there are no inferior laryngeal muscles, the contractors of the trachea ending one-third of an inch above the bifurcation, and only a delicate fan-shaped fascia going to the half-rings. Moreover the trachea itself, from being flat and cartilaginous, becomes round and then compressed, and osseous an inch above the bronchi, so that it cannot be mistaken for any other than the trachea of an anatine bird." In that the lower end of the trachea is of smaller diameter than is the tube higher up, in that in the same part the constituent rings are in close contact without scarcely any intervening membrane, in that there are two pairs of tracheal muscles running to the thoracic parietes, and in that the intrinsic lateral tracheal muscles end before they reach the bifurcation of the bronchi, the syrinx of the Screamers approaches that of some of the Anseres; but in that there is no special modification of the organ in the male, and in the absence of chondrification or ossification of what are **Page 193.** generally present as dilating rings or half-rings to the bronchi, the Screamers are not Anserine, and in the latter feature peculiar.

There is nothing remarkable in the rings of the windpipe, their interlocking producing the well-known key-pattern. The last two are greatly compressed laterally, so that the membranous bronchi, in each of which there are only a very few slender half-rings, arise quite close together. As can be seen from the figures, Plate [14] XII. figs. 2, 3, 4, the lateral muscles of the trachea are peculiarly powerful; the upper extrinsic pair is inserted into the middle of the membrane which runs between the body of the coracoid bone and the corresponding limb of the furcula on each side; the lower close to the costal process of the sternum, at the back of the sterno-coracoid articular margin of the former bone. The intrinsic muscle on each side descends the windpipe to end by bifurcating opposite the origin of the sterno-tracheal muscle, and ceases, its anterior portion higher than its posterior, six or seven rings lower down, some distance above the bifurcation of the

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* "Proceedings of the Zoological Society," 1864, p. 16.

† "Proceedings of the Zoological Society," 1863, p. 514.

‡ *Loc. cit.*

bronchi. The above-mentioned extremely delicate nature of the commencing bronchial tubes is most peculiar.

The lungs present no special features of interest.

There are several myological characters which, though small in themselves, all go to form the exact definition of any group of birds, and aid in the determination of affinities. Among the more important of these are the presence or absence of the ambiens muscle* (which is of fair size in *Chauna*), the presence or absence of the femoro-caudal, the semitendinosus, and their accessory heads (which are all four found in *Chauna*). Having dwelt fully on the importance of these muscles in the paper just referred to, all I need remark on the present occasion with regard to them is, that there is therefore a difference between this bird and all the true Anserine birds, in none of which is there ever a trace of the accessory semitendinosus. A reference to my paper on the muscles of the thigh of birds will show that in possessing all the five above-mentioned muscles the Screamers agree only with the Gallinæ and their nearest allies, the Rallidæ, Musophagidæ, Cuculidæ, Columbæ, and some of the Limicolæ.

With reference to secondary myological points, there are four which, in my estimation, deserve special attention. They are:—

1. The presence or absence of the *expansor secundariorum* muscle.
2. The presence or absence of a special muscular slip from the *biceps humeri* to the patagium.
3. The area of the origin of the *obturator internus.*
4. The degree of development of the *tensor-cruris fasciæ.*

These will be considered separately.

1. *The presence or absence of the Expansor secundariorum muscle.*

Expansor secundariorum is the name which it is my habit to employ for a very small and peculiar triangular muscle arising from the quills of the last few (generally two or three) secondary remiges at the elbow. Its remarkably long and slender tendon, which frequently traverses a fibrous pulley on the axillary margin of the *teres* muscle, runs up the arm side by side with the axillary vessels and nerves to be inserted in the thorax, into the middle of a tendon which runs from the inner side of the middle of the scapular element of the scapulo-coracoid articulation to near the middle of the thoracic border of the sterno-coracoid articulation, at right angles to it when the fore limb is extended. This arrangement being found very well differentiated in the Storks may, for the sake of convenience, be termed *Ciconine.* In *Chauna* it is exactly the same, as may be seen from the accompanying drawing (Plate [16] XIV. fig. 1, *e.s.*). Page 194.

In the majority of the Gallinaceous birds the *expansor secundari-*

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* *Vide* "Proceedings of the Zoological Society," 1874, p. 116. (*Suprà*, p. 213.)

orum, with the normal origin from the secondary quills, has a different method of insertion, which has led M. A. Milne-Edwards to describe the muscle in the common Fowl as a part of the *coraco-brachialis* (*brevis*) in his superb work on fossil birds.

In the genera *Tetrao*, *Francolinus*, *Rollulus*, *Phasianus*, *Euplocamus*, *Gallus*, *Ceriornis*, and *Pavo*, the muscle, instead of being inserted into the scapulo-sternal fibrous band above referred to, after blending to a certain extent with the axillary margin of the *teres*, ceases by becoming fixed to a fibrous intersection about one-third down the *coraco-brachialis brevis* muscle.

In *Francolinus clappertoni* from among the Francolins, *Coturnix*, *Odontophorus*, *Ortyx*, *Eupsychortyx*, and *Numida*, the tendon does not go so far as the short *coraco-brachialis*, but ends either by simply joining the axillary margin of the *teres*, or by at the same time sending a tendinous slip behind it to the scapula. In *Argus giganteus* the tendon, running from the elbow, turns round the axillary border of the *teres* to end by joining a triangular muscular fasciculus, attached by its base to the upper portion of the thoracic surface, which appears to be nothing but a differentiation-off of the upper portion of the last-named muscle. In the Cracidæ this insertion into the scapula is also found, but it is tendinous, like the upper element of the thoracic band above described in the Storks and *Chauna;* and in them there is also a second tendinous slip from the axillary margin of the *coraco-brachialis longus* (Plate [14] XII. fig. 5) (not the *brevis*). In the Megapodidæ also the attachment to the *coraco-brachialis brevis* is wanting, the tendon ending either by blending with the *teres*-margin, or running on to the scapula.

In the Ducks and Geese among the Anseres the tendons under consideration, when they enter the thorax, run towards one another and join, after having expanded out, in the middle line, in front of the œsophagus, and behind the trachea. In the Swans this arrangement is not found, the tendons ending in the ciconine manner, or by running to the upper end of the scapula; and in this respect *Sarcidiornis* resembles them.

From the tabular statement now exhibited (see p. 329) the nature as well as the presence or absence of this muscle can be determined in any special group of birds. The only Anomalogonatous birds in which I have found this muscle are the Coraciidæ.

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2. *The presence or absence of a special muscular slip from the Biceps humeri to the Patagium.*

The *biceps humeri*, the main flexor of the arm, arises from the upper end of the coracoid bone, and from the upper portion of the flexor surface of the humerus. In certain birds this muscle sends off from its upper end a slender fusiform belly, which runs through the proximal portion of the patagium to join its marginal tendon near the middle of its course (Plate [16] XIV. fig. 2). The presence or absence of this muscular fasciculus is a very constant character among closely allied birds. In the Table (p. 329) are recorded the names of all those birds in which, according to my experience, it is to be found. The only Anomalogonatous birds in which I have seen it are the Caprimulgidæ.

3. *The Area of Origin of the Obturator internus.*

It is not my intention on the present occasion to enter into the consideration of whether the muscle here called *obturator internus* is homologous with the same-named muscle in Mammalia; suffice it to say that it arises from the pelvic surface of the pubis and ischium, and ends by a tendon which is inserted into the outer surface of the head of the femur.

In a large number of birds, on looking at the pelvic view of this muscle when undisturbed, its shape is seen to be an elongated oval, occupying the obturator fossa, and covering the line of junction of the ischium and pubis. In another large number of birds, instead of being oval it is triangular, its posterior fibres expanding in such a way as to cover most of the pelvic surface of the ischium. There are a few birds in which an intermediate condition is found; they are, however, very few. In most there is not the least difficulty in deciding whether the *obturator internus* is *oval* or *triangular* (compare Plate [17] XV. figs. 1 and 2). From the Table (p. 329) the arrangement existing in most birds can be found.

4. *The degree of Development of the Tensor-cruris fasciæ.*

To this point I have referred in my paper on the muscles of Birds,* where its relations are explained. "It is the superficial muscle of the outside of the thigh, covering the femur. It is flat and triangular in shape, and arises as a membranous expansion which covers the gluteus ii., from the lower two-thirds of the posterior border of the iliac fossa in which that muscle is situated, and from the fibrous septum which separates that muscle from the gluteus iii. Further down it has origin also from the whole length of the ridge which separates the postacetabular area from the external lateral surface of the ischium, and which may be termed the postacetabular ridge, as well as from the posterior border of the ischium, as far

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* "Proceedings of the Zoological Society," 1873, p. 628. (*Suprà*, p. 189.)

forwards as its junction with the pubis, being here slightly overlapped by the semitendinosus. The fibres converge towards the knee; and the deep portion of the muscle blends in its course with the vastus Page 196. externus, together with which it continues forward to become part of the broad thin tendon which covers the knee and is inserted in the front of the tibia-head, the patella being situated in it, together with the long, slender, and flat tendon of the *ambiens* muscle, which is situated below it, running obliquely from inside and above, outwards and downwards. In many birds this muscle does not extend below the level of the femur, but ends inferiorly by blending with the vastus externus; and consequently, where such is the case, it evidently cannot, as it does otherwise, cover any of the flexors of the leg." Whether this postacetabular portion of the *tensor fasciæ* is present or absent can be found by referring to the Table (p. 329). There are not many birds in which it is very small.

As the Anserine affinities of the Screamers are being discussed, it ought to be mentioned that in all the former the great pectoral flexor of the wing is peculiarly elongate, and extends upwards above the *symphysis furculæ*, with its fellow forming a medium raphe as an anterior continuation of the *carina sterni*. The only other birds in which this occurs are the Penguins. In the Screamers the great pectoral flexor is not large, and does not extend upwards above the middle of the furcula.

In the Anseres the extensor pectoral (second pectoral) is always very long and broad, reaching the lower end of the sternum. In *Chauna* it does not extend nearly to the posterior margin of the sternum, and it is not bulky.

Again, the muscles of the Anseres are always intensely dark in colour, whilst in the Screamer they are quite pale. In this respect the two groups differ in the same way as do the Seals and the Sirenia among Mammals.

Osseous System.—The skull, being that portion of the skeleton which is least permeated with air, will receive the greatest attention on the present occasion. With reference to it Prof. Parker remarks*, "All the skull and face, except at its two ends, conforms to the lamellirostral type." Prof. Huxley also places *Palamedea* in his group "Chenomorphæ," among the several features characterizing those birds being that "the lachrymal region of the skull is remarkably long." That such is not the case in *Chauna*, Prof. Parker has remarked in his article "Birds" in the Encyclopædia Britannica †.

It may be well before proceeding further to inquire more fully

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* "Proceedings of the Zoological Society," 1863, p. 514.

† "Enc. Brit.," 8th edit., vol. iii., p. 712.

into the nature of the lamellirostral type. Prof. Parker tells us that "the great embryological distinctions between the skull and face of the Geese and Fowls are, first, that in the latter the space between the periotic mass and the superoccipital cartilage is a mere chink, in the former a persistent oval space; and secondly, that the anterior parts of the face, viz. the præmaxillæ, prævomers [maxillæ], and dentaries are small and compressed in the Fowls, large and outspread in the sifting birds." A glance at the accompanying figures of the posterior surface of the skulls of a Magellanic Goose, a Derbian Screamer, and a Razor-billed Curassow will enable the reader to decide for himself which of the two groups, the Anseres or the Gallinæ, the Screamer more closely approaches. It evidently does not share Page 197. the peculiarities of the former, in all species of which the surface of origin for the pair of large extensor muscles of the mandible is characteristically compressed from side to side, and elongated from above downwards, at the same time that there is the pair of openings above the foramen magnum (figs. 1, 2, 3, p. 328).

Again, from a comparison of the inferior surfaces of the same three skulls, it is equally evident that in the Screamer the præmaxillæ, maxillaries, and dentaries agree with the same bones in the Gallinaceous bird in not being large and outspreading. The palate of *Chauna* is represented in fig. 4.

In the Screamers the skull is, no doubt, as in the Anseres, desmognathous, having the maxillo-palatines united across the middle line; but this character is not sufficiently important to compel us to unite the two groups; for if such were the case it would be necessary to give credence to an association of birds which is in other respects extremely unnatural. In the Capitonidæ, for instance, *Megalæma* is not desmognathous, whilst *Tetragonops* is so.

As before stated, in the Anserine birds the lachrymal region is specially long. This is least marked in the *Cereopsis* Goose (*Cereopsis novæ-hollandiæ*), where, however, it is clearly apparent. In *Chauna*, the lachrymal region is as short as in the Gallinæ, not in the least elongated.

In both the Anseres and Gallinæ the pterygoid bones have large faceted surfaces for articulation with the basisphenoid rostrum. In both groups these facets are situated very far forwards—quite at the anterior ends of the bones in the latter; in *Chauna*, however, these articulations are quite independent of the anterior ends of the bones (fig. 4), being nearly as far backward as the middle of their otherwise free moieties.

As to the quadrate bones, their cranial articulations are bifid, which is the case in all birds except *Struthio*, *Rhea*, *Dromæus*, *Casuarius*, *Apteryx*, the Crypturi, and *some* (most) of the Gallinæ.

They do to a certain extent resemble the same bones in the Anseres in having the articular surfaces for the jugal arches situated some way behind the level of their mandibular articulations (not a Gallinaceous character), which latter they also resemble in configuration, the usually extended outer facet not running backwards and inwards as in most birds but not in the Gallinæ.

In the Gallinæ, as in the Crypturi, the pterygo-quadrate articulation is much longer than in other members of the class. In *Chauna* this is not the case.

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Fig. 1.

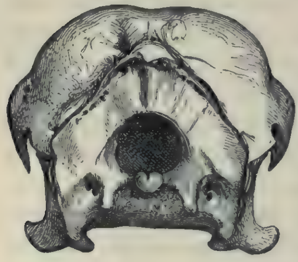

Fig. 2.

Fig. 3.

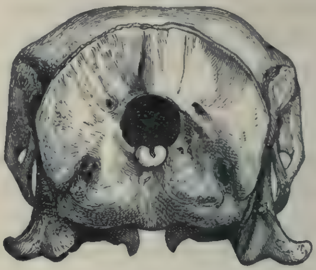

Fig. 4.

Fig. 1. *Chauna derbiana.* Back view of skull.
Fig. 2. *Chloëphaga magellanica.* Back view of skull.
Fig. 3. *Mitua tuberosa.* Back view of skull.
Fig. 4. *Chauna derbiana.* Base of skull.

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In *Chauna* the angle of the mandible is much prolonged and upcurved, as in the Anseres, from which it however differs in not being deeply excavated in the interval between the upturned process and the inwardly-directed articular angle. It must be remembered that the mandible is much the same in the Gallinæ.

It must also be remembered that the Screamers are the only birds in which there are no uncinate processes to the ribs, as has been shown by Mr. Parker.

TABLE.

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Name of family.	Expansor secundariorum (see p. 323).	Biceps slip to the patagium (see p. 324).	Obturator internus (see p. 325).	Postacetabular portion of tensor fasciæ (see p. 325).
TINAMIDÆ	Ciconine.	Absent.	Triangular.	Large.
PALAMEDEIDÆ .	Ciconine.	Absent.	Oval.	Absent.
GALLINÆ	Present (vide p. 324).	Absent only in Cracidæ.	Triangular.	Large.
RALLIDÆ	Ciconine.	Present.	Triangular.	Large.
OTIDÆ	Ciconine.	Absent.	Oval.	Present.
Cariama	Ciconine.	Absent.	Triangular.	Present.
Phœnicopterus ..	Ciconine.	Present.	Oval.	Present.
Serpentarius....	Ciconine.	Absent.	Triangular.	Absent.
MUSOPHAGIDÆ .	Ciconine.	Absent.	Triangular.	Present.
CUCULIDÆ	Ciconine.	Absent.	Triangular.	Present.
PSITTACI.......	Absent.	Absent.	....	Absent.
ANATIDÆ	Ciconine in Cygninæ, peculiar in others (vide p. 324).	Present.	Peculiar from elongation of pelvis.	Present, except in Cygninæ.
SPHENISCIDÆ ..	....	....	Triangular.	Absent.
COLYMBIDÆ	Not seen.	Present.	?	Present.
PODICIPIDÆ....	Not seen.	Present.	Oval.	Present.
PROCELLARIIDÆ	?	?	?	?
FULMARIDÆ....	?	?	Oval.	Absent.
PELARGI	Ciconine.	Absent.	Oval.	Absent, or extremely small.
CATHARTIDÆ ...	Ciconine.	Absent.	Triangular.	Present.
HERODIONES ...	Ciconine (not in *Cancroma* and *Egretta*).	Absent.	Triangular.	Absent, or extremely small.
STEGANOPODES .	Absent.	Absent, except in *Phalacrocoracidæ*.	Oval.	Absent.
ACCIPITRES	Absent (not in *Falco*, *Polyborus* and *Tinnunculus*).	Absent.	Triangular (except *Neophron*).	Absent.
STRIGIDÆ	Absent.	Absent.	Triangular (not *Scops*).	Absent.
COLUMBÆ......	Feeble or absent.	Present.	Oval.	Present.
CHARADRIIDÆ ..	Ciconine.	Present.	Oval.	Present.
GRUIDÆ	Ciconine.	Present.	Triangular.	Present.
LARIDÆ........	In some.	Present.	Oval.	Absent.
ALCIDÆ........	Absent.	Present.	Oval.	Present (not in *Arctica alle*?).

In conclusion, it seems to me that from considerations of pterylosis, visceral anatomy, myology, and osteology, the Screamers cannot be placed along with the Anserine birds. In the windpipe and the form of the angle of the jaw they, no doubt, closely approach them. In their alimentary canal they are much nearer to *Struthio* and *Rhea* (not *Dromæus* and *Casuarius*) than to any other birds. There is a Ciconine tendency in their myology, whilst their osteology points in no special direction. It seems, therefore, to me that, summing these Page 200. results, the Screamers must have sprung from the primary avian stock as an independent offshoot at much the same time as did most of the other important families. It may be fairly asked what reason there is for the assumption that there was a sudden break up of the bird-type at any particular period. It appears to me from the study of anatomy that this was the case; and it is evident that the acquisition of wings by the previously terrestrial type form must have suddenly interpolated a large number of intruders into domains already occupied, and must have all at once called forth a new aerial struggle for existence, which, from the generalness of its action must, within a short time, have brought out a great number of special characters by natural selection.

EXPLANATION OF THE PLATES.

Plate 14 (XII.)

Fig. 1. Proventriculus and gizzard of *Chauna derbiana*, cut open, and part of the front wall removed.
2. Anterior view of lower portion of windpipe of *C. derbiana*.
3. Back view of same, the muscles of the left side having been removed.
4. Right side view of same.
5. Portion of right coracoid bone (*c*) with *coraco-brachialis longus* (*c.b.c.*) and *coraco-brachialis brevis* (*c.b.b.*) *in situ* of *Crax globicera*. The *expansor secundariorum* (*e.s.*) is seen to spring partly from the first-named muscle.

Plate 15 (XIII).

Fig. 1. Cæca of *Chauna derbiana*, with the anterior wall partly removed to show the cavity intervening between the small and large intestine into which the cæca open.
2. The cæca, external view.

Plate 16 (XIV).

Fig. 1. Axillary muscles of right side of *Chauna derbiana*. *e.s*, expansor secundariorum; *p* 1, great pectoral; *p* 2, second pectoral; *c.b.l*, coraco-brachialis longus; *b*, biceps; *t*, triceps; *t.p.b*, tensor patagii brevis; *sc*, scapula; *st*, sternum; *c*, coracoid; *f*, furcula; *h*, humerus; *c.v*, cervical vertebræ; *tr*, trachea: *pat.*, patagium; *S.R*, secondary remiges.
2. The same part, left side, of *Gallinula chloropus*. *B. slip*, biceps slip; *t.p.* tensor patagii longus.

PLATE 17 (XV).

Fig. 1. Muscles of right side of interior of pelvis and inner side of thigh of *Chauna derbiana*, the muscles of the anterior abdominal wall having been removed. *o.i*, obturator internus: *Amb*, Ambiens; *Quad*, Quadriceps extensor; *Ad*, adductor; *S.t*, semitendinosus.

2. The same parts of *Euplocamus albocristatus*, similarly lettered. *Sart*, sartorius.

53. ON THE ANATOMY OF *ARAMUS SCOLOPACEUS*.*

IT being very seldom that an opportunity occurs for the study of the Page 275. anatomy of *Aramus*, a form the exact relations of which are but little understood, I take the opportunity of describing this bird from a female specimen which reached the Society's Gardens alive, and died, much emaciated, within a few days, on Oct. 7, 1875. I may mention that the generic name *Scolopax* was applied to it by Linnæus, and that Lichtenstein termed it *Rallus gigas*. Mr. G. R. Gray† places it among the Rallinæ, next to *Rallus aquaticus*, whilst Messrs. Sclater and Salvin‡ include it among the Alectorides, together with *Eurypyga*, *Cariama*, and *Psophia*. It seems to me, however, that, considering its different anatomical features, it is most intimately related to *Grus*, which, with it, is not distant from *Ibis*, *Platalea*, and *Eurypyga*.

With reference to the skeleton of *Aramus*, it may be mentioned that it is figured as a whole in Eyton's "Osteologia Avium" (pl. xiv. K), and in the same valuable work (pl. 27. fig. 2) a front view of the sternum, and a back view of the pelvis are given, though the plate is incorrectly lettered.

In Audubon's "Ornithological Biography"§ a full account of the viscera is given, with a woodcut of the alimentary canal. The author considers the bird to be most intimately allied to the Rails.

Aramus is a strongly schizorhinal bird;‖ in other words, the openings of the external osseous nares extend further backwards than the posterior ends of the nasal processes of the præmaxillæ. In this respect it agrees with *Grus*, *Eurypyga*, and the Limicolæ, but not with the Rallidæ, nor with *Cariama*, nor with *Psophia*.

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* "Proceedings of the Zoological Society," 1876, pp. 275–7. Read, March 7, 1876.

† "Hand-list of Birds," vol. iii. p. 58.

‡ "Nomenclator Avium Neotropicalium," p. 141.

§ Vol. iv. p. 547 *et. seq.*

‖ *Vide* "Proceedings of the Zoological Society," 1873, p. 33. (*Suprà*, p. 124.)

As in *Grus*, *Ibis*, and *Platalea*, the lachrymal bones do not blend with the region of the skull where they are attached; in the true Limicolæ they do so. The palate is schizognathous, the maxillo-palatines long, the vomer pointed, and the pterygoids out-spreading at both ends exactly as in *Grus*. As in that genus, also, there is a pair of occipital foramina, like those in *Ibis*, *Platalea*, and the Limicolæ; but these do not occur in the Rallidæ, nor in *Cariama*, nor in *Psophia*. (Figs. 1, 2, and 3 illustrate these points.)

The sternum is completely Gruine, as are the other parts of its skeleton.

The *pterylosis* of *Aramus* has been fully investigated by Nitzsch,*

Fig. 1. Skull of *Aramus scolopaceus*, palatal view.
2. Ditto ditto lower jaw.
3. Ditto ditto top view.

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* Ray Society's English Translation, p. 125.

who found that it agrees exactly with that of *Psophia* and *Grus*, and with no other bird. The peculiarities of the feathers themselves led that illustrious naturalist to place it with the Rails, from which it differs in more than one pterylographic particular.

There are two carotid arteries; and the right jugular vein, as is Page 276. frequently the case, is considerably the larger of the two.

The trachea is simple (the specimen is a female); the syrinx is somewhat dilated; and a single pair of intrinsic muscles is continued to the bronchial half-ring.

Myologically, the ambiens muscle is strong; the femoro-caudal (A) is absent, the accessory femoro-caudal (B) is thin and small; the semitendinosus (X) and the accessory semitendinosus (Y) are fairly developed. Its muscle-formula* is therefore B, XY. In *all* the Rallidæ the formula is AB, XY, the femoro-caudal being large. In *Psophia* it is B, XY, as it is in *Cariama* (in *Chunga* B is also absent). Page 277. In *Balearica regulorum* the formula is XY; in *Grus antigone* it is AB, XY, the femoro-caudal being reduced to almost a thread; in *Anthropoides virgo* the formula is AB, XY, as it is in *Ibis* and *Platalea*, as well as in *Eurypyga*. Myology therefore does not militate against the Gruine affinities of *Aramus*.

Further, as in *Grus*, the tensor fascia covers the biceps cruris; the biceps humeri muscle sends a special belly into the patagium; the expansor secundariorum is Ciconine; the obturator internus has a triangular origin.†

Alimentary canal.—The *tongue* is 2½ inches long, very slender, quite smooth, nearly cylindrical, and tapering to a fine point in front. It has a slight papillary fringing at its posterior edge. The *œsophagus* is very capacious, although no crop is developed. The *proventriculus* is zonary; its glands are cylindrical and short. Between it and the gizzard is a capacious dilatation of the termination of the gullet, lined, apparently, with squamous epithelium, the volume of which is greater than that of the interior of the gizzard itself. The gizzard is not large, and its muscular walls are not thick. The *liver* has the left lobe a little larger than the right, a condition far from common among birds; the gall-bladder is present. The average-sized, or slightly narrow, *intestines* are 40 inches in length. The *cœca* are somewhat dilated toward their blind ends; they are 2 and 2¼ inches long. They are peculiar in being situated laterally, and close together, instead of opposite one another, a condition approximated to in most of the non-columbine Schizorhinal birds, and in them only; the small intestine

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* *Vide* "Proceedings of the Zoological Society," 1874, p. 111. (*Suprà*, p. 208.)

† For further reference to these points, *vide* "Proceedings of the Zoological Society," 1876, p. 195. (*Suprà*, p. 324.)

therefore enters the colon by a lateral, slit-like opening. In the Cranes the cæca are generally between 5 and 6 inches long; and they being so much larger, the comparative size is much the same. In *Ibis*, *Platalea*, and *Eurypyga* they are very much shorter; in *Cariama* they measure 10 inches, whilst in *Psophia* their length is much the same as in *Aramus*.

54. NOTES ON THE ANATOMY OF *PLOTUS ANHINGA*.*

(Plates XVIII—XX.)

Page 335. THE Darter is one of those birds whose anatomy, with the exception of its skeleton, is comparatively little known; I therefore take the present opportunity of describing the organs and some of the most important muscles of *Plotus anhinga* from the two specimens which were recently living in the Society's collection, and which, from my prosectorial advantages, it has been my good fortune to be able to dissect.

On December 28th, 1872, the Society became possessed, for the first time, by purchase, of a male specimen of *Plotus anhinga*, which died on the 17th of last month, with general jaundice and distention of the gall-bladder from obstruction of the common bile-duct. The second specimen, a female, was purchased on the 30th of September, 1875; it was never quite healthy, and died on the 7th of February, without any special organic lesions, but with a dropsical condition of the subcutaneous areolar tissues, frequently found in Steganopod birds. It is this second specimen which I first dissected; and the other coming to hand, opportunely for me, has enabled me to verify my observations.

Pterylographically, there is nothing for me to add to the results arrived at by Nitzsch.† The skin is not in the least pneumatic, in which respect it contrasts greatly with *Sula* and *Pelecanus*, and agrees with *Phalacrocorax*.

With reference to the anatomy of its circulatory organs, it is to be noted that *Plotus anhinga* possesses only a single carotid artery, the

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* "Proceedings of the Zoological Society," 1876, pp. 335–45. Pls. XXVI—XXVIII. Read, April 4, 1876.

† "Pterylography," Ray Society's Translation, edited by P. L. Sclater, F.R.S., p. 151.

left. In *Sula bassana*, *Phalacrocorax carbo* and *P. lugubris*, *Fregata aquila*, and *Phaethon* there are two. In *Sula fusca* (a specimen in very bad immature plumage from Port Lemon, Porto Rico) the left carotid only exists, as also in *Pelecanus rufescens* and *P. onocrotalus*.

As to the respiratory organs, from Plate [20] XXVIII. fig. 3, it can be seen that the syrinx is in no way peculiar, a single pair of intrinsic lateral muscles being present. By the side of it I have figured the lower portion of the windpipe of a male Gannet (*Sula bassana*), in which a pair of fatty bodies are developed just above the bifurcation of the bronchi, the like of which I have not elsewhere seen.

Osteologically *Plotus anhinga* deserves some special attention. **Page 336.** Brandt[*] in his valuable memoir on avian anatomy has fully described and figured the skeleton. Nevertheless from his drawings of the vertebræ of the cervical region it is evident that he was not thoroughly acquainted with the peculiarities of their mutual articulation.

Eyton[†] describes chiefly the osteology of *Plotus novæ-hollandiæ*, but does not give figures. The specimen he refers to is in the College-of-Surgeons' Museum (No. 1179 A). His drawing of *Phalacrocorax cristatus*[‡], however, makes it apparent that he fully realizes the peculiarity of the mutual relationships of the cervical vertebræ of its close allies.

W. Donitz[§] draws attention to a peculiarity in the cervical region of *Plotus levaillantii* which will be referred to further on. This peculiarity is not represented in Brandt's figure of *P. anhinga;* and it is not to be found in either of the Society's specimens, one being at least three and a half years old.

In speaking of *Phalacrocorax cristatus* Mr. Eyton remarks, "The tubercle on the upper edge of the occipital bone has a pointed, movable, triangular process attached to it, which I suspect has also been the case with my specimen of *Plotus*, but has been lost."

In the Society's female specimen there is a fibro-cartilaginous similarly situated process, not more than one-sixth of an inch long, which is ossified in the evidently older male. In his notes on the anatomy of the Cormorant, Hunter tells us[||] that "a small bone, about an inch long, passes back from the os occipitis and gives origin to the temporal muscle, which is very strong." The same bone in the Darter, although comparatively not so long, performs the same function, the superficial temporal muscles meeting behind the skull along the median

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[*] "Mémoires de l'Acad. Imp. Sciences de St. Pétersbourg," tom. v. 6ème Série, Sect. d. Sc. Nat. 1839

[†] "Osteologia Avium," p. 218.

[‡] *Loc. cit.* pl. v. f. 1.

[§] "Archiv. für Anat. u. Physiol.," 1873, p. 357.

[||] "Essays and Observations," edited by Prof. Owen (1861), vol. ii. p. 328.

raphe, which becomes ossified to form the above-mentioned bony style in the adult bird. (See Plate [20] XXVIII. fig. 1 *a.*)

Before commencing the description of the cervical articulations of the Darters, it may be mentioned that the same condition is observed, only in a less marked degree, in the Cormorants, and still less in the Gannets and Pelicans.

The first eight cervical vertebræ (including the atlas and axis), when articulated together in such a way that all the articular surfaces are in their proper relations one to the other, form a continuous curve with a strong concavity forwards. So considerable is this curve, that when the beak of the bird is horizontal the axis of the peculiarly long eighth vertebra is parallel to that of the skull, or very nearly so. The curve is not a part of a circle, but is one which gradually augments in acuteness from above downwards, its most considerable development being between the 7th and 8th vertebræ, which are consequently articulated at a considerable angle with one another, more strongly marked than that between the 6th and 7th, and this, again, more decided than that between the 5th and 6th, and so on. Page 337.

The 8th and 9th vertebræ articulate so as to form an angle exactly the opposite in direction—namely, with its genu directed forwards instead of backwards. The same is the case with the 9th and 10th, the 10th and 11th, the 11th and 12th, the 12th and 13th; more slightly so between the 13th and 14th, and the 14th and 15th; whilst the 15th and following until the last (the 20th), which with the one above it carries imperfect ribs, form almost a straight line with one another, being slightly bowed, with the convexity directed backwards.

With the exception of the atlas and the 6th and 7th, the cervical vertebræ are peculiarly elongate, the 8th being more so than the others, as may be seen in Plate [18] XXVI. fig. 1.

Donitz figures a pair of accessory bony bridges on the dorsal surface of the vertebra following the most lengthy one, which must evidently therefore be the 9th. He however, speaks of it as the 8th, which seems to me to be an error depending on the omission of the consideration of the atlas, because in *Plotus anhinga* (both from Brandt's figure and my specimens) it is most certainly the 9th, as it is in *Plotus novæhollandiæ*, *Phalacrocorax carbo*, and *P. lugubris.* I have, however, not seen *Plotus levaillantii.*

Donitz attributes the peculiar kink of the neck of the Darters, which it is impossible to obliterate without lacerating the surrounding muscles, to the presence of the bony bridges he describes; in this, however, he is mistaken, it depending on the above-mentioned peculiarity in the 8th cervical vertebra, by which it is angularly articulated with the 7th and 9th vertebræ, the upper genu being posterior, and the lower anterior. In further verification of this, it may be stated that in *P. anhinga* the bony bridges do not exist, and yet the kinking is most strongly marked.

Myologically the cervical region of the Darter is very peculiar, on account of the great concentration of its muscular mechanism towards the thoracic end of that segment of the body, the tendons from them running lengthy courses up the neck. The anterior and the posterior cervical muscles will be considered separately.

Anterior cervical region.—Normally in birds, the *longus colli anterior* or great front flexor muscle of the neck, commences as a series of thin tendinous slips from the middle of the bodies of the first two or three vertebræ which carry complete ribs (true dorsals). The fibres diverge and ascend in such a manner that they form a bilateral median mass acutely triangular at its lower end. They receive continual accessions from the bodies and hæmapophyses of the cervical vertebræ, ending in slips which are attached, successively, to the apices of the anterior transverse processes three or four higher than the vertebræ whence they sprang. Through the whole length of the cervical region they are of very similar mass, and therefore help to maintain the otherwise fairly uniform diameter of the vertebral column*.

In *Plotus* this uniformity is considerably disturbed, irrespective of **Page 338.** the above-described kink, by the excessive development of the *longus colli* in its lower almost interthoracic portion, as well as, though to a less degree, by the enlargement of the *longus colli posterior* behind.

In *Plotus anhinga*, as above stated, there are 20 cervical vertebræ. A small slip of the *longus colli* arises from the body of the third dorsal vertebra, which is inserted into the transverse process of the 17th cervical. Above, and in contact with this, is another similar slip to the 16th cervical. From the bodies of the 2nd and 1st dorsal vertebræ, as well as from the antero-median portions of the six lower cervical vertebræ, a large muscle arises on each side, in layers (somewhat resembling the layers formed by the basally expanded petioles of an onion bulb)—the lower being partially enclosed in the upper—which ultimately form a bipenniform mass with a tendon running axially through it and continually receiving additions in the form of outer coverings of tendinous tissue arising from the enclosing muscles, till it forms a strong single tendon which courses up the front of the neck, close to the middle line on each side, to be inserted into the downward-directed, peculiarly long hæmapophysial spine of the 8th cervical

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* *Vide* Owen on *Apteryx*, "Transactions of the Zoological Society," vol. III. Pl. XXXIII. p. 310.

vertebra, and gives off slips, on its way up, to the serially homologous processes of the 9th and 10th vertebræ. A similar tendinous slip to the 11th vertebra has an independent origin from the bodies of the 15th and 16th vertebræ, internal to the main muscular mass, which is almost the size of a lemon, and with its fellow of the opposite side, of much the same shape, filling up and projecting beyond the slight anterior concavity above mentioned, formed by the mutual articulations of the 15th, 16th, 17th, 18th, and 19th cervical vertebræ. (In Plate [18] XXVI. figs. 1 and 2, these different details are clearly shown.)

Posterior cervical region.—Here is an exaggerated development of muscle in the juxta-thoracic part, opposite the similar enlargement in front, although it is not so considerable behind. The *longus colli posterior* is the muscle which is excessively developed. It becomes differentiated from the posterior dorso-spinal mass opposite the 14th and 15th cervical vertebræ to run up the neck in the form of a fleshy belly which receives additional origins, in the form of muscular slips, from the vertebræ as high as the 9th cervical. Where the slip from the 10th vertebra (which is a small one) joins it, the muscle becomes tendinous, forming a rounded cord, to the inner side of which the large fasciculus from the 9th vertebra is attached.

A reference to the account given above of the disposition of the vertebræ in this region will make it evident that the tendon of the *longus colli posterior* must make a considerable backward turn opposite the transverse line of articulation between the 8th and 9th cervicals —because there the two bones meet at a considerable angle, *with the genu directed forwards.* This being the case, some special mechanism is essential to prevent the tendon from breaking away from the
Page 339. vertebral column when the muscle with which it is associated contracts. In fact, a pulley has to be formed round which the tendon may turn in the same manner that at the knee, in birds, the *biceps cruris* is able to act upon the fibula from a point situated some way down it, because it is bound closely to the greatly bent knee-joint by the well-known sling-band in that region. In Plate [18] XXVI. figs. 1 and 2, the sling-band here described is clearly shown.

A similar sling-band is found in the posterior cervical region of those birds which have any great backward curve of the neck, it in the Gannets being also associated with the 9th vertebra. It is nothing more than a specialization and strengthening of the aponeurosis which is always found covering the muscles, opposite the place where the strain occurs. In *Phalacrocorax carbo* the general sheath is strong, and no specialized band can be distinguished.

In *Plotus anhinga* this sling-band is attached at its inner end, with its fellow of the opposite side, to the middle line of the posterior surface of the neural arch of the 9th vertebra, about half-way between its proximal and distal extremities; whilst at its outer end it is fixed to the tubercle which is situated just outside the upper articular process of the same vertebra, a backward and slanting loop of tendinous tissue joining the two (*vide* Plate [18] XXVI. figs. 1 and 2).

It is the ossification of this just-described tendinous loop which constitutes Donitz's bridge in *P. levaillantii* and *P. novæ-hollandiæ*. In neither of the Society's specimens of *P. anhinga*, nor in that figured by Brandt, nor in a specimen of the same species seen by Donitz himself, is this bridge ossified. It may therefore be that in *P. anhinga* it remains tendinous; or, less probably, it has happened that the four specimens inspected have none of them been adult birds. One is at least 3½ years old, we know.

Through this bridge, as has been briefly described by Donitz, from a dried specimen, the tendon of the *longus colli posterior* passes—which it does before it receives the considerable fleshy fasciculus originating from the neural arch of the 9th vertebra, as is rendered evident in Plate [18] XXVI. figs. 1 and 2.

The tendon, augmented by fibres from the just-mentioned additional origin, passes up the back of the neck, side by side with its fellow, to end by being inserted into the posterior surface of the lower articular process of the axis vertebra, it, in its course, sending small tendinous slips to the corresponding parts of the third and fourth cervical vertebræ. The tendon is peculiar in being ossified where it is opposite the bodies of the vertebræ with which it is related, and supple at the joints, which makes it appear to be composed of alternate bony and fibrous elements when it is removed from the body. From the fifth, fourth, and third vertebræ short muscular fibres ascend to join the corresponding portions of the main tendon in single penniform series.

It is nearly always the case in avian anatomy that the inner fibres of the cervical portion of the *longus colli posterior* muscle become differentiated to form the *digastrique du cou* of Cuvier, better known to us as the *biventer cervicis*, a muscle one peculiarly interesting modification of which, in the genus *Ceryle* among the Alcedinidæ, has been described and figured by Dr. Cunningham in the Society's "Proceedings" *. This, by the way, I may mention, I have had the opportunity of fully verifying. Meckel, in his "General Treatise on Comparative Anatomy," tells us † that he found it at its minimum of development in the Gallinæ, the Goose, and the Cormorant. In a specimen of *Sula fusca*, as well as in *Phalacrocorax carbo*, it is present, but extremely small, I find. It is entirely absent in *Plotus anhinga*, the *longus colli* **Page 340.**

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* "Proceedings of the Zoological Society," 1870, p. 280.

† French edition, Paris, 1829–30, vol. vi. p. 11.

posterior (*cervicalis ascendens*, Meckel) entirely ceasing at the lower margin of the axis vertebra, in the tendon above described.

There are other myological features deserving of special notice in the thoracic and crural regions of the Darters.

The *great pectoral* muscle is composed of two independent layers:—a superficial large one, arising from the inferior border of the sternum, its carina, and from the outer border of the furcula; and a deep one from the upper two-thirds of the deeper part of the carina, superficial to the *pectoralis secundus*, and from the symphysial half of the outer border of the furcula. The superficial layer is inserted by a broad linear attachment to the pectoral ridge of the humerus, whilst the deep layer ends in a rounded tendon which commences at the axillary margin of the triangular muscle, with which it is associated, and receives the fibres of the remainder of the muscle in its course to its attachment into the lower end of the pectoral ridge of the humerus, beyond the insertion of the lowest fibres of the superficial layer. In Plate [19] XXVII. this arrangement is clearly indicated. A condition exactly similar to this is observed in *Phaëthon*, *Pelecanus*, *Sula*, the Cathartidæ, all the Storks, and the Petrels, and in no other bird as far as I am aware. In *Phalacrocorax* it is not easily recognized.

As in *Phalacrocorax* and *Phaëthon*, but not in *Sula* or in *Pelecanus*, the *biceps* muscle of the arm sends a fleshy slip to the middle of the patagial tendon of the *tensor patagii longus* (Plate [19] XXVII. *b. s.*).

No trace of the *expansor secundariorum* * muscle could be detected.

As in all the other Steganopods, the *tensor fascia* of the thigh does not cover the *biceps cruris* in the least.

The *ambiens* is of fair size; it deeply grooves the large ossified patella; and some of the fibrous ligament overlapping this groove shows traces of ossification; so that in aged birds the groove may be converted into a foramen, as is always the case in *Phalacrocorax*, where the thus formed foramen is far from superficial (*vide* Plate [20] XXVIII. figs. 5, 6, and 7). In a specimen of *Pelecanus rufescens* the *patella* was not ossified.

The *semitendinosus* is very large, composed of parallel fibres, and without any accessory head developed to join it. The *femoro-caudal* also, in all other true Steganopods, lacks an *accessorius;* it closely Page 341. resembles that muscle in *Sula* and *Pelecanus*, being separated from the *obturator externus* by a well-marked interval, which is not the case in *Phalacrocorax*.† It is to be remembered, as I have had the oppor-

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* *Vide ante*, p. 193 (p. 323).

† *Vide* "Proceedings of the Zoological Society," 1873, p. 636. (*Suprà*, p. 198.)

tunity of stating elsewhere*, that in *Fregata aquila* the *semitendinosus* is entirely absent, as in the Accipitres, whilst in *Phaëthon* it has an accessory head as well as a considerable bulk itself, these facts tending strongly to verify Brandt's division of the Steganopods† into three well-differentiated groups, of two of which the above-named genera are the only examples.

The alimentary canal of the Darter presents features of especial interest, as in its stomach there is a modification in the structure of the proventriculus not referred to in zoological works generally. It is fully described by Mr. Macgillivray in Audubon's "Ornithological Biography,"‡ where an excellent figure illustrates the account. Mr. Macgillivray also accurately describes most of the other viscera. He, however, omits to refer to the hairy mat in the second stomach, which latter viscus, he strangely says, is soft and smooth inside. The observations here made, which are in accordance with those of Mr. Macgillivray, cannot be considered *de trop*, as the extremely abnormal conformation he describes required verification before it could be accepted as not being merely an individual peculiarity.

The *tongue*, as an independent organ, does not exist. It is very small in all Steganopods, but free at its anterior extremity; smallest proportionally in *Pelecanus*. In *Plotus*, however, it is not free at its apex, it forming merely a longitudinal groove along the middle of the floor of the mouth, and ending abruptly behind by a small transverse slightly projecting ridge, 2¼ inches in front of the *rima glottidis*, which is evidently the rudiment of the base of the organ. The hyoid cornua, 1½ inch long, running in the faucial membrane, here meet and blend.

There is no *crop*; the œsophagus, however, is very dilatable. The *proventriculus* does not form a zone, as is the rule; nor does it form a patch, as in *Struthio*, *Rhea*, *Chauna*, and a few other birds; but it forms a special gland-cavity into which the individual constituents of the organ open. This cavity communicates with the digestive tube by a small orifice which is situated on the right side of the stomach, just below the commencement of the yellow dense characteristic epithelium of the stomach in birds. Plate [20] XXVIII. fig. 2, will assist in rendering this explanation more distinct.

The proventricular compartment is covered by peritoneum, is nearly globose, about the size of a chestnut, and fixed to the right side of the lower end of the œsophagus. On superficial inspection it looks very like an enlarged spleen (that organ being subglobose in birds). Its cavity is very small, being much encroached upon by the great

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* "Proceedings of the Zoological Society," 1873, p. 636, and 1874, p. 122 (*Suprà*, pp. 198 and 221.)

† "Proceedings of the Zoological Society," 1874, p. 122. (*Suprà*, p. 221.)

‡ Vol. iv. p. 158.

depth of the cylindrical glands which compose its walls. The yellow stomach-epithelium surrounds its orifice and goes no further. There Page 342. are no indications of additional proventricular glands at the lower termination of the œsophagus, the epithelium in that part being quite smooth and apparently squamous.

This further development in *Plotus* of a special and well-differentiated gland-organ from what in other birds is a zone or a simple circular patch of glands, is very similar to the equally uncommon development of the cardiac gland-organ in the stomach of the Manatee, which is most certainly only a modification of the similarly situated gland-patch in the Dugong.

The stomach is not developed into a gizzard, its walls in no part exceeding one-sixth of an inch in thickness. It is divided into two compartments, a cardiac and a pyloric, as is that of the Pelican. The former of these corresponds to the gizzard in most birds, the latter to the imperfectly formed cavity associated with the pyloric valve in the Storks, Gannet, &c. (*vide* Plate [20] XXVIII. fig. 2).

Of the stomach of the Pelican, Hunter tells us* that "it is oblong much in the direction of the œsophagus, with a little curve, smallest at the lower end: it makes a quick turn and swells again into a round bag; or it may be supposed that from the side near the lower or smaller end is attached a bag whence the duodenum arises." In the Catalogue of the Museum of the Royal College of Surgeons (1852), Prof. Owen† remarks, with reference to a specimen (No. 519) of the stomach of a Pelican (*Pelecanus onocrotalus*), "The œsophagus is continued into the proventriculus or glandular cavity, without any marked constriction; and the latter passes insensibly into the part analogous to a gizzard. This part communicates by a transverse aperture with a small globular cavity, which is lined by a vascular membrane, and communicates with the duodenum by a very small oblique aperture. This superadded cavity renders the analogy between this stomach and that of the Crocodile complete, with the exception of the absence in the latter of distinctly developed gastric glands. These, in the Pelican, are simple elongated follicles, closely compacted together, and extended over a large surface." In *Plotus* the second cavity is similarly situated, intervening between the stomach proper and the duodenum. The dense yellow epithelium of the one, however, extends into the other, right up to the pyloric valve. [It may be that in the specimen described by Prof. Owen the lining had been previously stripped off, which may have led to the term vascular being applied to the mucous membrane of the second stomach.]

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* "Essays and Observations," Owen's edition, 1861.

† Vol. i. "Organs of Motion and Digestion," p. 148.

Hunter, in his dissection of *Sula* and *Phalacrocorax*, does not mention the existence of a second stomach; and I have not observed or found recorded such an arrangement in either of those genera, or in *Phaëthon*, or in *Fregata*.

In *Plotus* there is still another peculiarity, which, as far as I know, is found in only one other bird, namely *Cathartes aura*. In Audubon's "Ornithological Biography,"* Mr. Macgillivray tells us that in the stomach of *C. aura* "there is a pyloric lobe [second compartment] **Page 343.** about half an inch in diameter, which is lined with bristly hairs. They are all inserted at right angles to the surface, penetrate to the base of the epithelium, and are of various lengths, some of them not protruding beyond the surface, others upwards of half an inch, of various colours, some black, generally tipped with whitish, others light greyish yellow, all thick at the base, and tapering to a fine point. Being disposed in a regular manner, they might seem to form a part of the organization of the stomach, and not to be, like the hairs found in *Cuculus canorus* and *Coccyzus americanus*, merely extraneous." The pyloric orifice in *Plotus anhinga*, as is seen in Plate [20] XXVIII. fig. 2, is protected by a mat of lengthy hair-like processes, much like cocoa-nut fibre, which nearly half fills the second stomach. This second stomach is globose, and nearly an inch in external diameter. Its dense lining-membrane is raised into short rugæ and tubercles, as is that of the first; and it is evidently a modification of the epithelium which develops these tubercles in the region of the pylorus which gives rise to the above-mentioned mat-sieve. The hairs composing the mat are hispid, slender, and about half an inch long. They arise from a surface a little less than a square inch in area round the pylorus, which is in its centre. They cease at the very margin of the small circular orifice, where the commencement of the delicate mucous membrane of the duodenum can be just seen. My friend, Mr. E. A. Schäfer, Assistant Professor of Physiology at University College, has very kindly examined these hairs microscopically, and tells me that "they are much more like true hairs, both in structure and mode of attachment, than they are like the epithelial projections which are so often met with over the filiform papillæ of the human tongue, which, at first sight, they much resemble. Like hairs, they consist of an outer 'cuticular' part, and an inner 'fibrous' part; and in some places there is also yet another substance running along the middle of the fibrous part, which might be compared to the medulla of a hair. The cuticular part is much thicker in proportion than that of a cutaneous hair, and forms here and there dentate projections at the sides of the filament. The cuticle is continuous with the horny superficial portion

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* Vol. v. p. 340.

of the stratified epithelium which covers this part of the stomach; in neither can the outlines and nuclei of the component cells be distinctly seen, the cells having blended into a nearly homogeneous substance. That portion of the hair which extends below this into the deeper layers of the epithelium, appears not to be covered with a prolongation of the cuticle, but to be formed only of the fibrous part. This last-named seems, like the fibrous or cortical constituent of a cutaneous hair, to be composed of a closely set bundle of much elongated cornefied epithelial cells, slightly larger than those of a cutaneous hair, and with their extremities not fusiform (as in that) but truncated. The number in a cross section varies according to the size of the filament. They may, in many, be seen projecting at the end a little beyond the cuticular part.

Page 344. "The roots of the gastric hairs are so closely set as to occupy the greater portion of the mucous membrane, so that the connective tissue of the corium, which occupies the intermediate space, is very small in amount. Between the tissue and the hair-root is seen a layer of columnar epithelium cells, which in some places are of considerable length. They are continuous towards the surface with the deeper cells of the stratified epithelium. They represent the 'root-sheaths' of the cutaneous hair, and seem to have undergone a horny metamorphosis.

"At their extreme ends the roots are entirely different from those of the cutaneous hairs. There is no hair-knob and no papilla; but the root generally breaks up into two, three, or more short rootlets, each of which tapers to a pointed extremity. This, at least, is the appearance in vertical section; but transverse sections show that this branching of the hair-root has, at all events in the first instance, more of a laminated character.

"These rootlets are covered by a layer of cubical epithelium cells, which are continuous with the columnar cells surrounding the hair-root. The latter, as before remarked, is formed merely by the fibrous substance or cortical portion of the hair; and the fibres which compose this would therefore seem to be in some way produced by these cells.

"Some few hairs seem to end by a single tapering rootlet, but most of them spread out and branch in the way described."

This peculiar hairy mat must act as an excellent sieve to prevent the entrance of solid particles, fish-bones, &c., into the narrow intestines.

The small intestine is 55 inches long in the female, and 40 inches in the male; and it is not capacious. The duodenal loop measures 5 inches in each limb. The left lobe of the bilobed liver is about half the size of the right; and a gall-bladder of considerable size is present.

The large intestine is 6 inches long in the female, and 3 inches in the male. There is only a single cæcum, exactly like that in the Ardeidæ, in my specimens. This conformation of cæcum is found in no other Steganopod bird, there being two cæca in all the other genera. These, in *Pelecanus*, are a little over an inch in length, in *Sula* slightly shorter, whilst in *Phalacrocorax*, *Fregata*, and *Phaëthon* they are simple knob-like bodies, nearly globose in form. The rudiment of the vitelline duct is persistent.

In the distance of its diminutive cæcum from the cloaca (in other words, in the length of the large intestine) *Plotus* differs slightly from its allies. In *Pelecanus* the large intestine is under 2 inches in length; and it is much the same in *Sula*. In *Phaëthon* it does not exceed a quarter of an inch in length. It, however, differs considerably in my two specimens, being in both longer than the same in Audubon's specimen.

In the urino-genital system of *Plotus anhinga*, in both sexes, the ducts open in the normal manner into the cloaca, just above its lower orifice. This orifice, however, is not on the surface, but is into a cavity, behind the cloaca, which opens externally quite close to the place where the two communicate. Except for this nearly marginal orifice the second cavity is a cæcal sac, oval in shape, and about 1½ inch **Page 345.** high, covered at its blind end with the crypts of shallow glands, which also run down its sides. That it is a modification of the *bursa Fabricii* cannot be doubted.

EXPLANATION OF THE PLATES.

Plate 18. (XXVI.)

Fig. 1. View of left side of neck of *Plotus anhinga*, dissected. *l.c.a.* longus colli anterior muscle; *l.c.p.* longus colli posterior muscle. The fibrous representative of Donitz's bridge is seen attached to the ninth cervical vertebra.

2. View of part of the posterior region of the neck of *Plotus anhinga*. The roman figures refer to the cervical vertebræ counted from the head. Donitz's bridge is seen attached to the ninth; and at *a* is also seen a fibrous band, which is of similar function, attached to the eleventh. At *b* is seen the fasciculus of the tendon of the posterior neck-muscle which traverses the fibrous loop, which latter has been removed on the left side.

Plate 19. (XXVII.)

View of the anterior thoracic region of *Plotus anhinga*, dissected to show the superficial (*p.* 1, 1) and deep layer (*p.* 1, 2) of the pectoralis major muscle on the right side, as well as the pectoralis minor (*p.* 2) on the left. The insertion of the deeper layer of the pectoralis major is seen to be surrounded by the much more considerable mass of the similar portion of the superficial stronger layer. The triceps (*t*) and the biceps (*b*) of the cubitus are seen on the right side, as in the patagial slip (*b. s*) of the latter. The sternum (*st.*) is superficially bound to the lower end of the coracoid bone by the anterior sterno-coracoid ligament (*ant. st. cor. lig*), which is particularly powerful in the Steganopods and Storks.

PLATE 20. (XXVIII.)

Fig. 1. View of top of head of *Plotus anhinga*, showing the occipital style (*a*) and the temporal muscle (*t*) arising from it on one side.
2. Stomach of *Plotus anhinga*, inside view.
3. Anterior view of the lower end of the trachea in *Plotus anhinga.*
4. The same in *Sula bassana.*
5 and 6. Top and side view of the patella in *Phalacrocorax carbo*, showing the canal for the ambiens muscle. *N.B.* The side view (fig. 6) is accidentally drawn with the base uppermost.
7. Front of patella in *Plotus anhinga* deeply grooved by ambiens muscle.

55. NOTE ON POINTS IN THE ANATOMY OF LEVAILLANT'S DARTER (*PLOTUS LEVAILLANTI*).*

Page 679. IN a former communication† I had the opportunity of bringing before the Society several facts with reference to the anatomy of *Plotus anhinga*, and of confirming Mr. Macgillivray's account of its most peculiar proventriculus. Several specimens of the species have since passed through my hands which differ in no way from that first described.

On the 9th of March last the Society obtained for the first time, by purchase, a male specimen of Levaillant's Darter (*Plotus levaillanti*) from Senegal. It unfortunately died on the 7th of this month (May) from peritonitis, the result of a perforating ulcer in the stomach.

The severity of the peritonitis caused all the abdominal viscera to be agglutinated into a single mass, and rendered them particularly soft. Nevertheless I was able to disentangle most of the alimentary canal for examination; and it has proved of more than ordinary interest, as the following description will serve to show.

The tongue, as a free organ, is obsolete. The œsophagus is capacious, without any crop. The œsophageal epithelium ceases abruptly by a transverse line where the gastric portion of the canal commences, below which it is replaced by the tough yellow epithelium so characteristic of the situation.

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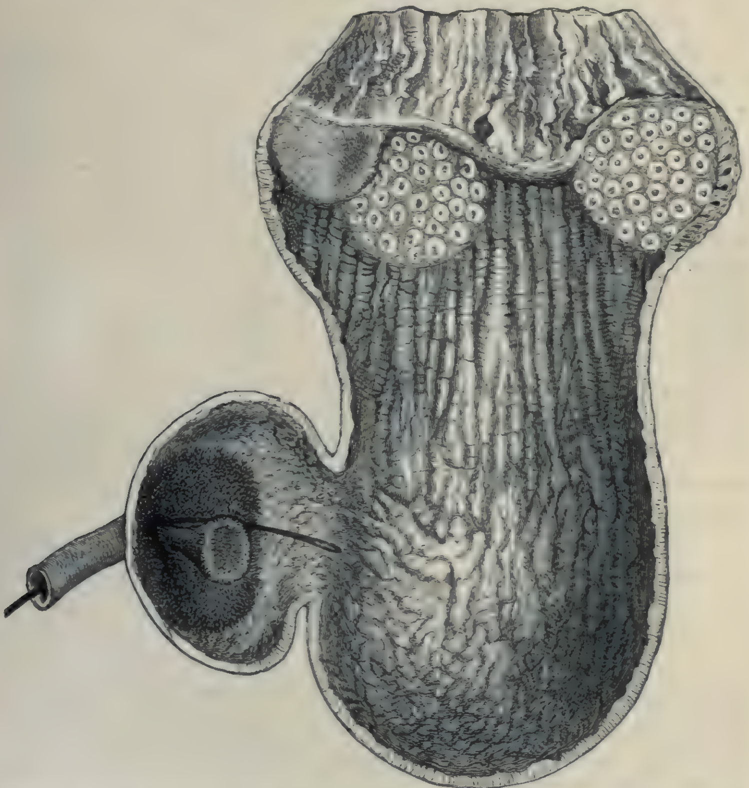
* "Proceedings of the Zoological Society," 1878, pp. 679–81. Read, June 18, 1878.

† "Proceedings of the Zoological Society," 1876, p. 335. (*Suprà.*)

The proventriculus is composed of two circular areas of deep glands, which latter are of considerable size and do not come into contact, being situated laterally upon opposite sides of the gullet. Page 680. These areas are flat, except at their upper margins, where a small transverse ridge is developed, which may be the slight foreshadowing of the special cavity developed in *Plotus anhinga* for the reception of the secretion of the gastric glands. But in *P. levaillanti* it is to be noticed that there are two gland-surfaces, whilst in *P. anhinga* it will be remembered there is but one gland-cavity.



View of the inner surface of the posterior wall of the stomach of *Plotus levaillanti*, with the œsophagus slit up anteriorly so as to show the whole of its proventricular surface, with the two gland-areas and the U-shaped elevation on its anterior wall (on the left of the figure), as well as the pyloric infundibuliform plug.

The calibre of the œsophagus must be somewhat diminished by the presence of a curious U-shaped ridge upon the mucous membrane of its anterior wall, which is situated between the antero-lateral

Page 681. margins of the gland areas, and has a small pit in the part corresponding to the surface between the limbs of the U, apparently not glandular in nature. All these structures are covered with the tough gastric epithelium, which ceases just above them.

The first true gastric cavity is larger than the second, though not much so. In the second the peculiar hairy covering of its pyloric portion is largely developed, and in a different manner from what it is in *P. anhinga*, where, as I have shown in my paper on the anatomy of that bird, it forms a kind of sieve to prevent large solid particles from entering the duodenum. In *P. levaillanti* a more elaborate arrangement obtains; the hairy epithelium surrounding the pyloric orifice, near the lower margin of the gastric surface of which it is developed, is produced into a considerable conical hair-covered process, projecting into the second stomach, and evidently acting as a valve to close the pylorus when necessary. In general appearance it much resembles the operculum of the Cheilostomatous Polyzoa, and is very striking at first sight, the hirsute conical plug when retracted, fitting exactly into the equally hirsute conical pyloric end of the second stomach-cavity. All the rest of the second stomach is lined with a non-hirsute epithelium, which ceases abruptly where it meets the hairy surface. I can find no trace of this operculum in *Plotus anhinga*, upon re-examination.

The small intestine measured two feet, and the large three inches; but they may have been contracted by the inflammation of their surfaces. Two minute cæca were clearly seen, one a little larger than the other. In *P. anhinga* there is no indication of a second cæcum.

As in *P. anhinga*, *P. levaillanti* possesses but one carotid artery, the left. In their myology the two species agree in every respect, as far as I can see. In *P. levaillanti* the ambiens is large, grooving the patella, the femoro-caudal is present without an accessorius, as is the semitendinosus. There is a slip from the biceps of the arm, which traverses the patagium; and the temporal muscles run back beyond the skull, being separated by a median fibrous raphé, which is *not* ossified into a separate bony style. The great pectoral muscle is formed of two layers.

Donitz's bridge is ossified, as in the specimen described by the author after whom it is named: it is developed on the ninth, and not on the eighth cervical vertebra, as I predicted would be the case.

The lower larynx is indistinguishable from that of *P. anhinga*.

It is interesting to notice that the Manatee and Dugong have special gastric gland-structures, the method of arrangement of which differs in exactly the same way as does that of the two species of *Plotus* under consideration, the peculiar flat gland-area found in

Halicore and *Plotus levaillanti* being converted into a glandular cavity in *Manatus* and *Plotus anhinga.*

56. NOTES ON THE ANATOMY OF THE COLIES (*COLIUS*).[*]

About the systematic position of the Colies there has always been considerable uncertainty, partly on account of the peculiarities of their habits, and partly because their internal structure is but incompletely known. One of the examples of *Colius castanonotus*, sent to the Society by Mr. H. C. Tait, C.M.Z.S., having died just as it reached this country, I have had the opportunity of dissecting the bird, and of examining several of its special anatomical details. Page 416.

Dr. Murie[†] has, not long since, given us an excellent *résumé* of the views entertained by different naturalists as to the systematic position of the Colies, few of which are based on any thing more than external form and habits. Burchell[‡] placed them close to *Corythaix;* and he has been followed by many. Mr. Wallace,[§] from a study of their habits, refers them to the Parrot tribe.

In his "Pterylography" Nitzsch[||] places *Colius* among his Amphibolæ, together with *Musophaga* and *Opisthocomus*, mentioning nevertheless that the genus "has a very remarkable arrangement of the feathers, and can only be compared in this respect with *Buceros.*"

In his important memoir "On the Classification of Birds," Prof. Huxley[¶] places *Colius* among his Desmognathæ, in the smaller group Coccygomorphæ, the genus being the sole representative of one of its minor divisions. Prof. Huxley makes no special reference to the skull.

Dr. Murie has given us valuable information on the osteology of the bird[**]; and I am able to confirm most of his observations. There is, however, one part of the skeleton (the palate) where my results differ considerably from those of my predecessor; and these it is necessary for me to record. Dr. Murie tells us that the speci-

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[*] "Proceedings of the Zoological Society," 1876, pp. 416–20. Read, May 2, 1876.

[†] "Ibis," 1872, p. 262.

[‡] "Travels in South Africa," vol. i. p. 214 (foot note).

[§] "Annals and Mag. of Nat. Hist.," 1856, p. 213.

[||] Ray Society's English Translation, edited by Mr. Sclater, p. 107.

[¶] "Proceedings of the Zoological Society," 1867, p. 466.

[**] *Loc. cit.* p. 266, Pl. X.

men at his disposal was somewhat injured; nevertheless, of the maxillo-palatine processes of the maxillary bones, he says that they intrude but a slight way beyond the palatal rods, and leave a wide middle space betwixt them, and that, "as respects the presence of a vomer, there is apparently a short one, tapering rather than abruptly truncate anteriorly, and not visibly cleft behind." Dr. Murie therefore removes *Colius* from among Prof. Huxley's Desmognathæ, and consequently from the Coccygomorphæ.

In the preparation of the skull of my specimen of *Colius castanonotus* I have taken special care; and I find that the bird, as will be seen by the drawing which I exhibit, is without doubt desmognathous. Moreover, as the desmognathism apparently depends on the fusion of the feebly developed maxillo-palatine plates across the middle line as well as with the ossified nasal septum, it should, according to the valuable nomenclature of Prof. Parker,* be termed *direct* (of the first variety), as in the Falcons. It is not, however, possible to determine with certainty from the adult skull (from mine at least) whether the nasal septum has intervened between the maxillo-palatines, as in the Eagles, Vultures, and Owls, and as it is in

Page 417.

Palate of *Colius castanonotus*, × 2½.

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* "Transactions of the Zoological Society," vol. IX, p. 293.

the Alcedinidæ, because in them there is a demonstrable interval between the free posterior ends of these plates, the intermediate septal bond but incompletely uniting them. A slightly more extensive ossification in this region would reproduce a Parrot's palate in that of the Coly.

Next, with reference to the vomer, the result of carefully watching the skull during maceration, and of a minute inspection of the palate in the prepared specimen, convinces me that that bone is not ossified. In thus lacking the vomer, *Colius* and *Alcedo* agree.

The sternum of my specimen closely resembles that figured by Dr. Murie; the crenulation, however, of the lateral margins of the keel-bearing middle xiphoid process is not apparent. The bone resembles that of the Capitonidæ more than the sternum of any other bird (see, for comparison, Eyton's "Osteologia Avium," plate 8). Page 419.

In the structure of its soft parts *Colius* presents several interesting features which assist in the determination of its affinities.

The skin is particularly tough, much like that of the Swifts in this respect. Only one carotid artery is present, the left. In the Musophagidæ, Cuculidæ, Coraciidæ, Galbulidæ, and Alcedinidæ we know that both a right and a left artery are always developed;* whilst in the Bucerotidæ *Toccus* possesses only the left, *Buceros* having both,—the left only being found, as in *Colius*, in the Picidæ (*i. e.* Picinæ, Ramphastinæ, and Capitoninæ), Upupidæ, Meropidæ, Trogonidæ, and Passeres. As far, therefore, as the carotid arteries are concerned, the Colies do not resemble the Musophagidæ, their supposed nearest allies. Their comparison with Parrots must be reserved till further on.

Myologically, *Colius* wants the *ambiens* muscle. It is therefore Anomalogonatous,† and agrees with the passeriform and piciform birds only, differing essentially from the Musophagidæ. The *femoro-caudal* is well developed, but has no accessory head. The *semi-tendinosus* and its accessory head are both fairly developed. The myological formula of the bird on the system adopted by me in my paper on classification, just referred to, is A,XY, the same as that of most Passeriformes and Piciformes, but differing importantly from that of the Musophagidæ (AB,XY) in the absence of B, the *accessory femoro-caudal* muscle. The *tensor fasciæ* of the thigh does not in the least cover the biceps muscle.

In the arrangement of its plantar tendons *Colius*, although so peculiar and uncertain in the manner in which it employs its toes, exactly resembles the feeble-footed Alcedinidæ, and hardly differs

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* "Proceedings of the Zoological Society," 1873, p. 464. (*Suprà*, p. 168.)

† "Proceedings of the Zoological Society," 1874, p. 116. (*Suprà*, p. 213.)

from the Coraciidæ, Meropidæ, Bucerotidæ, and Caprimulgidæ. In *Musophaga* the distribution of the tendons is on quite another principle, as it is in the Psittaci.*

The intestines of *Colius* are voluminous and short, being only 9 inches in length. I could find no trace of intestinal cæca. Nitzsch has shown that the oil-gland is tufted, and that there are ten rectrices.

In my paper on the classification of birds I proposed to distribute the Anomalogonatæ into two groups, according to whether the cæca are present and at the same time the oil-gland is nude, or the cæca are absent and the oil-gland is tufted, arranging them in the following manner:—

Page 420.

PICIFORMES. With tufted oil-gland and without cæca.	PASSERIFORMES. With nude oil-gland and with cæca.
Pici.	*Passeres.*
Capitoninæ.	*Bucconidæ* (? as to cæca).
Ramphastinæ.	*Trogonidæ.*
Upupidæ.	*Meropidæ.*
(*Coliidæ*).	*Galbulidæ.*
Bucerotidæ.	*Caprimulgidæ.*
Alcedinidæ.	*Coraciidæ.*
	Momotidæ.

From what has been said above it is evident that *Colius* must be included among the Piciformes, and near those of this division with a left carotid only, a four-notched sternum, and a blended plantar-tendon arrangement. No other piciform bird, however, combines all these characters. In the Alcedinidæ the sternum and plantar arrangement correspond; in the Bucerotidæ *Toccus* agrees as to the carotid and the plantar tendons. The Picidæ (Picinæ + Capitoninæ + Ramphastinæ) have a left carotid, a two-notched sternum, but a specialized plantar-tendon distribution. Consequently the fact that the combination of characters is unique justifies us in retaining the Coliidæ in a separate family, related on the one hand to the Picidæ, and on the other to the Alcedinidæ and Bucerotidæ.

Something must be said with reference to the probability of *Colius* having psittacine affinities. It is an interesting fact that in those species of the genus *Cacatua* (*galerita*, *leadbeateri*, *moluccensis*, &c.) in which the oil-gland is not lost, the resemblances (only accidental I assume) to the genus *Colius* are peculiarly numerous. In these *Cacatuæ* there is a left carotid artery only, no ambiens muscle, and a

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* *Vide* "Proceedings of the Zoological Society," 1875, p. 339. (*Suprà*, p. 289.)

myological formula A,XY. Nevertheless I hope that in my paper on the Order Psittaci* the impression left by its perusal is that the Parrots all sprang straight away from a stock with two carotids and an ambiens muscle. Such being the case, and *Colius* most certainly not being a true Parrot, the arguments in favour of its having arisen independently from the psittacine ancestor, and of its having undergone (also independently) cacatuiform modifications during the progress of its evolution, are less easy to accept than those which suppose it to have sprung, as I have above assumed, from the less specialized stock whence has been derived all the Anomalogonatæ. The form of the sternum and the distribution of the plantar tendons are in favour of this view of the question.

It may be mentioned that the syrinx of *Colius* (which has been figured by Johannes Müller† in a closely allied species) is most nearly related to that of *Ceryle* among the Kingfishers.

57. ON SOME ANATOMICAL PECULIARITIES WHICH BEAR UPON THE MAJOR DIVISIONS OF THE PASSERINE BIRDS. PART I.‡

(Plates XXI—XXVI.)

A SPECIAL analysis of the peculiarities of structure presented by different Passerine birds can hardly be considered premature. Since the investigations of Nitzsch, Sundevall, Keyserling and Blasius, Johannes Müller, and Cabanis little of decided importance has been made out with reference to the distinguishing characters of the group or of its primary divisions, if we except the researches of Professors Huxley and Parker on the palate in the class Aves generally. A glance at the history of the Order will be the best introduction which I can offer to the facts which it is my desire upon the present occasion to bring before the Society. **Page 506.**

Although the name "Passeres" was coined by Linnæus, that illustrious naturalist did not appreciate the unity of the group, his classification compelling him to include the Columbæ in the order, which was defined as having "rostrum conico-attenuatum," and *Paradisea*,

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* "Proceedings of the Zoological Society," 1874, p. 586. (*Suprà*, p. 247.)

† "Ueber die bisher unbekannten typischen Verschiedenheiten der Stimmorgane der Passerinen," 1847, Pl. V. figs. 9–12.

‡ "Proceedings of the Zoological Society," 1877, pp. 506–19. Pls. XLVIII—LIII. Read, June 6th, 1876.

Corvus, together with *Certhia* among the "Picæ," "rostro superne compresso convexo."

Cuvier, in 1798*, made a great step in advance by forming an order "Passeres" to include all those now so called, together with those non-swimming, non-wading, non-climbing, non-raptorial, non-gallinaceous birds in which there are not two toes of the foot retroverted.

Nitzsch† was the first to appreciate the true limits of the order, when in 1829 he grouped together the birds now termed Passeres in a single section, entirely by themselves.

Page 507. C. J. Sundevall, in 1831, discovered that in the birds which he had the opportunity of examining that belonged to the order Passeres of Nitzsch, and only elsewhere in *Upupa*, the tendon of the *flexor longus hallucis* is quite independent of the *flexor perforans digitorum pedis*, a bond of union of one kind or other‡ joining them in other birds.

Keyserling and Blasius§, in 1839, established the law that (with the exception of the Alaudidæ) those Passerine birds in which the form of the lower larynx (named "syrinx" by Professor Huxley) is what is known as "oscine," possess a pair of long scutes as a covering to the back of the tarso-metatarse. They may therefore be called *bilaminate*, to facilitate description, the term referring to the tarsal scutellation only.

Johannes Müller‖, from his elaborate investigations on the structure of the syrinx in the South-American Passeres, was led to divide the group into two major sections—those in which the intrinsic muscles of the voice-organ are inserted into the ends of the bronchial semi-rings, and those in which they are inserted into their middle parts. I would suggest the name *Acromyodi* for the former of these divisions, and *Mesomyodi* for the latter—an acromyodian bird being one in which the muscles of the syrinx are attached to the extremities of the bronchial semi-rings, a mesomyodian bird being one in which the muscles of the syrinx join the semi-rings in their middles. It seems to me advisable to restrict these terms to Passerine birds.

Müller found that among the mesomyodian Passeres there is a large collection of genera in which an easily recognized special type of syrinx exists. This group he separated off as "Tracheophonæ," so naming them on account of the large share taken by the peculiarly modified lower end of the trachea in the formation of the voice-organ.

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* "Tableau Elémentaire," p. 199, *et seq.*

† "Observationes de Avium arteriâ carotide communi."

‡ *Vide* "Methodi naturalis Avium disponendarum Tentamen," 1872, p. xl.

§ "Wiegmann's 'Archiv,'" 1839, i, p. 332.

‖ "Abhandl. d. Berl. Akad.," 1846, p. 367.

In one respect he made a retrograde step, because he did not lay sufficient stress upon the value of Nitzsch's work; and this was that he united the mesomyodian Passerine birds which are not tracheophone with those families which constituted the more expanded "Passeres" of Cuvier and with the Scansores, wavering between the two classifications, which may be expressed, with the employment of the term introduced above, as follows:—

1. Passeres Acromyodi (Oscines).
2. Passeres Mesomyodi Tracheophoni.
3. Picariæ.
    a. Passeres Mesomyodi non-tracheophoni.
    &c.

1. Passeres Acromyodi (Oscines).
2. Picariæ.
    a. Passeres mesomyodi tracheophoni.
    b. Passeres mesomyodi non-tracheophoni.
    &c.

From the above remarks it is evident that Müller was led to lay too great stress upon the nature of the syrinx as a distinctive feature of the Passeres; and although Nitzsch was unacquainted with the existence of the mesomyodian voice-organ, there can be scarcely any Page 508. doubt that had he lived subsequently to Müller he would never have separated its possessors off from their oscine allies, considering that he had fundamental palatal and pterylographic characters to fall back upon.

The investigations of Macgillivray* and others have made it evident that colic cæca (of small size) are present in all true Passerine birds; and this fact, when correlated with the universal presence of a nude coccygeal oil-gland, has led me† to place them in near relationship with those other Cuvierian Passeres (the Cuculidæ excepted) in which the oil-gland is nude and cæca coli are always present—away from the remainder of his group, in which no cæca are developed and the oil-gland is tufted. The Passeriformes and Piciformes thus defined, all wanting the ambiens muscle across the knee, are included in my major division of the *Anomalogonatæ*.

Taking the summation of the characters above referred to, in association with others too well known to require special mention, the Passeres may be defined as those Anomalogonatous birds with the 2nd, 3rd, and 4th toes of the foot directed forwards, and the hallux backwards, in which the *flexor longus hallucis* muscle is independent of the *flexor perforans digitorum*, the colic cæca are short, the oil-gland nude, at the same time that it is of a characteristic shape, and the palate ægithognathous‡.

Among the Anomalogonatæ there are three toes directed forwards in the Bucerotidæ, Alcedinidæ, Coliidæ, Upupidæ, Coraciinæ, Momo-

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* "Audubon's Ornithological Biography," 1838.

† "Proceedings of the Zoological Society," 1874, p. 119. (*Suprà*, p. 217).

‡ Professor Huxley, "Classification of Birds," "Proceedings of the Zoological Society," 1867, p. 456.

tinæ, Caprimulgidæ, and Meropidæ; the *flexor longus hallucis* is free from the *flexor perforans digitorum* in the Upupidæ; colic cæca are present in the Caprimulgidæ, Coraciinæ, Momotinæ, Galbulidæ, Trogonidæ, Meropidæ, and almost certainly so in the Bucconidæ,* in which families also the oil-gland is nude; the palate is ægithognathous in *Thinocorus*, *Turnix*, and the Cypselinæ, nearly so in the Caprimulgidæ and Trochilinæ.

My investigations into the myology of birds have supplied me with another character of great practical value, which, though in one or two cases slightly disguised, is never found in any but veritable Passeres. It is a peculiarity in the method of insertion of the tendon of the *tensor patagii brevis* of the wing.

In the triangular patagium of the wing of the bird the tendons of two muscles are to be found. One is that of the *tensor patagii longus*, which forms the supporting cord of the free margin of the membrane itself. The second is that of the *tensor patagii brevis*, which courses parallel with the humerus, not distant from that bone, to the muscles and fasciæ of the forearm. In the Ramphastinæ, Capitoninæ, and Picinæ, where this muscle is less complicated than in any other birds, it arises, as is generally the case, from the apex of the upper of the two processes at the scapular extremity of the furcula, as well as by a small special slip from the superficial fibres of the *pectoralis major*
Page 509. muscle, which differentiates itself off from the main muscle near the upper part of its inserted extremity. The comparatively insignificant triangular or compound fleshy belly thus formed, with its apex directed towards the elbow, terminates in a cylindrical tendon, which, included between the layers of the fibro-cutaneous patagium, takes a straight course to its insertion into the axially-running tendon of origin of the *extensor metacarpi radialis longus* of Schöpss, at a short distance from the tubercle on the humerus whence the muscle springs.

As a result of this disposition, when the forearm is half-flexed, the tendon of the *tensor patagii brevis* is seen to enter the substance of the fibrous origin of the *extensor met. rad. longus*, and at right angles. This arrangement is indicated in Plate [21] XLVIII. fig. 1, and is characteristic of the Picariæ, as defined by myself to include the three subfamilies above referred to and them only.†

Among the Passeres a slight, but easily recognizable, difference in the manner of insertion of the muscle maintains. The similarly single cylindroid tendon runs from the muscular belly, which has its origin at the shoulder, as above described, to the upper margin of the

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* [The accuracy of Prof. Garrod's surmise is established by Burmeister's observations on the anatomy of *Malacoptila torquata*, and *Chelidoptera brasiliensis*, "Syst. Uebers.," ii. pp. 292 and 295.—Ed.]

† "Proceedings of the Zoological Society," 1874, p. 123. (*Suprà*, p. 222.)

extensor met. rad. longus muscle, at an exactly similar spot: it does not, however, simply blend with the fibrous origin of that muscle: it becomes attached to it at the spot indicated, and then (again considering the forearm as half bent upon the humerus) runs back *independently* to be attached to the base of the tubercle of origin of the *extensor met. rad. longus*, slightly below that muscle's springing-point. As a consequence of this arrangement there are two tendons to be seen running to one spot (that on the upper margin of the *extensor met. rad. longus*, where the tendon of the *tensor* meets it) from two points, one the apex of the tubercle on the humerus above referred to, and the other, the depression at its base. These tendons therefore converge as they leave the elbow, having at first an appreciable interval between them, which is gradually diminished as they approach, although they remain quite free from one another, that of the *tensor* being superficial. A glance at Plate [21] XLVIII. fig. 2, will serve to make this more clear.

I have had the opportunity of looking at this muscle in nearly 150 species of Passerine birds, belonging to nearly all the most important sections. I first observed it in *Pitangus sulphuratus*, and shortly afterwards recognized the same arrangement in *Hirundo urbica*. A humming-bird (*Patagona gigas*) and a Swift (*Cypselus apus*) coming to hand at about the same time (the former through the kindness of Professor Newton) impressed me with the distinction between the Macrochires and the Swallows, as far as these elbow-muscles are concerned. Thus stimulated by the significance of the character, I have since taken every opportunity at my disposal to test its importance, the result being very favourable. Among the more aberrant genera I have examined are

Page 510.

Struthidea,
Heteralocha,
Dicrurus,
Prosthemadera,
Melanocorypha,
Strepera,
Menura,
Atrichia,
Pitta,
Rupicola,
Lipaugus,
Tyrannus,
Chasmorhynchus,
Pipra,
Tityra,
Hadrostomus,
Cotinga,
Furnarius,
Picolaptes,
Thamnophilus,
Grallaria,
Pteroptochus,
Hylactes.

The only apparent exceptions I have found are the following. In *Pteroptochus albicollis* and in *Hylactes megapodius* the muscular fibres of the *extensor met. rad. longus* almost surround and enclose the tendons in question. Such being the case, the arrangement does not at first sight appear typically Passerine. Nevertheless, upon removing or pushing to one side these covering fibres, the two tendons are seen arranged exactly as in other members of the Order.

In *Menura superba* and in *Atrichia rufescens*, feeble-winged birds again, the arrangement is not typical, and the disposition of the parts is almost exactly as in the Piçi, as above described. In other words there are not two tendons, one only being found, simple and broad, apparently produced by the blending of the two. Plate [24] LI. fig. 2 represents the elbow-region of *Menura* as seen from its outer side.

All other Passerine birds which I have examined follow the single type, differing only in the angular divergence of the tendons, their humeral attachments being much separated in most Sturnidæ, Gymnorhinæ, and Tyrannidæ for example, but closely approximated in *Tropidorhynchus*, *Rupicola*, and others.

A short review of the peculiarities of the insertion of the *tensor patagii brevis* muscle in other birds will tend to render the importance of the character more clear, and may add some facts of interest in an ornithological point of view; for it is not in the least difficult for any one who has compared these structures in the various orders of the class to decide by an inspection of the outer surface of the elbow to which division any specimen belongs; and for the satisfaction of those naturalists who consider it essential that characters of importance should be verifiable on all occasions, it may be mentioned that from almost any skin it is possible to decide the point by soaking it, or the wing alone, in cold water, and carefully removing the tegument thus relaxed. On the present occasion the arrangement in the Anomalogonatæ will also be almost solely discussed, although among the Homalogonatæ characters of nearly equal significance are attainable, somewhat diminished in clearness in some cases by the diffused state of the tendons.

In the Galbulidæ, as represented by *Galbula albirostris* and *Urogalba paradisea* (spirit-specimens of both of which genera have been kindly placed at my disposal by Mr. Salvin), the tendon of the short *tensor* is simple, or it splits slightly before it meets the metacarpal extensor (where the distal moiety there terminates). Its main
Page 511. continuation sends back to the outer side of the lower end of the humerus a free fasciculus exactly like that above described in the Passeres, except that from about the middle of its lower margin a thin slip runs downwards and wristwards to the fascia of the ulnar side of the outer surface of the forearm. This is represented in Plate [23] L. fig. 1.

In the Meropidæ, as represented by *Merops apiaster* and *M. ornatus*, the only difference from the Galbulidæ is that the distal branch is more clearly differentiated, and the slip to the ulnar side of the forearm is nearer the angular bend. This arrangement is represented in Plate [21] XLVIII. fig. 3. In *Todus viridis* the tendons are similarly disposed.

In the Coraciidæ, as represented by *Coracias garrula* and a species of *Eurystomus* which was not in sufficiently good condition to be more definitely determined, Plate [22] XLIX. fig. 1 represents the distribution of the tendons, there being two parallel to one another, the anterior one of which runs to the superficial ulnar fascia before terminating, and sends wristwards a slip, like that in the Meropidæ, to the long *extensor*. There is a passeriform free tendon running back to the lower end of the humerus from the outer tendon.

In the Momotidæ the condition is the same, except that the outer tendon does not split, and therefore sends forward no wristward slip. This condition I have found in *Momotus lessoni*, in *M. æquatorialis*, and in *Eumomota superciliaris*. The extension on to the ulnar superficial fascia springs from the portion of the horizontal tendon intermediate between the points of junction of the two parallel long tendons, and is not a direct continuation of either. It is frequently very thin.

In the Trogonidæ, as exemplified by *Trogon mexicana*, *T. puella*, and *Pharomacrus mocinno*, the condition is very complicated. It is seen in Plate [24] LI. fig. 3. A superficial long muscular mass runs nearly to the long *extensor* of the forearm. It has a short broad tendinous insertion into the fascia of the outer surface of the forearm; and this is specially developed in a line running back to the humerus in a passeriform manner. Deep of this are two parallel tendons; the one nearer the humerus terminates exactly like the single one of the Passeres; that further off ends as in the Pici above described.

In the Caprimulgidæ, as found in *Caprimulgus europæus* and *Chordeiles texensis*, the arrangement is almost exactly the same as in the Meropidæ. The second outer tendon, however, is shorter.

In the Macrochires, including the Trochilidæ and the Cypselidæ, as found in many genera and species the arrangement is uniform. The fleshy belly runs on to a special tendon which springs from the lower end of the outer surface of the humerus (where the horizontal slip in the Passeres terminates), and is continued,' parallel to the forearm, along the radial margin to the hand. Plate [24] LI. fig. 1 exhibits this condition. It can be here seen that the tendon of the *tensor patagii brevis* is not developed, being replaced by the fleshy continuation of the muscle.

In *Upupa epops* the arrangement is fairly simple. The main tendon runs past the free lateral margin of the long *extensor* to the ulnar superficial fascia, where it becomes lost. It sends forwards a fasciculus from about its middle, to end like the similar band in the Meropidæ. It is figured in Plate [23] L. fig. 2. Its difference from the Passerine arrangement is well-marked. **Page 512.**

In the Bucerotidæ, as found in several species of *Buceros*, *Toccus*, and *Bucorvus*, the only difference from *Upupa* is that the extra outer fasciculus is very much shorter, as seen in Plate [22] XLIX. fig. 2. The lengthy tendon from the major pectoral, which is particularly large, is represented.

In the Alcedinidæ the differences are so considerable in the several genera that I reserve the description of the muscle in this order for a future occasion.

As the Cuculidæ and Musophagidæ are frequently included together with the families above referred to, the arrangement of the short tensor in these birds is represented in Plate [23] L. fig. 3 and in Plate [22] XLIX. fig. 3. In all the Cuculidæ the undivided tendon runs on to the ulnar superficial fascia without any complication. In the Musophagidæ the whole tendon is comparatively feeble, and, if it were more definite at its margins, would be exactly like that in *Upupa*.

Next, with reference to the division of the order Passeres into minor sections.

Four or five pairs of muscles running to the ends of the topmost three bronchial semirings constitute the Oscine syrinx, the distinctive features of which are therefore its acromyodian and complex nature. MM. Keyserling and Blasius were the first to associate with this the bilaminate planta—an exception to which occurs in the case of the Alaudidæ, as we all know, these birds possessing a divided planta together with an Oscine syrinx. Mr. Sclater has kindly referred me to a paper by Mr. Strickland* on *Heterocnemis nævia* (there called *Holocnemis flammata*), in which it is shown that in that Formicarian bird the character of the planta is indistinguishable from that of the bilaminate Oscines. With reference to this and closely allied genera it must be noted that the scutellation of the front of the tarsus is also obliterated, so that the simplicity of the planta is only a participation of the condition which maintains in the tarsus generally. Therefore, with this exception (which from its associations can hardly be looked upon as such), it may be said as yet that *no bird which is not acromyodian has a bilaminate planta.*

Nevertheless the law enunciated by Cabanis, to the effect that when in a Passerine bird possessing ten primary remiges the first is very long, then that bird is not Oscine (or Acromyodian), but "Clamatorial" (or Mesomyodian), led that able ornithologist to place *Pitta* in the latter group, although it possesses a bilaminate planta; since which time Johannes Müller is not the only biologist who has

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* "Annals and Mag. Nat. Hist.," 1844, vol. xiii. p. 415.

wished to know the nature of the syrinx of that bird, of which Sundevall*, in 1872, remarks, "musculi laryngis inferioris ignoti."

Through the kind permission of Dr. Günther I have had the Page 513. opportunity of dissecting two specimens of each of two species of the genus *Pitta*, namely *P. cyanura* and *P. angolensis*, from the National Collection; and Mr. Sharpe had previously very liberally given me a specimen of the Javan species, the dissection of which had led me in my paper "On the Carotid Arteries of Birds" to remove it from the Oscines,† as Cabanis had done from its wing-characters. Two specimens of *Pitta angolensis* from Fantee, and three of *P. cyanura* from Java, have therefore formed the material for the present description.

In *Pitta angolensis* the unmodified trachea terminates thoracically in a ring, split behind, and deep in front; which, from the fact that it presents irregularly placed fenestræ on its anterior surface, arranged in a somewhat transversely linear manner, appears to have been formed by the fusion of two rings. This terminal segment of the trachea does not, as in the Oscines and several other Passeres, form a three-way piece, because there is no antero-posterior bar traversing its inferior margin in the middle line. Of this, however, there is an indication in the form of a median backward-directed process, which advances a short distance into the inferior membraniform completion of the tube, from its anterior border. The tracheal ring last but one is complete, and has a slight median indentation in its inferior margin behind. These points are seen in Plate [26] LIII. figs. 1, 2, and 3.

The first and second bronchial ring-segments are semirings—not modified into the somewhat separate, round-margined, slightly oblique semicircles of fibro-cartilage or bone which, as usual, are found nearer the lungs, but are like moieties of true tracheal rings, approximate, sharp-edged, and at right angles to the axis of the tube. They present no peculiar processes, and are slightly swollen at their anterior extremities.

There is only a single pair of bronchial muscles, continued down from the sides of the windpipe; insignificant in size; quite lateral, and terminating by being inserted into the middle of the outer surface of the second bronchial semiring.

Pitta cyanura differs from *P. angolensis* only in detail, not in plan of conformation. There are four instead of two syringeal bronchial semirings, to the middle of the last of which the single extremely feeble lateral muscle is attached on each side. In it also the last two tracheal rings, and not the last only, are incomplete behind, the last

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* "Method. nat. Av. disp. Tentamen," 1872, p. 5.

† "Proceedings of the Zoological Society," 1873, p. 463. (*Suprà*, p. 167.)

presenting a greater gap than the one above it. This syrinx is figured in Plate [26] LIII. figs. 4, 5, and 6.

Pitta is therefore mesomyodian, in which respect it differs from all the known Old-World Passeres—although *Philepitta*, with its lengthy first primary, is most probably the same in this respect.*

With reference to other points in the anatomy of the genus, it may be mentioned that in both *Pitta angolensis* and *P. cyanura* there is but one carotid artery, the left. The oil-gland is nude. The colic Page 514. cæca are between one eighth and one tenth of an inch in length; and the muscles of the thigh are similarly arranged to those of most Passeres, the myological formula† being *A,XY*, the *ambiens* muscle being absent, at the same time that the *flexor longus hallucis* is quite independent of the *flexor digitorum perforans.* The palate is beautifully figured by Mr. Parker in his memoir on Ægithognathous birds;‡ and I take this opportunity of giving a view of the back of the skull and of the sternum, which present features of interest. It will be noticed that the temporal fossæ extend across the occipital region of the skull, and nearly meet in the middle line behind; this condition, though frequently found in other families, is not one possessed by any Passerine birds except *Pitta*, as far as I am aware. Plate [26] LIII. fig. 8 shows the sternum of *P. cyanura;* in it the sternal notches are particularly deep.

Menura superba is another bird in which our knowledge of the structure of the syrinx is very deficient. Mr. Eyton has described it;§ but his account will bear supplementing. He tells us that "in addition to the usual sterno-tracheal muscles this curious bird has two other pair, both of which have their origin on the rings of the trachea on each side, at the point where it enters the cavity of the thorax. The anterior pair is inserted on the knobs at the extremities of the fourth bones of the bronchiæ; the posterior pair are also inserted on the bronchiæ, but on the three uppermost rings and on the posterior extremity of the fifth."

Several opportunities have occurred to me (partly through the kindness of Professor Flower in allowing me to dissect a specimen beautifully preserved in the Royal College of Surgeons, partly through the assistance of Mr. Edward Gerrard, and partly from my prosectorial advantages) of dissecting the syrinx of *Menura superba*, I take the present opportunity of describing it in detail and figuring it.

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* [Since the above was written, I have been able to fully verify the correctness of Prof. Garrod's supposition. *Vide* "Proceedings of the Zoological Society," 1880, p. 390.—Ed.]

† *Vide* "Proceedings of the Zoological Society," 1874, p. 111. (*Suprà*, p. 208.)

‡ "Transactions of the Zoological Society," vol. IX. Pl. LVI, fig. 6.

§ "Ann. and Mag. Nat. Hist.," 1841 vol. vii, p. 49.

In *Menura superba* the last sixteen rings of the trachea are peculiarly narrow from above downwards. These are carinate in front; in other words, instead of being flattened from without inwards (as is usually the case, and is so in the rings above the sixteenth in this bird), they are compressed from above downwards, by which means a sharp-edged ridge is developed, which projects outwards a short way beyond the level of the interannular membrane. The lowest of these rings, the last tracheal, whilst participating in this peculiarity, is modified to form the three-way piece, whence start the bronchi, an antero-posterior bar joining the downward-directed angles which are developed on the middle of the front and back of the ring, and supporting the syringeal semilunar membrane.

As in the typical Oscines, the first three bronchial semirings participate in the formation of the syrinx, and are modified accordingly, being stronger, deeper, more flattened, and more approximate than those which follow. The first of these is simple; the second is peculiar in being hollow and thin-walled, broader in front than behind, and broadest a short distance (about equal to its depth at the spot) posterior to its anterior extremity; the third is narrower, and terminates behind by a short descending hook. Page 515.

The syringeal muscles are three in number on each side at their insertion, although at their origin only two can be distinguished. These are an anterior and posterior longitudinal, which, from a lateral point situated opposite the tracheal ring 19 above the last one, diverge forwards and backwards to the tips of the bronchial semirings. In Plate [25] LII. figs. 1, 2, and 3 the front, back, and side views of the syrinx of *Menura* are figured.

The *anterior longitudinal* muscle, whose diameter is about four times that of the *depressor tracheæ*, is of uniform size throughout, being constituted of parallel fibres. It is inserted into the lower margin of the expansion at the anterior extremity of the second bronchial semiring, at a short distance behind its apex.

The *posterior longitudinal* muscle, from being single above, divides into two below.

Before proceeding further it will be necessary to explain the way in which these muscles arise. There is a large air-cell, the anterior thoracic,* in which the syrinx and base of the heart are situated. The visceral walls of this cell are so thin that the trachea may, to all intents and purposes, be said to perforate it. Where it does so, the membrane blends with its fascial sheath most intimately; and it is from the thus formed ring of junction that the long fibres of the syringeal muscles spring. This ring is not a simple horizontal circle

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* *Vide* Owen's "Anatomy of Vertebrates," vol. ii., p. 211.

of fibrous tissue surrounding the trachea. In its anterior half it is so; but behind it descends for some distance on each side to a median spot situated below its general level, at a distance beneath it equal to the diameter of the tube itself, to blend at the angle thus formed with a strong fibro-cartilaginous ribbon, which expands below the level of the bronchial bifurcation, to terminate as a membranous covering to the front of the œsophagus.

From the postero-lateral portion of the horizontal moiety of the ring just described, and from its descending limb, the posterior longitudinal muscle of the syrinx arises, on each side, powerful, and in a single mass, of which the longer postero-external fibres, as it descends, differentiate themselves off to form an independent fasciculus, which is inserted into the posterior hooked extremity of the third bronchial semiring. The other much larger internal portion, composed mostly of much shorter and oblique fibres, is inserted into the posterior triangular surface of the tracheal three-way piece (last tracheal ring), and into the posterior extremity of the first bronchial semiring, a few of its tendinous fibres of termination apparently running on to the back of the membrane between the first and second semiring, and perhaps slightly to the back of the second semiring itself, although this last seems to be independent in this respect.

The comparatively slender *musculus sterno-trachealis* springs from the lateral surfaces of the four or five tracheal rings above the last two, emerging between the anterior and posterior intrinsic muscles.

Page 516. *Menura superba*, from the above description, is therefore acromyodian, although not typically Oscine.

Atrichia rufescens presents precisely the same arrangement as *Menura*. There are three modified bronchial semirings, the third descending posteriorly, and the second expanded a short distance before it reaches its anterior termination, the anterior longitudinal muscle being there inserted. The posterior muscle, however, does not clearly separate into two before it reaches its points of insertion, which are identical with those in *Menura*. The lower tracheal rings are different, in that they are not flattened from above downwards; they retain the characters of those above them to a great extent. The last forms the characteristic three-way piece. In Plate [25] LII. figs. 4, 5, and 6 these points are clearly seen.

Atrichia is therefore also Acromyodian, although far from being normally Oscine. It would require but little modification in either it or *Menura* to convert their syringeal muscular masses into more numerous independent muscles. In the Crow, Starling, and most of the other Oscines I have examined, the third semiring is the one to which the long anterior muscle runs, the long posterior not going beyond the second. This condition is just reversed in the two birds under consideration. In the Finches the arrangement described by Cuvier maintains, both anterior and posterior long muscles running to the third bronchial semiring.

In Plate [25] LII. fig. 7 the sternum of *Atrichia* is figured with the rudimentary clavicles (*f*), which are nothing more than granules of bone. No other Passerine bird wants the furcula, so far as is yet known. The manubrium sterni is not largely expanded.

There is another feature in Passerine anatomy which has interested me considerably during my investigations. It is the rule among birds, almost without exception, that the main artery of the leg is that which must be supposed to be represented in Man by the *comes nervi ischiatici*, it accompanying the sciatic nerve—the sciatic artery. The main nerve of the leg is the sciatic; the main vein the femoral. The only known exceptions to this rule are the cases of the genus *Dacelo* among the Alcedinidæ, and *Centropus* among the Cuculidæ. In the former the femoral vein is replaced by the one which is intermediate in situation between its usual course and the sciatic artery; in the latter the sciatic artery is absent,* and is replaced by the femoral.†

In a certain few Passerine birds the main artery of the leg is the femoral, and not the sciatic. These genera are all members of the Oligomyodi of Müller; and the accompanying list contains the names of all the Oligomyodian species (taken from Messrs. Sclater and Salvin's "Nomenclator Avium Neotropicalium" ‡) which I have had the opportunity of examining, with the results arrived at, as far as this peculiarity is concerned.

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Passeres Oligomyodi.	
With a femoral artery.	With a sciatic artery.
Chiroxiphia linearis,	*Mionectes oleagineus*,
Chiromachæris vitellina,	*Tyranniscus vilissimus*,
Heteropelma verœpacis,	*Pitangus sulphuratus*,
Tityra personata,	*Myiodynastes luteiventris*,
Hadrostomus aglaiæ,	*Empidonax minimus*,
Lipaugus sp.,	*Myiarchus crinitus*,
Cotinga cincta,	*Tyrannus melancholicus*,
Chasmorhynchus nudicollis.	*Rupicola crocea*,
	Pitta angolensis,
	Pitta cyanura.

I must mention also that in a specimen of the minute *Mitrephorus*

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* [This is so only in *Centropus phasianus*, and does not occur in two other species of that genus dissected by Prof. Garrod.—Ed.]

† "Proceedings of the Zoological Society," 1873, p. 629. (*Suprà*, p. 191.)

‡ London, 1873.

phæocercus, it appeared to me that the artery of the leg was the femoral; but I should like to see more specimens before I can feel justified in disturbing any generalizations by using this single example.

All acromyodian Passeres of species which I have examined, over one hundred in number, possess the sciatic artery, including *Menura* and *Atrichia;* and the Tracheophonæ quite agree with them in this respect. Such being the case, it seems to me that from among the mesomyodian Passeres a small section may be divided off, including the families Pipridæ and Cotingidæ, in which a characterizing feature is the development of a femoral in place of a sciatic artery; and this being the case, *Rupicola* must be removed from the Cotingidæ.

Although, as yet, our knowledge of the anatomical characters which are the bases of the minor divisions of the Passerine group is still so little advanced, nevertheless a rough sketch of the classification of the order, in which no attempt to fill-in details can be made, is quite within our power.

To commence with Müller's character depending on the situation of the insertions of the syringeal muscles, Passerine birds fall primarily into two main sections, the ACROMYODI, in which the intrinsic muscles of the voice-organ are fixed to the end of the bronchial semirings, and the MESOMYODI, in which they join them at or near their middle. The former group includes all the true Oscines, together with *Menura* and *Atrichia;* the latter the Tracheophonæ, together with those Passeres included by Müller with the Picariæ, as well as *Pitta.*

The Mesomyodi fall into two groups, according to the situation of the main artery of the leg. Those in which the sciatic is the artery of the thigh may, because they therein agree with other birds, be termed *Homœomeri;* those in which the femoral artery is developed, from being in this respect abnormal, may be termed *Heteromeri.*

Of the Homœomeri the Tracheophonæ of Müller form a special well-marked section,—the rest, including the Tyrannidæ, *Rupicola*, and *Pitta*, forming a division which may be termed Haplophonæ until there is reason for further splitting them up.

The following tabular arrangement expresses these views:—

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- **PASSERES.**
  - ACROMYODI (Oscines).
    - NORMALES.
    - ABNORMALES.
      - *Menura.* Menurinæ.
      - *Atrichia.* Menurinæ.
  - MESOMYODI.
    - HETEROMERI.
      - Pipridæ.
      - Cotingidæ.
    - HOMŒOMERI.
      - Tracheophonæ.
      - Haploophonæ.
        - Tyrannidæ.
        - *Rupicola.*
        - *Pitta.*

In conclusion I have specially to thank Mr. O. Salvin for the extremely kind way in which he has placed at my disposal a large collection of mesomyodian birds in spirit. From this I have been able to make out the peculiarity in the distribution of the vessels in the leg; and from it also I hope to obtain materials for another paper shortly, in which the syrinx of some of the yet little-known forms will be described.

EXPLANATION OF THE PLATES.

Plate 21. (XLVIII.)

Fig. 1. View, from the outer side, of the muscles of the patagium of the left wing of *Ramphastos cuvieri*, the radius and ulna being bent at right angles to the humerus; *t.p.l*, tensor patagii longus; *t.p.b*, tensor patagii brevis; *e.m.r.l*, extensor metacarpi radialis longus; *t*, triceps; *b*, biceps; *S.R*, secondary remiges.
2. Same of *Icterus vulgaris*.
3. Same of *Merops apiaster*.

Plate 22. (XLIX.)

Fig. 1. Same of *Coracias garrula*.
2. Same of *Buceros rhinoceros*.
3. Same of *Musophaga violacea*.

Plate 23. (L.)

Fig. 1. Same of *Urogalba paradisea*.
2. Same of *Upupa epops*.
3. Same of *Cuculus canorus*.

Plate 24. (LI.)

Fig. 1. Same of *Patagona gigas*.
2. Same of *Menura superba*.
3. Same of *Trogon puella*.

Plate 25. (LII.)

Fig. 1. Syrinx of *Menura superba*, front view.
2. Same, back view, with median fibrous attachment retained.
3. Same, view of right side.
4. Syrinx of *Atrichia rufescens*, front view.
5. Same, back view.
6. Same, view of right side.
7. Sternum of *Atrichia rufescens*; *f*, rudiment of furcula.

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Plate 26. (LIII.)

Fig. 1. Syrinx of *Pitta angolensis*.
2. Same, back view.
3. Same, side view (left).
4. Syrinx of *Pitta cyanura*.
5. Same, back view.
6. Same, side view (left).

Fig. 7. Back view of skull of *Pitta cyanura*.
8. Sternum of same.

N.B. Although the artist has done all in his power to make clear the peculiarities of the insertion of the *tensor patagii brevis* in the families of birds here depicted, it is important to mention that in actual specimens the differences are much more easily recognizable than might be inferred from the figures.

58. NOTES ON THE ANATOMY OF PASSERINE BIRDS.
PART II.*

Page 447. IN my former communication on the anatomy of the Passeres† I adopted a definition of the group in which was included the important character made known by C. J. Sundevall in 1831, and expressed in the 1872 edition of his valuable "Methodi naturalis Avium disponendarum Tentamen" in the following words:—"Hallux . . . . . per se mobilis. Musculus enim *flexor hallucis longus* articulum ejus ultimum flectens, a flexore digitorum communi perfecte solutus. (In avibus reliquis, omnibus, tendo hujus musculi cum tendinibus alterius conjungitur. Hallux igitur simul cum reliquis digitis semper flectitur.)" *Upupa epops*, agreeing with the Passeres in this respect, is by the author included with them. As mentioned in my paper on the deep plantar tendons of birds‡, I have so frequently been able to verify this statement of the Swedish naturalist, that I felt justified in making the fact part of my definition of the group. Recently, however, from skins which have been placed at my disposal by Mr. Salvin, I have found reason for overthrowing the character, because in the Eurylæmidæ there is a strong vinculum which joins the two muscles exactly in the same manner as in many of the non-passerine families.

Eurylæmus ochromelas, *Cymbirhynchus macrorhynchus*, and *Calyptomena viridis* are the species which I have examined (more than one specimen of each); and in all of them there is a narrow but strong vinculum, situated just above the metatarso-phalangeal articulations, and running from the tendon of the *flexor hallucis longus* downwards to the tendon of the *flexor digitorum profundus*. No other Passerine bird which I have dissected possesses this vinculum, not even *Rupicola crocea*, which has been thought by some to be intimately related to the

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* "Proceedings of the Zoological Society," 1877, pp. 447–53. Read, May 15th, 1877.

† "Proceedings of the Zoological Society," 1876, p. 508. (*Suprà.*)

‡ "Proceedings of the Zoological Society," 1875, p. 348. (*Suprà*, p. 298.)

Eurylæminæ. Such being the case, either Sundevall's character no longer holds, or the Eurylæmidæ are not Passeres.

In his invaluable memoir on the voice-organs of Passerine birds,* a translation of which, by my friend Mr. F. J. Bell, will shortly be published at Oxford (by the Clarendon Press), J. Müller was so overcome by the flood of facts which he had discovered, that he remarks "It is, then, now thoroughly proved that the singing birds cannot be separated, as an order, from the rest of the Passeres (of Cuvier). There is only a large division of *Insessores* or Passerines which must also include the *Scansores.* This order of *Insessores* will contain birds with the most varied supply of vocal muscles, as well as birds which do not possess these muscles, every intermediate condition being found." The fact that an important generalization, such as that of Sundevall above considered, breaks down in the case of *Eurylæmus* would have further Page 448. confirmed Müller in his views, and makes the question as to the ordinal importance of the Passerine group one of vital ornithological interest.

My subclass Anomalogonatæ† very closely corresponds with the Müllerian "Insessores," which comprises the Cuvierian order so termed, together with the Scansores. At the present time its importance would be considered supraordinal by all; and it is not customary now to divide that large division into three sections, 1. *Oscines*, 2. *Tracheophonæ*, 3. *Picarii*, as was done, though not with any great feeling of certainty, by the able German biologist. We include the Oscines and Tracheophonæ, together with the "Ampelidæ and Tyrannidæ," in the order PASSERES. Why do we do so? For many reasons.

First, because, since the promulgation of the theory of natural selection by Mr. Darwin, the doctrine of evolution has obtained a hold upon biologists. This doctrine makes us look upon the classification of animals and plants in a different aspect to that in which the biologists of thirty years ago and more were wont to do. We do not expect to find all intermediate links between any two allied forms of life. Groups have become differentiated from their parent stocks, and when once independent have gone on developing in their special lines, without admixture with any other types. When the ancestral Passeres were first developed they possessed the potentiality for the production of all the peculiarities of their offspring; and the peculiarities which made them Passerine must form the fundamental basis for a definition of the group. The determination of what these fundamental characters happened to be can be only made at the present time (as far as

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* "Abh. k. Akademie d. Wiss. zu Berlin," 1847.

† "Proceedings of the Zoological Society," 1874, p. 111. (*Suprà*, p. 208.)

soft parts are concerned, at least) by a correlation of the non-varying details. No Passerine bird being otherwise, they probably had (1) the hallux alone of all the toes directed backwards, (2) short, simple colic cæca, (3) a nude oil-gland, together with the special pterylosis of the group, (4) only one carotid artery, the left, (5) a sternum with a single notch on each side of the carina, together with a bifurcate manubrium, (6) a truncated vomer with the anterior angles of which the nasal cartilages joined, (7) a peculiar insertion to the *tensor patagii brevis* muscle of the wing.

As in all but the Eurylæmidæ, the deep flexor tendon of the hallux is free from that to the other digits of the foot, at the same time that the Eurylæmidæ agree with by far the majority of the class Aves in this respect (whilst in the characterizing features above stated they are completely Passerine), it is evident that the ancestral type which forms the basis of our definition, lived at a period prior to the loss of the vinculum between the pedal deep flexor tendons, because the probability that the vinculum may have reappeared in them in a condition identical with that in other birds is infinitely small. This view is confirmed by the nature of the syrinx, as far as we are acquainted with it, J. Müller not having been able to detect any intrinsic muscles Page 449. in *Corydon sumatranus*,* the only species he had the opportunity of examining. And the length of the first primary among the remiges tells the same tale.

The order Passeres falls, therefore, into two sections to start with:—those with the hallux not free, the Eurylæmidæ; and those with the hallux independently movable. This latter suborder may be again divided up in the manner suggested in Part I. of this communication.† I much regret that, not having been able, as yet, to obtain any of the Eurylæmidæ in spirit, I have not had an opportunity of making out the arrangement of the *tensor patagii brevis* muscle at its insertion. From skins however, I have been able to procure the skulls, with the palates uninjured, of *Eurylæmus ochromelas*, *Cymbirhynchus macrorhynchus*, and *Calyptomena viridis*. The first and last of these are figured here (figs. 1 and 2), *Cymbirhynchus* agreeing very closely with *Eurylæmus*. The truly Passerine nature of the vomer at its anterior end, with the alinasal cartilages ossified in connexion with them, is undoubted; at the same time the more than usually transverse and lengthy maxillo-palatines with their unexpanded knobbed ends are worthy of notice. *Calyptomena* is seen to resemble the other genera in this latter point, though the vomer is much narrower throughout. The feeble development of the postero-external or "transpalatine"

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* *Loc. cit.* p. 32.

† "Proceedings of the Zoological Society," 1876, p. 518. (*Suprà*, p. 366.)

portions of the palatine bones, as termed by Mr. Parker, is to be seen in both the genera.

Fig. 1.

Fig. 2.

Fig. 1. Palatal view of skull of *Eurylæmus ochromelas*.
Fig. 2. Palatal view of skull of *Calyptomena viridis*.

Turning to a different subject, I desire to direct attention to a peculiarity in the skulls of some of the Dendrocolaptidæ among the Tracheophone Passeres, which has, in my opinion, some significance in the arrangement of the genera of that family.

From an examination of *Furnarius rufus*, *Leptasthenura ægithaloides*, *Synallaxis frontalis*, *Sclerurus caudacutus*, and *Phlœocryptes melanops*, I find that these birds present features in the conformation of their nasal bones not present in *Conopophaga aurita*, *Dendrocolaptes* Page 450. *albicollis*, *Picolaptes affinis*, *Thamnophilus murinus*, *Thamnophilus doliatus*, *Thamnomanes glaucus*, *Grallaria guatemalensis*, *Hylactes megapodius*, *Pteroptochus albicollis*, or any other Passerine bird with which I am acquainted. They are, in fact, schizorhinal, like the Charadriiformes; in other words, the osseous external nares are in the form of triangular openings, the apical angle of each of the triangles being situated between the inner and outer process of the nasal bone of the corresponding side.* Figure 3 gives a view of the upper surface of the skull of *Furnarius rufus*. It has been my habit to group all the birds possessing the schizorhinal skull in a single major division, including the restricted Limicolæ, the Gruidæ, Laridæ, Alcidæ, and the Columbidæ; but the independent development of an identical disposition in the small division of the Passerine birds above mentioned weakens the importance of the character to a certain extent, although it is not at all necessary to assume that it overthrows its significance. Collateral evidence, from visceral and other details, compels me still

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* *Vide* "Proceedings of the Zoological Society," 1873, p. 33. (*Suprà*, p. 124.)

to think that those schizorhinal birds which possess the ambiens muscle—or are, in other words, homalogonatous*—must be retained

Fig. 3.

Superior surface of skull of *Furnarius rufus*, to show the schizorhinal form.

in one great order, the Charadriiformes, until some important structural differences are discovered which necessitate their being otherwise arranged. The schizorhinal disposition is most certainly one which is a secondary development upon the normal holorhinal nares; and that it has been independently arrived at in two non-related orders of the class is proof that it results from most simple causes, because the probability that the same complex conformation should appear *de novo* varies inversely as the complexity: the greater the elaborateness the less the chance that it, in all its details, comes into existence more than once. A still more simple variation is found in the number of the carotid arteries, the normal two being reduced to Page 451. the left only in certain members of almost every order—in *Rhea* and the Megapodes among the Galliformes, in *Arctica alle* and *Turnix* among the Charadriiformes, in *Sula fusca* and *Plotus anhinga* among the Ciconiiformes, &c. The disappearance here and there of the ambiens muscle and of the femoro-caudal, as well as of the colic cæca, all come under the same category, as simple operations which lose their significance in the determination of affinity in proportion to the frequency of their appearance, or to the facility with which they are induced, as I would assume.

The figure of the superior surface of the skull of *Furnarius rufus* (fig. 3), when compared with those of Charadriiform birds in my paper above quoted,† will show the resemblance between the two, as far as the point under discussion is concerned.

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* *Vide* "Proceedings of the Zoological Society," 1874, p. 116. (*Suprà*, p. 213.)

† "Proceedings of the Zoological Society," 1873, p. 34. (*Suprà*, p. 125.)

In questions of doubtful affinity among the birds under consideration, this character proves to be of service. For example, the genus *Margarornis* is differently placed by leading ornithologists—by some along with the Sclerurinæ on account of the shortness of its outer toe, by others with the Dendrocolaptinæ because of the stiffness of its tail-feathers. From the skull, an example of which I have had the opportunity of removing from a skin of *Margarornis perlata*, through the kindness of Mr. Salvin, I feel no doubt that it is *not* Dendrocolaptine, because the nasal bones agree exactly with those of *Furnarius rufus* and the other schizorhinal Passeres above mentioned.

I may also mention that in these schizorhinal tracheophone Passeres, as also in their allies the Pteroptochidæ, the maxillo-palatine plates of the maxillary bones, instead of terminating by blunt uncurved tips, as in the non-oscine (mesomyodian*) Passeres generally, including *Dendrocolaptes*, *Thamnophilus*, and their nearest allies, are slender and curved backwards as in the Oscines. A study of the superb plates in Mr. Parker's Memoir on Ægithognathous Birds† will illustrate this point, which an inspection of other skulls still further verifies. Figure 4 shows this formation in the palate of *Pteroptochus albicollis*. Page 453.

Fig. 4.

Palatal view of skull of *Pteroptochus albicollis*.

These facts, when correlated, suggest a slight modification of the arrangement of the Tracheophonæ as based upon the nature of the tarsal scutellation and the structure of the tails. In their valuable "Nomenclator Avium Neotropicalium," Messrs. Sclater and Salvin divide the suborder thus:—

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[*] "Proceedings of the Zoological Society," 1876. (*Suprà*, p. 366.)

[†] "Transactions of the Zoological Society," Vol. IX. p. 289, Pl. LVI. figs. 8-10, LVII. figs. 8-10, et LIX. figs. 1-3 and 6-8.

Suborder TRACHEOPHONÆ.
- Fam. 1. *Dendrocolaptidæ.*
  - Subfam. 1. Furnariinæ.
  - Subfam. 2. Sclerurinæ.
  - Subfam. 3. Synallaxinæ.
  - Subfam. 4. Philydorinæ.
  - Subfam. 5. Dendrocolaptinæ.
- Fam. 2. *Formicariidæ.*
- Fam. 3. *Pteroptochidæ.*

To me it would appear that the following arrangement better represents their mutual alliances:—

Suborder TRACHEOPHONÆ.
- Fam. 1. *Furnariidæ.*
  - Subfam. 1. Furnariinæ.
  - Subfam. 2. Sclerurinæ.
  - Subfam. 3. Synallaxinæ.
  - Subfam. 4. Philydorinæ.
- Fam. 2. *Pteroptochidæ.*
- Fam. 3. *Dendrocolaptidæ.*
- Fam. 4. *Conopophagidæ.*
- Fam. 5. *Formicariidæ.*

59. NOTES ON THE ANATOMY OF PASSERINE BIRDS. PART III.*

(Plate XXVII.)

Page 523. ON the present occasion I take the opportunity of describing the voice-organ in some species of the non-oscinine (mesomyodian) Passeres in which that structure is, so far as I am aware, unknown.

Leaving any deductions until I have recorded the nature of the structures, I will commence with an account of the syrinx in some of the Tracheophonæ.

Hylactes megapodius.—In this species the syrinx is not identical with any of those described by J. Müller.† It does not differ much from those of *Scytalopus indigoticus* and *Chamæza brevicauda* in its essential structure. By Müller, however, no mention is made of a peculiarity which I find in this species, which seems to me to throw

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* "Proceedings of the Zoological Society," 1877, pp. 523–6. Pl. LIII. Read June 5, 1877.

† "Abh. Akad. der Wissenschaften zu Berlin," 1847.

some light upon the method of development of the tracheophone syrinx. This consists in the way in which the characteristic very slender rings of the specialized voice-organ, instead of ceasing abruptly at its upper end, continue upwards on the anterior surface of the trachea for a considerable distance, whilst posteriorly they suddenly change their breadth superiorly where the syrinx ceases. Figures 4 and 5 of Plate [27] LIII represent the anterior and posterior views of the organ.

The *processus vocales*, which rest on the first and second modified and ossified bronchial semi-rings, extend up as far as the tracheal true ring, twelfth from the bottom. These twelve lowermost tracheal rings are incomplete opposite the *processus vocales* (in other words, at Page 524. their sides), as they are in all the Tracheophonæ; and the lowest is also broken, as it were, in the middle line behind.

Posteriorly the lower nine are extremely slender; the tenth (counting upwards) is somewhat thicker, the eleventh still more evidently so, whilst the twelfth is as thick as any of the superior rings.

Anteriorly there are twenty-three of the lower tracheal rings, which are quite slender in the middle line, especially the lowest three; and of these the twelve lowest (those split laterally) are slender from one side to the other, whilst the upper eleven appear thick at their extreme ends on account of the intrusion, for a short distance round the sides of the tracheal tube, of the thickening above recorded of their hinder parts, which diminishes rapidly in a spindle-pointed manner.

The lowest tracheal ring is as slender as those just above it; and it is worthy of note that the *processus vocales* rest upon the thickened second bronchial semi-ring as well as on the first. These vocal processes cannot be detached from the sides of the trachea without injuring it; and the sterno-tracheal muscles arise from their apices, to which are also attached thin muscular sheets which extend up the windpipe laterally and a little posteriorly.

Grallaria guatemalensis.—In this species also the specialized syrinx does not cease abruptly at its upper end, the superior rings of the trachea, which help to constitute it, gradually losing their individual character. Figs. 1 and 2 (Plate [27] LIII.) represent the front and back view of the organ, which is peculiarly shallow for its width, and involves but six of the lowermost tracheal rings. These six are incomplete at their sides where they are in contact with the *processus vocales*, which latter are small, flat, fusiform ossifications, pointed both at their upper and lower ends, and just touch the upper of the two superior enlarged and ossified bronchial semi-rings, the remainder of each bronchus being of the normal character. The lowermost tracheal is incomplete in the middle line in front, as well as at the sides, whilst behind it is thickened, and sends small downward processes on each side of the middle line in such a manner as to develop a notch between them. Figure 3 represents the left-side view of these structures, seen from the interior of the organ, *a* being the *processus vocalis.* From figure 1 it can be seen that the tracheal rings four, five, and six from the bottom are not ossified at all in front, and that rings seven, eight, and nine are only so at their sides, whilst ring ten, with those just above it, are extremely thin in the middle. Posteriorly also, from figure 2 it can be inferred that the rings above the bottom ones are very slender, becoming thicker by degrees above the sixth, which is the highest of those constituting the voice-organ.

With reference to the muscles, it may be stated that the lateral muscle of the trachea on each side covers and joins the upper extremity of the *processus vocalis*, turning off to become the *musculus sterno-trachealis* opposite the ring third from the end, and sending no Page 525. continuation on to act directly upon the bronchial semi-rings.

Lipaugus cineraceus.—In this species the single specimen at my disposal, which Mr. Edward Bartlett has most kindly given me, has the lower part of the windpipe considerably damaged by shot. Nevertheless, as one side is comparatively uninjured, I have been able to make out the essential points in the structure of the syrinx, which does not differ much from that of *Pipra leucocilla*, as represented by Müller.* The lowermost rings of the trachea are not peculiar, each one being deep, and meeting, at its superior and inferior margins, the rings above and below it. The first and second bronchial semi-rings resemble those of the trachea in their flatness, depth, and approximation, the third being the first normal bronchial ring. It, with those which follow, are slightly peculiar in that they are ossified throughout, except in a small part, equal to about one sixth the breadth of each semi-ring, one third distant from their anterior ends, where they retain their primitive cartilaginous structure (*vide* Plate [27] LIII. figs. 6 and 7).

The lateral muscle of the trachea is of considerable breadth, being most developed anteriorly, those of the opposite sides coming nearly into contact in the middle line in front. Opposite the tracheal ring seventh from the bottom, the small sterno-trachealis is differentiated off from the posterior portion of this muscle, by far its larger anterior part continuing downwards to become the intrinsic muscle of the syrinx, which ceases at its insertion into the anterior half of the third bronchial semi-ring. It exhibits no tendency to split into two as in *Pipra leucocilla.*

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* *Loc cit.* Plate IV. figs. 9–11.

It may be mentioned that the second bronchial semi-ring is somewhat expanded at its ends, intruding more into the membranous completion of the bronchial tube than do those which follow it. The damaged condition of my specimen makes it impossible to determine whether the antero-posterior bar, which is situated at the point of bifurcation of the trachea, is formed by the last tracheal ring, or by the completion and junction of the first bronchial rings of either side. I am inclined to think it depends on the latter of these conditions.

Chiromachæris manacus, according to the description given by Müller, agrees exactly with this species, as far as its syrinx is concerned.

Heteropelma veræ-pacis.—It is Mr. Salvin whom I have to thank for a specimen of this species, as well as the next to be described, in spirit. Its voice-organ is most simple. The single, broad lateral muscle of each side of the trachea continues down to the middle of the second bronchial semi-ring, which is scarcely different from those below it either in bulk or appearance; and the one above it resembles it. There is, however, a considerable interval between it and the third, whilst it almost touches the first. None of the lowermost tracheal rings are peculiar in any way.

Hadrostomus aglaiæ is a bird in which the calibre of the lower end of the trachea is very inconsiderable, and the syrinx is correspondingly difficult to investigate. The tracheal rings are not modified, except the last, which is developed into a three-way piece from the Page 526. presence of a bar running from before backwards at the middle of the lower margin. The first bronchial half-ring is of the same flattened and deep nature as the tracheal rings, and, like them also, is not separated from the three-way piece by any interval. To its anterior end, on each side, as well as to the front of the three-way piece, the intrinsic muscle is attached, which descends, broad and thin, down the front of the lower part of the trachea, in contact with its fellow of the opposite side, there to terminate (*vide* Plate [27] LIII. fig. 8).

The second bronchial semi-ring is not modified. It is separated by a short interval from the first, and by a strikingly considerable one from the third, which is the commencement of the normal bronchus. I could not find that the muscles of the syrinx sent any fibres to this second ring, as in *Pachyrhamphus atricapillus*, described by Müller, although otherwise this structure is almost identical in the two birds. If they are present they must be extremely feeble; and the relative distances of the upper bronchial semi-rings favours the view that some special arrangement exists.

The account, above given, of the voice-organs in the aberrant Passeres in question, is entirely confirmatory of the results arrived at by Johannes Müller. Both *Hylactes* and *Grallaria* are completely tracheophone, as he predicted they would be found to be, although they agree with one another, and differ from those previously described in having the syringeal end of the trachea less abruptly distinguishable as being composed of two parts. Neither *Lipaugus*, nor *Heteropelma*, nor *Hadrostomus* are far from the mesomyodian types already known, as far as their voice-organs are concerned, which structure clearly shows that our nomenclature is an inefficient one when it places *Hadrostomus* as far from *Pachyrhamphus* as either is from *Tityra*.

Again, also, that the Pipridæ and Cotingidæ should be considered to be different families is not borne out by the nature of the lower larynx; and it seems hardly possible to allow a difference in tarsal scutellation to constitute a family difference, when not borne out by more important points of internal structure.

EXPLANATION OF PLATE 27. (LIII.)

Fig. 1. Syrinx of *Grallaria guatemalensis*, front view.
2. The same, back view.
3. The same, lateral view, from within, showing the fusiform *processus vocalis*.
4. Syrinx of *Hylactes megapodius*, front view.
5. The same, back view.
6. Syrinx of *Lipaugus cineraceus*, front view.
7. The same, side view.
8. Syrinx of *Hadrostomus aglaiæ*, front view.

60. NOTES ON THE ANATOMY OF PASSERINE BIRDS.
PART IV.[*]

In my "Notes on the Anatomy of Passerine Birds," Part II., whilst discussing the systematic position of the Eurylæmidæ, I mention that the method of insertion of the tensor patagii brevis muscle of the arm is unknown.[†] Through the kindness of Lieut.-Colonel Godwin-Austen, who has placed at my disposal carbolized specimens of *Psarisomus dalhousiæ* and *Serilophus rubropygius*, I have recently had the opportunity of dissecting these species, and am now able to state that in both of them the tendon of the tensor patagii brevis is perfectly Passerine, agreeing precisely with the typical arrangement previously described by me in the Order[‡]—the two tendons which traverse the distance between the point where the main tendon joins the extensor metacarpi radialis longus and the elbow running independently and parallel as they course to their humeral attachment. Page 143.

In neither specimen was I able to dissect out the plantar tendons, because they were so dry and brittle that no amount of soaking would render them fit for observation. I was, however, able to determine some other anatomical points, including the existence of a single carotid artery (the left), a normal disposition of the vessels of the thigh (the main artery of the leg being the sciatic), the considerable size of the femoro-caudal, of the semitendinosus, and of the accessory semitendinosus, and the absence of the accessory femoro-caudal and of the ambiens muscles.

Previous evisceration, I regret to say, prevents my adding any thing with reference to the syrinx and the abdominal viscera; nevertheless I think that now the vomer and the tensor patagii brevis are known to conform exactly with the Passerine type, all shadow of doubt as to the perfectly Passerine structure of the Eurylæmidæ may be dismissed, notwithstanding the aberrant vinculum joining their deep flexor tendons.

So far as its sternum is concerned, *Psarisomus dalhousiæ* so closely resembles *Eurylæmus javanicus*, as figured by Mr. Sclater in "The Ibis,"[§] that no further remark with reference to it is necessary, except to draw attention to the unforked condition of the manubrium. My specimen of *Serilophus* was too much shot for me to make out its sternal peculiarities.

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[*] "Proceedings of the Zoological Society," 1878, p. 143. Read, Feb. 5, 1878.

[†] "Proceedings of the Zoological Society," 1877, p. 449. (*Suprà*, p. 370.)

[‡] "Proceedings of the Zoological Society," 1876, p. 508 (*Suprà*, p. 356.)

[§] Third Series, vol. ii., 1872, p. 179.

61. ON THE CHINESE DEER NAMED *LOPHOTRAGUS MICHIANUS* BY MR. SWINHOE.*

(Plate XXVIII.)

Page 757. At a meeting of this Society in 1874 ("Proceedings of the Zoological Society," 1874, p. 453), Mr. R. Swinhoe described a small Deer sent him from the neighbourhood of Ningpo by Mr. Michie, of Shanghai, and gave it the name *Lophotragus michianus*, after its discoverer. The specimen consisted of a skin, without the skull or any other bones. Mr. Sclater, at the time, suggested that it might be the *Elaphodus cephalophus*, which had been described shortly before† by M. Alphonse Milne-Edwards from specimens obtained by Père David in Moupin. Mr. Michie informed Mr. Swinhoe that the specimen was a female; and Dr. Peters, of Berlin, who carefully examined it before it was mounted for the national collection in that city, has courteously answered questions which I put to him with reference to it (the type) in the following words:—"It does not show a trace of horns . . . . It shows *well developed* teats, and not a trace of a penis; there is no trace of an impression on the lower lip, as would have been the case if it had been furnished with the male tusks, figured from imagination in Swinhoe's figure." From what will be said further on it can be evidently inferred that the type specimen is a female.

A second specimen, a living male, of the same Deer was purchased by the Society on February 12th last from Mr. Michie's agent. It also came from the Ningpo district. Mr. Sclater's note with reference to it, together with a woodcut of the animal, will be found in the "Proceedings"‡ for this year. In this he tells us that "the canines Page 758. project from the sides of the mouth, as in *Hydropotes*. There are no external antlers; but there are hard projecting cores, sensible to the touch, beneath the elongated hairs which form a flattened disk on the forehead."

Shortly after its arrival the animal began to show symptoms of paralysis, which led to its death on the 14th of July. The following are measurements made a few hours after its death, before any incisions had been made:—

	inches.
From tip of nose to base of tail	36
Fleshy tail	3

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* "Proceedings of the Zoological Society," 1876, pp. 757–765. Pl. LXXVII. Read, Nov. 21, 1876.

† "Nouv. Arch. du Mus. 1874, Bull." p. 93.

‡ [*Loc. cit.* p. 273.]

	inches.
Length of head	9½
Length of ear	5½
Greatest breadth of ear	3½
From the middle line of the back straight down to the elbow	10
From the elbow to the wrist	5½
From the wrist to the base of hoofs	6½
From the middle line of back straight down to the knee	11¼
From the knee to the ankle	9
From the ankle to the base of the hoof	10

A minute examination of the skull and skin of this specimen, in association with the description and figures given of *Elaphodus cephalophus*, made it quite evident to me that Michie's Deer is of the same genus as it; and I wrote to M. Milne-Edwards to ask him some questions of detail with reference to the Moupin species. In reply that gentleman told me that, besides the specimen figured by him, he has two other skins of the same species in very bad condition, which much resemble *Lophotragus* in their colour, and that he believes they clearly show that the species is variable in its coloration, and that the Deer described by Mr. Swinhoe is the same as that obtained by Père David. At the same time he very courteously sent me the two skins above mentioned, from the larger (male) of which the figure of the skull given by him was taken, and also gave me permission to remove the skull from the smaller (young female) skin. This I have done, and find that in age it is exactly the same as the Society's specimen.

A comparison of the skins makes it immediately evident that the animals from Moupin and those from Ningpo scarcely differ from one another at all, and that *Lophotragus michianus* and *Elaphodus cephalophus* are the same species, slightly modified in accordance with the difference in their habitats.

The following description of the species may serve to render its characteristics more apparent:—

Elaphodus cephalophus is a Deer of about the same size as the Indian Muntjac (*Cervulus muntjac*), with minute simple antlers, which are situated on slender convergent pedestals; and with enormous canine teeth. The supraorbital glands, found in the Muntjacs, are not present; nor is there a tufted gland on the outside of the metatarsus.

The hair is coarse and slightly quill-like. In the Moupin specimens it is of two kinds as regards general coloration—all in front of a vertical line drawn through the shoulder-joint, with the exceptions to be mentioned below, being whitish at the base, and gradually Page 759.

becoming dark-brown towards the tip, quite close to which there is a distinctly marked narrow *white* ring. This white ring near the extremity of each hair gives a speckled appearance to the parts covered with it.

Over all the body behind the above-mentioned line this white ring is absent; and each hair, from being white at the root, gradually darkens to become of a rich brown at the tip, over the sides and back of the animal, more pronounced along the middle line—at the same time that, whilst deepening in intensity down the legs, below the carpus and tarsus the colour is almost black itself, as are the hoofs. In the female figured by M. Milne-Edwards, which is of a more rufous tint generally than the pair of skins lent by him to me, there is, as is sometimes the case in *Cervulus reevesi*, a white line just above the hoofs.

The under surface of the tail is white, as is also the hair in the pudendal region.

Much resembling, though more developed than in the females and the young males of, the genus *Cervulus*, there is a crest of lengthy deep-brown, almost black hair arranged in a horse-shoe shape in the frontal region. It is anteriorly that the crest is deficient, the short speckled hair of the nose extending backwards, at the same time that it lengthens, to enter the interior of the enclosure thus formed. This crest is slightly prolonged between the ears as a pointed process, with the equally dark hair of the base of the exterior of which it does not blend, a narrow speckled isthmus intervening. M. Milne-Edwards tells us* that the interior of the ears is whitish, and that the tips of these organs, as well as the greater part of their inner edge, are of a nearly pure white. A transverse black bar extends across the inner surface of the ear, about three quarters of an inch broad. Along the lateral margin of the outside of the horse-shoe crest the short hair forms a light grey line in front of the eye, becoming reddish-brown behind it. The long hair of the crest itself is directed backwards.

In the young male specimen from the hills near Ningpo which forms the subject of the present paper, the only hair which is ringed is situated in the front of the base of each ear, occupying an extremely small area. Elsewhere the chocolate-brown of the Moupin examples is replaced by greyish-black, each hair being white for a considerable distance from its base. The face and neck are therefore not speckled or brown, but uniformly dark grey. The head is figured, as it appeared immediately after death, in the accompanying drawing (Plate [28] LXXVI.).

The *skull* of the Ningpo *Elaphodus* cannot be said to differ essen-

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* *Loc. cit.* p. 355.

tially from the Moupin specimens. Although there are exquisite figures in the "Recherches pour servir à l'histoire Naturelle des Mammifères"* of the skull of the adult male, M. Milne-Edwards has most obligingly allowed me to remove the cranium from the skin of the Page 760. female that he has lent me, which fortunately happens to be of exactly the same age as the Society's male; in other words, the median milk-incisors are gone, whilst the third molars are just protruding, all the milk-molars being in place. In the Society's specimen the frontal pedestals are fairly long, but without any antlers at their extremities. Their bases are slightly further from one another than in the Moupin male; and there is a second slight difference from both it and the female, which is, that just at the root of the ascending orbital process of the malar bone the ring of the orbit does not become ossified upwards so as to reduce its size by the formation of a shallow lamina above the masseteric ridge. This peculiarity may also be expressed by saying that the surface of origin of the masseter muscle extends upwards as far as the margin of the orbit in the Ningpo male, whilst in those from the more western locality it ceases some distance below it. But it must be noted that the Ningpo specimen died in very bad condition, the bones being spongy and ill-marked,† whilst the others were shot wild. In it, strangely enough, there is also an abnormality with which I am not at all acquainted. It is that the malar bones on both sides, instead of being single, are made up of two independent parts, an orbital and a zygomatic, with the suture longitudinal and nearly straight, extending from the anterior extremity of the zygomatic process of the temporal bone to the posterior inferior part of the large crumenal depression.

Sir Victor Brooke,‡ in his paper on the *Cervuli*, has drawn attention to the very peculiar distribution of the ankyloses in the tarsus of

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* Atlas, Pls. LXVI and LXVII.

† The following are the measurements of the skull of the Ningpo male, side by side with which those of the male (adult) Moupin specimen are given, from M. Milne-Edwards's figure:—

	Ningpo spec. in.	Moupin spec. in.
Extreme length of skull	$6\frac{1}{4}$	$7\frac{15}{16}$
Extreme breadth from zygoma to zygoma	$3\frac{1}{32}$	$3\frac{7}{16}$
Interval between inner sides of frontal pedestals	$1\frac{13}{32}$	$1\frac{1}{8}$
Extreme length of nasal bones	$2\frac{3}{16}$	$2\frac{1}{2}$
Breadth of facial plane opposite lachrymal foramina	$1\frac{21}{32}$	$2\frac{1}{32}$
Mandible from angle to incisor margin	$5\frac{1}{2}$	$6\frac{1}{2}$
Extreme length of præmaxilla	$1\frac{23}{32}$	$2\frac{5}{32}$
Extreme intermolar breadth	$1\frac{1}{4}$	

‡ "Proceedings of the Zoological Society," 1874, p. 33.

that family, he having demonstrated that in it the external and middle cuneiform bones blend with the naviculo-cuboid to form a single bone. The same condition exactly exists in *Elaphodus cephalophus*, the innermost cuneiform bone remaining free. But, strange to relate, in my specimen of Michie's Deer, on both sides, this internal cuneiform bone is completely anchylosed with the metatarsus, a further specialization than is found in any other ruminant, so far as I can make out.

In Michie's Deer no trace of the lateral metacarpal rudiments could be detected. It possesses thirteen pairs of ribs, six lumbar vertebræ, six ankylosed sacrals, and nine caudals, making forty-one Page 761. vertebræ in all. The bones, in the specimen under consideration, especially those of the limbs, are extremely porous and badly marked; nevertheless, on making a section of the head of the metatarsus, it is apparent that the internal tarsal cuneiform bone has so completely fused with it as to leave no line of demarcation. In the Paris specimens of *Elaphodus* the tarsus exactly resembles that of *Cervulus*, and the lateral metacarpals are very nearly lost.

In the young female from Moupin the milk canine teeth are in place, their permanent successors appearing, in the dry skull, above them. In the male of the same age from Ningpo, the tusks have a remarkably permanent appearance, and there is no evidence from the condition of the maxillary bones that they belong to the milk series. Such being the case, it must be presumed that the milk canines in the male are shed earlier than in the females, as it is not in accordance with any known facts that they should have persistent pulps which would remove any necessity for their replacement.

Anatomy of the Alimentary Canal and other Viscera.

The muffle is more considerable than in the Elaphine Deer, but resembles that of the Rusinæ and Muntjacs in extending upwards along the outer border of each nostril as far as its superior margin. The canine tusks protrude an inch below the upper lip, and mark the lower lip at the spots at which they come into contact with them.

The *palate* in front of the intermolar region is transversely ridged by folds of the mucous membrane, slightly crenulated at their free backwardly directed edges. These folds are deficient in the middle line; and those on one side are not continuous with those of the other, but with the spaces which intervene between them. The intermolar region and the palatal surface behind it are smooth, and black instead of flesh-coloured, as it is anteriorly.

The *tongue* is like that in most ruminating animals, broad near the tip, then narrower, and again slightly broader opposite the intermolar eminence. Its mucous membrane is covered with two kinds of papillæ—first the filiform, small, thick-set, short and blunt over the anterior part of the organ, conical and larger in the middle of the intermolar eminence, and secondly the fungiform, disk-shaped and flattened, scattered sparsely over the fore part, and at the sides of the intermolar eminence gradually enlarging and becoming arranged in a linear manner, converging as they run back to form the circumvallate papillæ, eleven on one side and twelve on the other.

The salivary glands present no special features of interest. The tonsils open each by an orifice situated in the middle of a slight depression. The epiglottis is rounded, with a slight notch in the middle line of its contour.

The *stomach* possesses much the proportions of that of the Musk (*Moschus moschiferus*).* In the *rumen* perhaps the converging left lateral cæcal extensions of the upper and lower compartments are slightly longer. The villi are there very close-set, elongated, flattened, and slender, with nearly parallel sides, the largest being slightly Page 762.
spooned at their free ends. In most parts they are about a quarter of an inch long; but on the folds they are much shorter. Nowhere are they absent. They are all blunt-tipped and slightly crenulated along their margins. No trace of the special gland found by Prof. Flower on the anterior wall of the paunch of the Musk could be detected. Neither in *Cervulus muntjac* nor in *C. reevesi* are the villi of the rumen flattened, they being cylindrical. The cells of the *reticulum* are shallow and not large, covered with minute papillæ on their floors, and with a regularly arranged row on the top of each cell-wall.

The *psalterium* resembles that of the ordinary Deer, and differs from that of *Moschus* in that the plicæ are unequal in length. There are thirteen folds of what may be termed the first power, because they are the deepest, between each two of which one of the second power is developed. On each side of each secondary fold is a tertiary, about a quarter of an inch deep; and, again, there is a longitudinal row of papillæ on each side of each tertiary fold, which may be considered to be a rudimentary set of the fourth power. Such a psalterium may be called *quadruplicate*, because folds are present of four different depths. The stomach of *Moschus* would be simpliciplicate, were it not that there is a row of papillæ developed between the plicæ in some parts; it is therefore duplicate upon the nomenclature here suggested.

The *abomasum* presents no peculiarities.

The following are the measurements of the intestines:—

	ft.	in.
Small intestine	23	2
Large intestine	9	8
Cæcum		9¼

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* *Vide* "Proceedings of the Zoological Society," 1875, p. 168.

The colic coil was not disposed in quite the ordinary manner; but the peculiarity was probably an individual one. At its end the large intestine made a complete transverse reduplication before turning forward from the right iliac fossa to form its terminal and irregular curve round to the sigmoid flexure.

The *spleen* is flat on one side, domed on the other, and circular.

The *liver* is composed of two nearly equal lobes, from the abdominal surface of the right of which is developed the triangular and laterally directed caudal lobe. The Spigelian lobe is only rudimentary, being represented by a slight tumefaction of the vertebral border of the portal fissure. There is no gall-bladder.

In the arteries of the neck the arrangement is that found in the Ruminantia generally, the ascending aorta giving origin, first to the left brachial with the corresponding vertebral, then to the left carotid, and finally to the same three vessels of the right side.

There are thirty-eight tracheal rings above the accessory bronchus and nine below it, making forty-seven in all. In the lungs the two lobes of the left side and the five on the right were found, the right lung being the larger. The lower lobe of each lung is comparatively small.

Page 763. The *brain* (figs. 1 and 2) is richly convoluted for its size, its measurements, after having been hardened in spirit, being:—

	in.
Greatest length of hemispheres	$2\frac{19}{32}$
Greatest depth of hemispheres	$1\frac{1}{2}$
Greatest breadth of brain..................	$2\frac{3}{16}$

It is therefore somewhat larger than in *Cervus humilis*, as may be inferred from the measurements given by Professor Flower*. This species it also closely resembles in its convolutions, as well as in the considerable development of the anterior lobes. The hippocampal, inferior external, together with superior and middle external gyri, are easily recognizable, the sulcus separating the last two being long, and the middle external gyrus traversed in the direction of its length by
Page 764. a minor sulcus. There is a break in the sulcus which separates the middle and inferior external gyri a little more than an inch from the anterior border of the hemisphere, which is peculiar. As in *Moschus* and in *Cervus humilis*, the calloso-marginal sulcus appears on the superior surface of the brain, allowing the hippocampal gyrus to appear between it and the middle line. In *Cervulus muntjac* the convolutions are slightly less developed than in Michie's Deer, and the

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* "Proceedings of the Zoological Society," 1875, p. 176, note.

calloso-marginal sulcus is even more superficial; it is, however, narrower anteriorly.

Fig. 1.

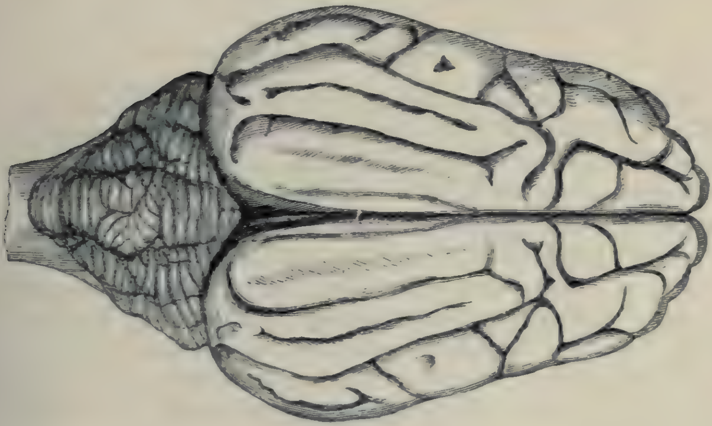
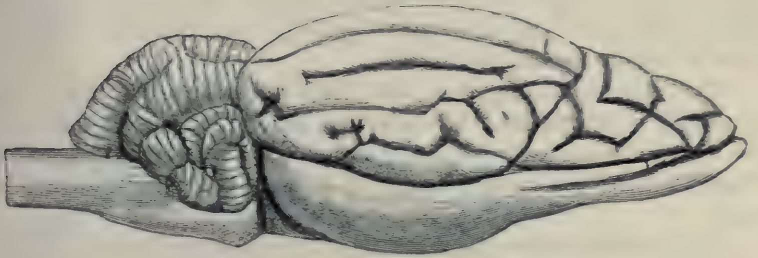


Fig. 2.



In its *generative organs*, the glans penis (fig. 3), instead of being blunt, is an elongated and slender cone, terminating much like the tip of a wooden pen-holder, the urethral orifice being situated just behind the extreme tip, slightly turned upwards. The Muntjacs and the Roe Deer agree with Michie's Deer in the shape of the glans; but whereas there is no trace of Cowper's glands in *Capreolus* and Michie's Deer, they are large in *Cervulus* (in *C. muntjac* at least). There are four nipples. On the outside of the skin covering the metatarsus I

Fig. 3.

found in the recently dead animal a deep smegma-secreting depression, evidently homologous with the metatarsal glands in most Cervidæ. There were no tufts of hair round these; and I cannot recognize their situation in the prepared specimen of the skin.

General Remarks.

From what has been said above, it is evident that the *Lophotragus michianus* of Swinhoe is the same animal as the earlier-named *Elaphodus cephalophus* of A. Milne-Edwards, and that it was because his specimen was a female in which the skull was wanting, at the same time that the figure given by M. Milne-Edwards is from a remarkably light-coloured and red skin, that Mr. Swinhoe was misled as to its affinities. It seems, however, that the Ningpo animal is of a greyer tint than that from Moupin; for the description given by Mr. Michie*, namely that "it is a dark iron-grey or pepper-and-salt colour, like some Scotch terriers," exactly applies to the Society's example, whilst the Paris skins are all decidedly chocolate, although differing in tint among themselves.

As to the affinities of *Elaphodus cephalophus*, M. Milne-Edwards† has remarked that "it is intermediate between the Muntjacs and the ordinary Deer, in certain respects appearing even to unite these animals to *Hydropotes* and *Moschus*."

That *Moschus* has any close affinities with *Cervulus* and its allies is extremely doubtful; and a comparison of the above description of Page 757. the visceral anatomy of *Elaphodus* with the facts brought forward in Prof. Flower's important memoir on *Moschus* tends to confirm this view.

The internal anatomy of *Hydropotes* is not known; but the absence of any frontal tuft, the presence of an inflated auditory bulla, together with the non-ankylosis of the cuneiform bones with the naviculo-cuboid of the tarsus, are against its Cervuline affinities.

With *Cervulus* there is every reason to believe that *Elaphodus* is most intimately related. The size of the animal, the conformation of the skull, the fusion of the cuneiform bones with the naviculo-cuboid, the non-development of the metatarsal tufts, and the presence of the frontal crest are all evidences in that direction, as is the similarity of the shape of the glans penis in the two genera. It appears to me that *Cervulus*, together with *Elaphodus*, form a sub-family of the Cervidæ, which might be termed the Cervulinæ and be defined as follows:—

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* "Proceedings of the Zoological Society," 1874, p. 453.

† *Loc. cit.* p. 353.

CERVULINÆ. Small Cervidæ in which the proportionally small antlers are situated on elongated pedestals, up the front of which the lengthy hair of the crest which is developed in the frontal region extends. Females hornless. Suborbital glands large in both sexes. No metatarsal tufts. Canine tusks large in the males, minute in the females. The second and third cuneiform bones of the tarsus ankylosed with the naviculo-cuboid. The lateral metatarsals wanting, and the lateral metacarpals present only as slender bones opposite the upper ends of the third and fourth metacarpals, or wanting altogether.

Two genera are contained in this subfamily.

Cervulus. Cervulinæ in which the pedestals of the antlers are divergent, and send downwards from their roots strong supraorbital ridges, the antlers themselves diverging into a brow-antler and a simple beam. Cutaneous glands developed on the inner side of each supraorbital ridge.

Elaphodus. Cervulinæ in which the pedestals of the antlers are convergent and do not send downwards supraorbital ridges. Antlers minute and simple, scarcely projecting beyond the much-developed frontal hair-tuft. Frontal glands absent.

62. NOTES ON THE VISCERAL ANATOMY AND OSTEOLOGY OF THE RUMINANTS, WITH A SUGGESTION REGARDING A METHOD OF EXPRESSING THE RELATIONS OF SPECIES BY MEANS OF FORMULÆ.*

THERE is so little known of the differences in the visceral anatomy Page 2.
of the many genera and species of the ruminating animals, that I feel
that no apology is necessary for bringing before this Society the facts
which my prosectorial opportunities afford me with reference to parts
which are either too large or too perishable to be easily preserved in
our museums. The following "Notes" will be found to contain an Page 3.
account of those parts in certain species of the Cavicornia and Cervidæ
(such as the stomach, liver, generative organs, and brain), which are
subject to variation in the different species that I have had the opportunity of examining.

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* "Proceedings of the Zoological Society," 1877, pp. 2–18. Read, Jan. 2, 1877.

The *stomach* of the Ruminantia, on account of its complexity, presents features of special interest. As far as the general shape and proportions of its cavities are concerned, my observations tend to show that the relative size of the psalterium in the different genera is the only characterizing feature. In the abomasum I have not detected any variation.

The rumen varies as to the shape and distribution of the villi on its mucous membrane. In most of the smaller species the folds which constrict the viscus, as well as the pouches between them, are covered internally with villi, though these are larger in the latter situations. In most of the larger species the villi are absent on the folds, and are largest in the middle of the pouches. This is specially the case in the Rusine Deer. In the Sheep and its allies they are peculiarly scattered and broad at their bases, as is also the case in *Moschus*. In most of the smaller species of the order they are cylindrical or flattened cylinders, as close-set as the "pile" in velvet. In *Portax picta* they are very elaborate, close-set, pedunculated and foliaceous. In *Cervus alfredi* they are flattened and expanded apically, in other words tongue-shaped, as they are in *Camelopardalis giraffa*. In *Tetraceros subquadricornutus* all the villi are flattened, broad, and rounded, absent on the folds. In Table I. column VIII. (pp. 392, 3), further notes on the peculiarities in the rumen will be found.

The reticulum varies in the depth and size of its cells, but not to any great extent. I have not ever seen them deeper than in *Cervus duvaucelli* ($\frac{1}{6}$ inch), or shallower than in the Giraffe. In some species the cell-walls are thicker than in others, as may be seen on reference to Table I. column IX.

The psalterium varies more than any other section of the stomach; and a study of its laminæ brings to mind the septa of some of the more elaborate and fully calcified corals; for, as in them, the laminæ are of different lengths, and their arrangement is subject to definite laws.

This organ may be defined as a subglobose dilatation of the upper wall of the canal leading from the reticulum to the abomasum, the lumen of which is much reduced by the development from all but its lower wall of longitudinal villous-covered folds of its mucous lining. In size it differs greatly, being very large in the genus *Bos*, minute in *Nannotragus* and *Cephalophus*.

Of the laminæ there are a certain number (frequently ten) of a definitely greater depth than any of their neighbours; and these may be termed *primary* laminæ. Between each two of these there are *secondary* laminæ of smaller size; and such being the case, nineteen is the average number of the two sets combined. When the organ is more complex a still shallower *tertiary* lamina appears on each side of each secondary one; and there may be *quarternary* laminæ on each side of each tertiary, on either side, again, of which there may be a row of papillæ indicating the rudiments of laminæ of a fifth power; for, when disappearing, laminæ always ends as rows of papillæ.

Page 6.

In the case of a transverse section of a quadruplicate psalterium (in other words, in one of which there are laminæ of four powers), the quaternary folds being rudimentary, imagine it to be cut through longitudinally along the middle of its groove, and opened out in such a way that the outer wall forms a straight line, whilst the laminæ depend from it; then the appearance will be that of fig. 1. This being from an actual specimen, there is a slight want of uniformity at *b* and *c*, which is usually found to be the case. The laminæ of each cycle, or power, gradually diminish in size laterally; and it will be noticed that, though the organ is quadruplicate where the folds are relatively largest, the smallest laminæ disappear at the sides. This is nearly always the case, as it is also that near the orifice of communication with the reticulum they are stronger than they are further on.

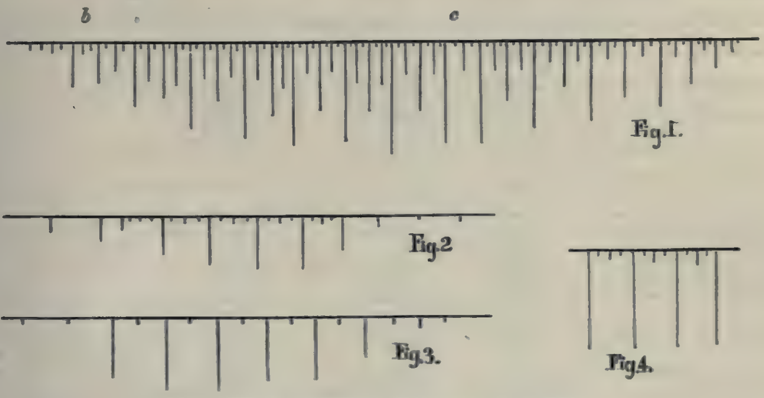

Diagram of transverse sections of psalterium.

In different genera the relative depths of the laminæ which constitute the separate cycles is not always the same. The arrangement depicted above is the most usual, in which the secondary folds are about two thirds the size of the primary, a similar difference existing between them and the tertiary, and so on.

Fig. 4 is from the psalterium of *Gazella arabica*, in which, though the disposition is triplicate, it is seen that the secondary laminæ are very little larger than the papillary rows which form the tertiary cycle, the primary laminæ being of considerable depth. The structure in *Cephalophus* is the same, only that, the psalterium being much smaller, all the parts are much reduced in size, the lateral laminæ

Page 4.

TABLE I.

I. Name.	II. Gall-bladder.	III. Caudate Lobe.	IV. Spigelian Lobe.	V. Depth of Umbilical Fissure.
Cervus elaphus	Absent.	Lateral in young, small in adult.	Absent.	Almost nil.
—— *cashmeerianus*	Absent.	....	....	....
—— *dama*	Absent.	Almost nil.	Absent.	1/4
—— *aristotelis*	Absent.	Square.	Oviform in one, rusiform in another.	1/3
—— *swinhoii*	Absent.	Large, square.	Rusiform.	1/4
—— *kuhlii*	Absent.	Square.	Absent.	....
—— *moluccensis*	Absent.	Squarish.	Oviform.	1/4
—— *mariannus*	Absent.	Square.	Absent.	1/4
—— *duvaucelli*	Absent.	Square.	Rusiform.	1/6
—— *porcinus*	Absent.	Lateral.	An oviform rudiment.	1/3
—— *alfredi*	Absent.	Large, square.	Oviform, small (juv.).	1/4
—— *capreolus*	Absent.	Lateral.	Oviform and everted.	1/3
Cervulus muntjac	Absent.	Lateral.	Rudimentary.	1/4
—— *reevesi*	Absent.	....	....	....
Elaphodus cephalophus	Absent.	Small, lateral.	Oviform rudiment.	1/2
Cervus pudu	Absent.	Lateral.	Absent.	
—— *campestris*	Absent.	Lateral.	Absent or rudimentary.	Nil.
—— *rufus*	Absent.	Squarish.	Absent.	1/3
—— *mexicanus*	Absent.	Lateral.	Absent or rudimentary.	1/3
Camelopardalis giraffa	Absent.	Absent.	Absent.	1/6
Moschus moschiferus	In fossa.	Small, lateral.	Large, rusiform.	1/6
Antilocapra americana	In fossa.	Very small, lateral.	Rusiform.	3/8
Ovis cycloceros	Very elongate.	Lateral.	Oviform.	1/4
Capra picta	Very elongate.	Short, lateral.	Oviform.	1/4
—— *jemlaica*	Very elongate.	Short, lateral.	Oviform.	
Gazella dorcas	In fossa.	Small, lateral.	Absent.	1/4
—— *granti*	In fossa.	Small, lateral.	Small, rusiform.	1/6
—— *subgutturosa*	In fossa.	Small, lateral.	Oviform, or absent.	1/5
—— *muscatensis*	In fossa.	Small, lateral.	Absent.	1/4
—— *rufifrons*	In fossa.	Small, lateral.	Rudimentary.	1/4
—— *arabica*	In fossa.	Small, lateral.	Oviform.	1/4
Nannotragus nigricaudatus	Present.	Rudimentary.	Modified, rusiform.	1/5
Cephalophus maxwelli	Absent.	Short.	Modified, rusiform.	1/3
—— *pygmæus*	Absent.	Short.	Modified, or absent.	1/3
Tetraceros subquadricornutus	Present, as is cystic fissure.	Absent.	Absent.	1/4
Strepsiceros kudu	Elongate.	Lateral.	Rudimentary.	1/3
Oreas canna	Present.	....	Oviform.	....
Tragelaphus scriptus	Elongate.	Lateral.	Absent.	1/6
Damalis pygarga	Present.	Small, lateral.	Enormous, rusiform.	1/5
Catoblepas gnu	Elongate.	....	....	....
Addax naso-maculatus	Very elongate.	Very short.	Oviform.	Rudimentary.
Portax picta	Present.	Short.	Absent.	1/3

TABLE I.

Page 5.

VI. Length of Cæcum and Sex of specimen.	VII. Intestinal lengths.	VIII. Papillæ of Rumen.	IX. Cells of Reticulum.	X. Psalterium.
1⅛ ft. ♀, adult.	S.I. 42 ft. L.I. 30⅓ ft.	Cylindroid, elongate, flattened.	Not deep.	Quadruplicate, 13.
....	....	....	....	Quadruplicate, 10.
♂, adult.	....	Cylindrical, except longest (1 in.), flattened and expanded.	Shallow.	Triplicate.
♂, nearly adult.	....	Cylindroid.	Broad-walled.	Quadruplicate, 10.
1⅓ ft. ♂, adult.	S.I. 48⅓ ft. L.I. 25⅓ ft.	Cylindroid, slightly flattened.	Broad-walled.	Quinquiplicate, 12.
5 in. ♂, adult.	S.I. 29½ ft. L.I. 10 ft.	Cylindroid, slightly flattened.	....	Quadruplicate, 9.
1⅓ in. ♂, new-born.	S.I. 14⅓ ft. L.I. 3⅓ ft.	....	....	Quadruplicate, 10.
10 in. ♀, adult.	S.I. 39⅓ ft. L.I. 15 ft.			
1 ft. ♀, aged.	S.I. 45 ft. L.I. 25⅓ ft.	Cylindroid and tongue-shaped.	Deep, ⅛ inch.	Quadruplicate.
7 in. ♂, a year old.	S.I. 25½ ft. L.I. 13⅓ ft.	Slender, small, cylindroid.	Broad-walled.	Quadruplicate.
10 in. ♂, adult.	S.I. 34 ft. L.I. 18 ft.	Some large and tongue-shaped.	Fairly deep.	Quadruplicate, 10.
10 in. ♂, adult.	S.I. 31⅜ ft. L.I. 15½ ft.	Cylindrical.	Very shallow.	Quadruplicate.
7 in. ♂, adult.	S.I. 18⅓ ft. L.I. 8½ ft.	Cylindrical.	....	*Triplicate*, 10.
9¾ in. ♂, not adult.	S.I. 23⅛ ft. L.I. 9⅓ ft.			
6 in. ♂.	S.I. 24⅚ ft. L.I. 9⅓ft.	Cylindrical and slightly flattened.	Very shallow.	*Triplicate*, 10.
11 in. ♀, adult.	S.I. 28⅚ ft. L.I. 16½ ft.	Cylindrical.	....	*Quadruplicate*, 9.
5½ in. ♂.	S.I. 29⅔ ft. L.I. 9½ ft.	Short, flattened.	Very shallow.	*Quadruplicate*, 11.
$2\frac{7}{13}$ ft. ♀, adult.	S.I. 196 ft. L.I. 75 ft.	....	....	*Quadruplicate*, 18.
....	....	....	....	*Duplicate*, 19.
1⅛ ft. ♀, adult.				
....	....	....	....	*Quinquiplicate*, 9.
1¼ ft. ♂, adult.	S.I. 45⅓ ft. L.I. 19 ft.			
1¼ ft. ♂, adult.	S.I. 45¼ ft. L.I. 19 ft.			
8½ in. ♀.	S.I. 42⅓ ft. L.I. 15¼ ft.			
8⅓ in. ♂.	S.I. 36¼ in. L.I. 11⅓ ft.	Small, slightly flattened.	Shallow.	*Triplicate*, 10.
5¼ in. ♂.	S.I. 19 ft. L.I. $9\frac{1}{13}$ ft.			
♂, juv.	....	Uniformly short and a little flattened.	Fair depth.	*Triplicate*.
7 in. ♂.	S.I. 16¾ ft. L.I. 11 ft.	Mostly cylindrical, some tongue-shaped.	Fair depth.	*Duplicate*, 9.
8 in. ♂.	S.I. 21⅔ ft. L.I. 9⅙ ft.	Cylindrical and short.	....	*Duplicate*, 10.
6 in. ♂, adult.	S.I. 20⅚ ft. L.I. 9½ ft.	Cylindrical and short.	Fair depth.	*Triplicate*, 10.
6 in. ♀.	S.I. 20¼ ft. L.I. 9⅛ ft.	All flattened.	Shallow.	Triplicate, 10.
2½ ft. ♂, adult.	S.I. 108 ft. L.I. 78 ft.			
8 in. ♂, adult.	S.I. 26½ ft. L.I. 16 ft.	All flattened and tongue-shaped.	....	*Quadruplicate*, 9.
10 in. ♀.	S.I. 42⅓ ft. L.I. $17\frac{1}{13}$ ft.	Sparse, flattened.	Fair depth.	*Quadruplicate*, 15.
1¼ ft.	Total length of intestines 118⅚ ft.			
1 ft. 5 in. ♂, aged.	S.I. 53¾ ft. L.I. 29⅓ ft.	Mostly elongated, cylindrical, some foliaceous.	Shallow.	*Quadruplicate*, 15.
1⅜ ft. ♀, adult.	S.I. 82⅓ ft. L.I. 42 ft.	Large and foliated.	Well developed.	*Quinquiplicate*, 10.

especially so. In *Nannotragus nigricaudatus* the equally small psalterium is even more simple, there being but six primary laminæ of any depth; and these are covered with peculiarly large and pointed papillæ, three more being evidently their lateral homologues, although reduced to papillary rows. The conditions are represented in figs. 2 (*Cephalophus*) and 3 (*Nannotragus*).

Page 7. The psalterium of *Moschus moschiferus* differs essentially from any other with which I am acquainted. Prof. Flower has fully described and figured it*, at the same time that he has pointed out how much the specimen in the Museum of the College of Surgeons differs from that the account of which is given by Pallas.† Mr. Flower has kindly permitted me to examine the specimen. The nineteen plicæ all belong to the primary cycle without doubt; and as this number is that of the primary together with the secondary folds in most ruminants of the same size, it appears to me that their peculiarity consists in the exaggerated development (to the size of the primary) of the second cycle. These laminæ are also peculiarly close to one another at their lines of attachment, which is further in favour of this view. Between some of the folds I have detected lines of papillæ; but their presence is the exception, not the rule.

Where the psalterium is large it is sometimes found that longitudinal rows of papillary lines are present at intervals on the primary folds, and even the secondary laminæ. These are very conspicuous in *Portax picta.*

In some quadruplicate and in all quinquiplicate psalteria the cycles of smallest laminæ are nothing more than rows of papillæ. In other quadruplicate psalteria the cycles of the fourth power are developed as true folds without any ultimate lines of papillæ. Whether or not this is the case is indicated in Table I. (p. 393) by the descriptive name in column X., whatever the power, being printed in roman letters or italics. When in italics the laminæ of the highest power are only represented by papillary rows.

The *liver* is always simple and small, being situated almost entirely on the right side of the median line. The umbilical fissure never extends more than one half through the organ, generally less. The lateral fissures never exist.

The gall-bladder is absent in all the Cervidæ, according to my observations, and in the genus *Cephalophus* among the Bovidæ.

The caudate lobe is very variable in size, and is frequently smaller in adult than in young individuals. In most species it is elongate,

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* "Proceedings of the Zoological Society," 1875, p. 170.

† "Spicilegia Zoologica," fasc. xiii. (1779).

Livers of various Ruminants. Page 8.

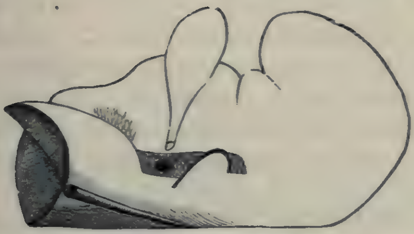


Fig. 5. *Ovis aries.*

Fig. 6. *Cephalophus maxwelli.*

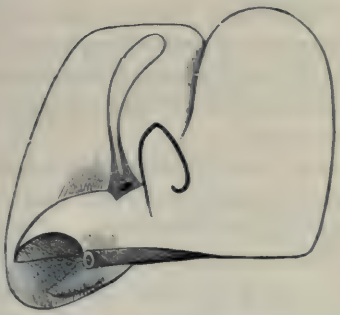


Fig. 7. *Damalis pygarga.*

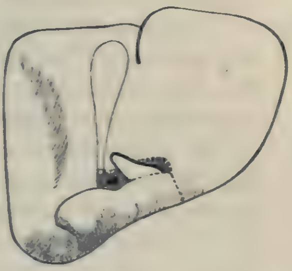


Fig. 8. *Nannotragus nigricaudatus.*

Fig. 9. *Tetraceros subquadricornutus.*

Fig. 10. *Cervus mexicanus.*

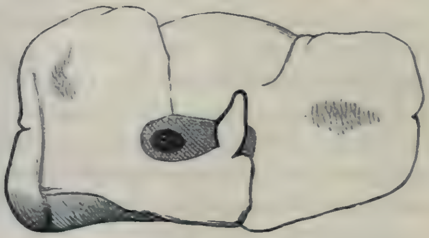


Fig. 11. *Cervus swinhoii.*

Fig. 12. *Cervus duvaucelli.*

slender, and lateral, forming little more than an incomplete cap to the right kidney; in some it is quadrate from the development ventrally of its basal portion.

The Spigelian lobe is frequently entirely absent, as such. When present it is a development of the median portion of the posterior margin of the portal fissure, extending so as to overlap it. When its base is broad, as in the Sheep, it may be termed *oviform;* when it is pedunculate, as is generally the case in the genus *Rusa*, it may be termed *rusiform*.

Variations of slight degree are found in individuals of the same species. From Table I. (p. 392) the peculiarities of the different varying parts of the organ in the specimens which I have had the opportunity of examining may be determined (columns II. to V.).

Page 9. The *generative organs* of the Ruminantia present many features of interest bearing on classification. These are mainly to be found in the shape of the glans penis, the development of Cowper's glands, and the number of cotyledons in the placenta.

The glans penis is very different in shape in the various genera of the Ovidæ as well as of the Cervidæ. In all it is the case that the terminal portion of the urethra is extremely small in calibre. Figs. 13–15 (p. 397) give views of the lateral, anterior, and inferior surfaces of the organ in *Cervus cashmeerianus*, with which the following species agree in structure—*C. elaphus*, *C. dama*, *C. aristotelis*, *C. moluccensis*, *C. kuhlii*, *C. alfredi*, and *C. porcinus*. In them the glans constitutes a cylinder, slightly flattened from side to side, about one fourth as deep as it is long, measured from the preputial reflection. Its extremity is obtuse, vertically grooved, and slightly flattened, the orifice of the urethra appearing on the apex of a simple blunt cone about one sixth of an inch in height, the base of which is slightly included in the lower termination of the apical vertical fold, near its lower or frænal margin.

In *Cervus mexicanus*, *C. pudu*, and *C. campestris* the arrangement is somewhat different, the vertical groove being absent, the termination of the glans being a blunt cone, with the urethral orifice at its apex, as is seen in fig. 16 (p. 397).

In *Capreolus caprea*, *Cervulus muntjac*, and *Elaphodus cephalophus* the glans is peculiarly long and slender, at the same time that it is nearly cylindrical, with a rounded apex, at the lower part of which the urethra opens by a simple orifice. This is seen in fig. 17 (p. 397) taken from the Roebuck. In *Tragelaphus scriptus* it is the same.

In *Bos taurus* the glans is elongated, forming an irregular cylinder, smoothly rounded at the apex, the urethra (which has no free terminal extension) opening below it at a little distance from the extremity in a downward direction. This is seen in fig. 19 (p. 397).

Page 10. In the Sheep the apex is somewhat enlarged, but not uniformly so, the expansion forming a partial twist from below and behind, upwards and forwards to the tip, along the left side of the organ. The actual point at which the attached part of the urethra terminates is nearly the same as in the Ox, from which, besides the turn it takes, it differs in that it continues on free, as a filiform tube, for an inch at least.

Fig. 13.

Fig. 14.

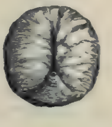
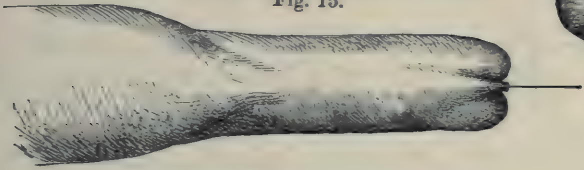


Fig. 15.



Penis of *Cervus cashmeerianus.*

Fig. 16. *Cervus mexicanus.*

Fig. 17. *Capreolus capræa.*

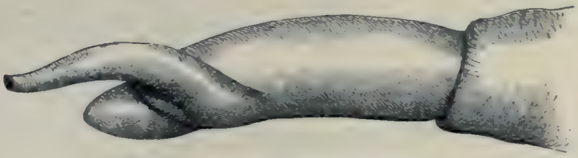


Fig. 18. *Addax naso-maculatus.*

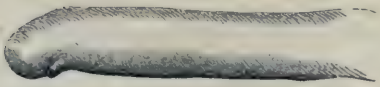


Fig. 19. *Bos taurus.*

The glans in *Capra* (*picta* and *jemlaica*) and *Gazella* (*arabica, sub-*

gutturosa, *rufifrons*) is the same; as is that of *Cephalophus* (fig. 20) (*maxwelli* and *pygmæus*), except that it is more symmetrical. In *Addax naso-maculatus* an almost identical condition obtains; the glans, how- Page 11. ever, is nearly regular in shape and cylindroid, whilst the free filiform urethra, an inch in length, turns upwards round it to the left (fig. 18, p. 397).

Fig. 20. *Cephalophus maxwelli.*

In the other Cavicornia the glans penis is different. In *Nannotragus* (*nigricaudatus*) it does not in the least resemble that of *Cephalophus;* for it forms a slender, elongated, tapering cone, beyond which the urethra, which is free from it for the terminal ⅛ of an inch, continues straight on for ⅛ of an inch (fig. 21). *Tragelaphus* (*scriptus*) differs but little from this, except that the free portion of the urethra is wanting, and the end of it slightly turned upwards; and in *Damalis* (*pygarga*) (fig. 22) the arrangement resembles that of *Tragelaphus*, except that the whole glans is shorter and thicker, at the same time that it is flattened from side to side. According to Dr. Murie's account of the Prongbuck* (*Antilocapra americana*) and the Saiga† (*Saiga tartarica*) the glans in these two animals differs from that in any of those above described, whilst from Pallas's account of the Musk

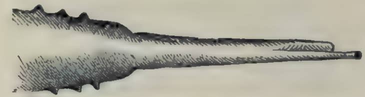


Fig. 21. *Nannotragus nigricaudatus.*

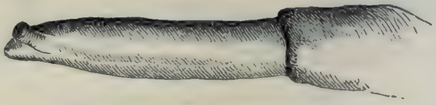


Fig. 22. *Damalis pygarga.*

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* "Proceedings of the Zoological Society," 1870, p. 352.

† "Proceedings of the Zoological Society," 1870, p. 485.

(*Moschus moschiferus*)* its penis is apparently ovine, as that of the Giraffe (*Camelopardalis giraffa*) (fig. 23).

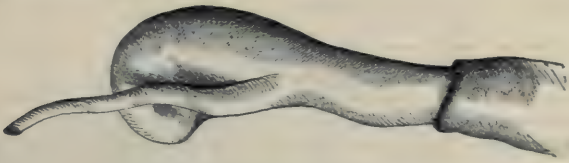

Fig. 23. *Camelopardalis giraffa.*

Cowper's glands are present, according to my observation, in *Cervulus muntjac* and *Cervus mexicanus;* and I have noted that they are small in *C. alfredi*. Their absence I have recorded in *C. elaphus*, *C. dama*, *C. cashmeerianus*, *C. aristotelis*, *C. moluccensis*, *C. porcinus*, *C. kuhlii*, and *C. campestris*. Prof. Flower found them in *C. pudu*. I have seen them also in all species of *Ovis*, *Capra*, and *Gazella* examined, as well as in *Cephalophus* (*maxwelli* and *pygmæus*), *Nannotragus* Page 12.
(*nigricaudatus*), *Tragelaphus* (*scriptus*), *Damalis* (*albifrons*), and *Addax* (*naso-maculatus*). According to Dr. Murie they exist in the Prongbuck and Saiga; in *Moschus* according to Pallas, and in the Giraffe according to Prof. Owen.†

In the uterus of the Cotyledontophora it is well known that there are papilliform developments of the inner walls which serve for the attachment of the cotyledons in the impregnated organ. Although it has not been actually proved, so far as I am aware, by direct evidence that the cotyledonary papillæ and the cotyledons are exactly the same in number in each individual, yet there is every reason to believe that it is so. On this assumption I take the number of these papillæ as an index of the nature of the placenta itself, this being so difficult to obtain on account of the universal habit among the females to eat it immediately it is expelled, parturition generally occurring at night-time.

The following Table contains a statement of the number of papillæ or cotyledons (as the case may have been) which I have found, together with those made by Prof. Turner on the same subject.‡ From it I feel justified in deducing the law that the cotyledons are few in the Cervidæ, numerous in the Bovidæ—at the same time that I would suggest the name OLIGOCOTYLEDONTOPHORA for the former, and POLYCOTYLEDONTOPHORA for the latter.

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* "Spicilegia Zoologica," fasc. xii.

† "Transactions of the Zoological Society," vol. II. p. 240.

‡ "Comp. Anat. of Placenta," 1875, p. 66.

TABLE II.

Name.	Authority.	Number of Cotyledons.	Number of Papillæ.
Cervus elaphus	Turner & A. H. G.	12 or 8.	
—— *duvaucelli*	A. H. G.	... .	4 in each cornu.
—— *campestris*	,,	9,8 large and 1 small.	
—— *rufus*	,,	....	5 in one cornu, 4 in the other.
Hydropotes inermis	,,	2 fœtus, with 3 cotyledons in one cornu and 5 in the other.	
Capreolus caprea	Bischoff.	5 or 6.	
Ovis aries	Turner.	60 to 100.	
Bos taurus	,,	60 to 100.	
Damalis pygarga	A. H. G.	....	Very many.
Camelopardalis giraffa	Owen.	180 large and small.	
Rupicapra tragus	A. H. G.	As in *Ovis*.	
Rangifer tarandus	Spec. No. 2755 in R. C. S. Museum, and Catalogue description.	....	4 in one cornu.

Osteologically, among the Cervidæ, the skull presents features which correspond in great measure with their geographical distribution; and, dentally, the peculiarities of the third lower premolar are most
Page 13. instructive. The consideration of these latter I hope to be able to bring before the Society on a future occasion, when my material has become more abundant.

In all Old-World Cervidæ examined by me, with the exception of the Reindeer, the vomer is not so much ossified as to divide the posterior osseous nares into two distinct orifices, whilst in *Rangifer tarandus* and all the New-World Deer, excepting *Alces machlis* and *Cervus canadensis*, it is so. I have seen most of the skulls of the Deer which are to be found in the superb osteological collection of the British Museum; and it is upon the study of them that this generalization is based. In the following species the vomer is completely ossified behind, so as to separate off the two posterior nares in the macerated skull:

Cervus pudu.
—— *campestris.*
—— *columbianus.*
—— *leucurus.*

Cervus leucotis.
—— *antisiensis.*
—— *virginianus.*
—— *mexicanus.*

Neither in *Alces machlis* nor in *Cervus canadensis* is the vomer so extended posteriorly. The condition described is represented in fig. 24, which is from the skull of *Cervus virginianus.*

In his "Catalogue of Ruminant Animals in the British Museum," Dr. Gray lays considerable stress upon the degree of development of the nasal processes of the premaxillary bones, whether or not they meet the nasals. In *Rangifer tarandus* they do not do so, the gap being filled up by the appearance, superficially, of portions of the nasal turbinal. This is also the case in *Cervus pudu* and *C. columbianus*. In *C. leucurus* the nasal processes of the præmaxillæ are also very short, and they therefore do not join the nasal bones; nor do they in *C. campestris*, nor, generally, in *C. rufus*, and only just in *C. virginianus*. They do join the nasals in *C. leucotis* and *C. antisiensis*. In *Alces machlis*, on account of the extreme shortness of the nasal bones, the premaxillary processes do not meet them; but in all the Old-World Cervidæ the line of junction of the two is considerable, except in *Elaphodus cephalophus* and *Cervulus reevesi*. Page 14.

Fig. 24. Base of skull of *Cervus virginianus.*

In all the American Cervidæ and in the Reindeer the floor of the posterior osseous nares is prolonged backwards more than in their Old-World allies, from the extension backwards of the palatine plates of the palatal bones. In *Cervulus* there is a tendency to this condition, but not in any other Old-World genus.

In his invaluable paper* "On the Evidences of Affinity afforded by the Skull in the Ungulate Mammalia," Mr. H. N. Turner remarks:—"I have noticed that in the Moschidæ [*Hyomoschus*, *Tragulus*, and

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* "Proceedings of the Zoological Society," 1849, p. 152.

Moschus] the styloid process [tympano-hyal] becomes free almost immediately at the base of the auditory process, while in the Bovidæ, or Cavicorn Ruminants, it is enclosed, more or less completely, for some distance in the downward and forward direction." And in all the Cavicornia which I have examined, the tympano-hyal bone is situated on the outer side of the petrosal; whilst in many of the Cervidæ it is posterior, between the petrosal of the temporal and the paramastoid of the occipital bone. In *Cervus porcinus* and *Axis maculata*, however, the expanded auditory bulla insinuates itself from the inner side, between the tympano-hyal and the paroccipital process, as in the Cavicornia. Neither in any of the American Cervidæ, except *C. leucotis*, nor in *Rangifer tarandus*, *Alces machlis*, *Capreolus caprea*, *Cervus dama*, nor in the genera *Cervulus* and *Elaphodus*, does it do so.

In the other Deer (Elaphine, Rusine, and their allies), including *Elaphurus davidianus* and *C. leucotis*, there is a small process of the petrosal, incomparably less than in the Cavicornia, which, from the inner side, partially or just removes the tympano-hyal from the paroccipital (as seen without damage to the skull). This is well marked in *Hydropotes inermis;* and *Moschus moschiferus* is peculiar, in that from the outer side a process is sent inwards to join the other, and so completely to encircle the tympano-hyal with a ring of bone in a very suspiciously Cavicorn manner. The Giraffe, in this respect, much resembles *Moschus*.

It is worthy of note that in *Cervus antisiensis* the median incisors are not triangular, in which respect it agrees with *Rangifer* and *Moschus* and differs from the Cervidæ generally. In *C. leucotis* they are so. In *C. pudu*, as in *Moschus*, the Giraffe, and many Cavicornia, there is only one submental foramen on each side—not two, as in by far the majority of the Deer.

The peculiar way in which, on each side, the palatal surface of the
Page 15. interval between the canine tooth and the first premolar is cut away in all the true Ruminantia, and not in the Tragulidæ, is interesting as a separating feature. In the Cervidæ there is a difference from the Cavicornia in the arrangement of the region just in front of this. In the Sheep and its allies the median palatal process of each premaxillary bone extends back in the palatal region between the maxillæ for some distance behind the most anterior portion of the facial surface of the maxillary bone, broadening as they go backwards for some distance, and then narrowing to a point somewhat abruptly. In no Deer which carries antlers have I found this arrangement, the median palatal processes of the præmaxillæ in them being always slender (sometimes only incompletely developed), of uniform breadth, and terminating posteriorly at a point scarcely behind the line which joins the canine

teeth. Both *Moschus moschiferus* and *Hydropotes inermis* agree with *Ovis* in this respect, as does the Giraffe.

Again, in the squamosal of the temporal there is a feature of value in the separation of the two major divisions of the typical Ruminantia. In the Cervidæ this bone is deeper from above downwards than in the Bovidæ; in other words, the parieto-squamosal suture is situated nearer the upper border of the temporal fossa (more than halfway up it) in the former group, the general proportions produced by which are more easily recognized by inspection than from description. The squamosal of *Moschus* is oviform, that of *Camelopardalis* intermediate.

Whilst comparing the skulls of the Cervidæ which I have examined, the antlers have naturally attracted my attention; and many of their peculiarities seem to me to be subject to definite laws.

What may be called the typical antler is composed of a bifurcate beam, with a brow antler springing from the front of its basal portion. These three parts may be termed A, B, and C, as in the accompanying diagram (see p. 404). They occur, uncomplicated, in the genus *Rusa*, in *C. porcinus*, *C. axis*, and *C. alfredi* (fig. 25. 1).

On the assumption that most of the complicated many-pointed antlers that occur are the result of the exaggerated development of one or other or both of the extremities B and C, their special features may be explained. For instance, imagine that both B and C bifurcate, remaining of equal size, and we arrive at the condition found in *Cervus schomburgki* (fig. 25. 2). *C. duvaucelli* differs in that B is extra-developed at the expense of C (fig. 25. 3), the latter often being not bifurcate, though sometimes so to a small extent. Following out the ingenious hypothesis of Mr. Blyth[*], *C. eldi* only differs in the still greater development of the anterior of the branches of B (fig. 25. 4). With this last-named form *C. virginianus* and *C. mexicanus* agree, as does *Rangifer tarandus*, as far as its beam-branches are concerned.

In *Cervus dama*, and in the species included in the genus *Pseudaxis* by Dr. Gray (*C. sika*, *taëvanus*, and *mantchuricus*), a different condition maintains, B being reduced greatly and C correspondingly enlarged (fig. 25. 5). In the Elaphine Deer this is carried further, the continuation of the beam C being divided terminally into many points (fig. 25. 6) in *C. elaphus*, *C. canadensis*, *C. maral*, and *C. cashmeerianus*. According to Mr. Blyth, *C. sika* "belongs strictly to the *Elaphine*, and not to the *Axine*, group"[†] of Deer; and the conforma-

Page 16.

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[*] "Proceedings of the Zoological Society," 1867, p. 835.

[†] "J. A. S. B.," xxix. p. 90.

tion of its horns is decidedly in favour of this view. Nevertheless it must be noted that in its ally, *C. mantchuricus*, and in *C. kopschi* (Swinhoe)—I cannot find a skull of *C. sika* in any museum for comparison—the auditory bulla is considerably inflated, as in *C. porcinus* and *C. axis*. This feature is not, however, of particular importance, as *C. virginianus* in this respect differs from most of the American Cervidæ, possessing a very inflated bulla.

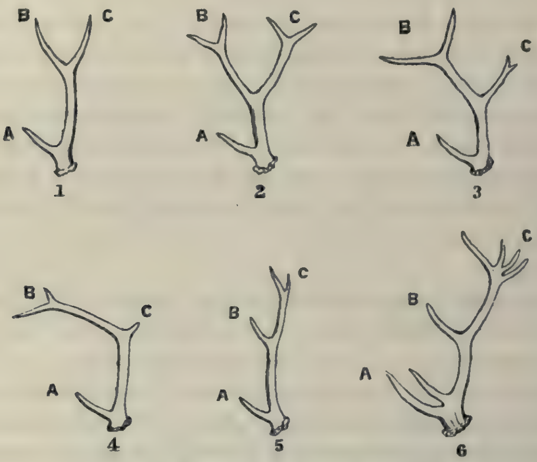

Fig. 25. Diagram of types of antlers.

With reference to the brow-antler (A), it is evident that its duplication in the true Elaphine Deer and in *Rangifer* is more associated with the actual size of the antlers than with any other peculiarity.

The antlers of *Elaphurus davidianus* are at present quite beyond my comprehension.

General Remarks.

Whilst working at any special group of animals, there is nothing which must strike most students so much as the inefficient scientific capacities of the Linnæan binomial nomenclature as it is at present employed. For the simple identification of species among themselves and of genera it is excellent, no doubt; but immediately the generic position is assigned to any collection of related species, the animals or plants which constitute them are, so far as nomenclature is concerned, lost in the plurality of mundane organized forms. In the science of Page 17. chemistry—an older one, it is true—the case is very different. There, the knowledge of the composition of any non-elementary substance is sufficient for the determination of the name by which it should be designated; and, *vice versâ*, from the name its composition may be inferred. Why should we not be able to do the same in biology?

We form estimates as to the mutual affinities of genera which can bear the test of criticism as well as any rational chemical formula; is it not just as possible to express them in our nomenclature as do the chemists in theirs? It is quite conceivable that it should be done; and I have the boldness, on the present occasion, to endeavour to make a step in the direction indicated, taking the Cervidæ to illustrate my method. I should not desire any one to think that the method I am about to suggest is at all a final one; for it only comprehends a single small group of Mammalian animals. Nevertheless, if by it I am able to demonstrate its practical utility, and to develop in others a desire that it should be extended in its scope, there is nothing easier than to expand it.

From what has been remarked earlier in this paper, it is evident that there are osteological reasons for separating off the Old-World from the New-World Cervidæ. Representing degrees of slightly more than generic importance by Roman capitals, this difference between the two groups may be indicated by the employment of letters separated by some distance in the alphabet. I therefore commence with A in formulating the Old-World species, and with P in those of America. Following the initial capital I place a small letter, which represents the genus; and the species of each of the latter are indicated by numbers following, raised above the line, as in mathematics when the square, cube, &c. are expressed. When a species, like the Elk, stands by itself, it is not necessary to append the smaller signs. With this amount of explanation, the following Table (III) will need no further description:—

TABLE III.

CERVIDÆ.

A. *Alces machlis.*
Ba^1. *C. elaphus.*
Ba^2. *C. canadensis.*
Ba^3. *C. cashmeerianus*
Ba^4. *C. barbarus.*
Ba^5. *C. maral.*
Ba^6. *C. affinis.*
Bb^1. *Dama vulgaris*
Bb^2. *D. mesopotamica.*
Bc^1. *Pseudaxis sika.*
Bc^2. *P. mantchuricus.*
Bc^3. *P. taëvanus.*
Ca^1. *Rusa aristotelis.*
Ca^2. *R. hippelaphus.*
Ca^3. *R. moluccensis.*
Ca^4. *R. equina.*
Ca^5. *R. swinhoii.*
Ca^6. *R. marianna.*
Ca^7. *R. peronii.*
Ca^8. *R. kuhlii.*
Ca^9. *R. alfredi.*
Cb. *C. axis.*
Cc. *C. porcinus.*
Cd^1. *Rucervus schomburgki.*
Cd^2. *R. duvaucelli.*
Cd^3. *R. eldi.*
D. *Elaphurus davidianus.*
Ea^1. *Cervulus muntjac.*

TABLE III. (*continued*).

Ea^2.	*C. reevesi.*
Eb.	*Elaphodus cephalophus.*
F.	*Capreolus caprea.*
G.	*Hydropotes inermis.*
Page 18. P.	*Rangifer tarandus.*
Qa^1.	*Cariacus virginianus.*
Qa^2.	*C. mexicanus.*
Qa^3.	*C. leucurus.*
Qa^4.	*C. macrotis.*
Qa^5.	*C. columbianus.*
Ra^1.	*Cervus campestris.*
Ra^2.	*C. paludosus.*
S.	*C. antisiensis.*
T.	*C. leucotis.*
Va^1.	*C. nemorivagus.*
Va^2.	*C. simplicicornis.*
Va^3.	*C. rufus.*
Va^4.	*C. superciliaris.*
W.	*Pudua humilis.*

This synoptical sketch of the affinities of the different species of the Deer tribe expresses much more with reference to the mutual relationships of its component members than could be done by the employment of the binomial nomenclature. For instance, taking the Barasingha Deer, here expressed by Ca^2. In that it is of the C group, its close affinities to the Sambur, Axis, and Hog-Deer is asserted. C being next to B (Elaphine), its not great distance from the Elaphinæ is expressed; whilst, although the Reindeer and the Long-tailed Deer have their antlers developed on very similar types, the distance of their relationship is signified by their alphabetical interval—that between C and P or Q.

Further, in that *Rucervus duvaucelli* is represented by Cd^2, the d proves that there are other genera closely allied to it, namely, a, b, and c, at the same time that, as there is a figure appended, it is to be inferred that there is more than a single species in the genus. On the whole, I know no so concise a way of expressing the relationships of species.

As to the affinities of the genera here expressed, some are more certainly based than others. *Capreolus caprea* is one of the most difficult of the Deer tribe to localize; and I have placed it not far from *Cervulus* on account of the configuration of its glans penis. *Dama vulgaris*, as well as *Dama mesopotamica*, from the shape of their antlers—neglecting the palmation, an evidently insignificant character—are intimately allied to the Pseudaxine group; and, as the late Mr. Blyth has so satisfactorily demonstrated, there is no reason why Eld's Deer should be in any genus other than that in which the Barasingha is situated. The abnormal furcation of the antlers of *Elaphurus davidianus* renders it extremely difficult to place their species in any definite position among the Old-World Cervidæ.

63. NOTE ON THE SOLID-HOOFED PIGS IN THE SOCIETY'S COLLECTION.*

ON November 2nd, 1876, there arrived in the Gardens a pair of Page 33. Pigs (domestic variety) presented to the Society by Don J. Alfonso de Aldama, from Cuba, peculiar in that the hoofs of all the feet, instead of being cloven, are solid, much resembling those of the Ass, with the lateral diminutive digits as they are always found in the Pig.

The sow gave birth on November 15th to a litter of six, three males and three females. Of these the hoofs were solid (like those in the parents) in three, namely in two males and one female. In the remaining male and two females the hoofs were double, as in the animal under ordinary circumstances.

Four of the young pigs are now living (a pair of solid-hoofed and a pair of normal-hoofed), a male solid hoofed and a female split-hoofed specimen having died within a few days of birth.

On examining the feet of the deceased male solid-hoofed specimen, it was seen, as might have been inferred from an inspection of the living animals, that all the monstrosity is confined to the ungual phalanges. The proximal and second phalanges are separated as usual, whilst at the extreme distal ends of the ungual phalanges these bones are completely fused together; and, further, there is a third ossicle developed at their proximal ends, where they are not completely united, between and above them.

It might have been imagined that the deformity was simply the result of an agglutination along the middle line of the two completely formed digits; but such is not the case, the nail-structure being absent in the interval, where it is replaced by bone with a transverse cartilage below it. The nail is continued straight across the middle line of the hoof, as in the horse. In Mr. Darwin's "Animals and Plants under Domestication" (ed. 2, vol. i, p. 78), a full account will be found of several cases in which an exactly similar deformity existed.

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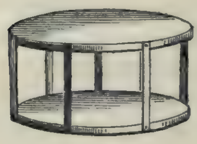
* "Proceedings of the Zoological Society," 1877, p. 33. Read, Jan. 16, 1877.

64. ON THE MECHANISM OF THE INTERVERTEBRAL SUBSTANCE, AND ON SOME EFFECTS OF THE ERECT POSITION OF MAN.*

Page 49. In all works on human anatomy the structure of the disks of fibro-elastic tissue which intervene between the bodies of the vertebræ is described as being composed of a central elastic cushion with a laminated fibrous investment, the individual fibres of which, instead of running straight from the lower edge of one vertebra to the upper edge of the one below it, are arranged obliquely, those of one layer crossing those of the next at a considerable angle. That this is an accurate statement of the condition which exists no one will doubt. Of its mechanical advantages, however, I have nowhere found any explanation.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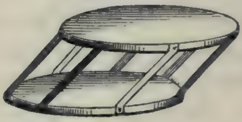
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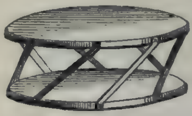
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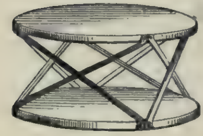
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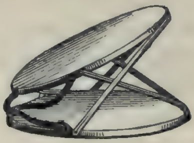
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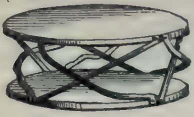
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If the fibres, instead of crossing had run parallel, and at right angles to the surfaces which they joined (fig. 1), it is evident that the median elastic pad would have efficiently retained the vertebræ at a distance from one another under ordinary circumstances. But in the act of jumping, for instance, when the feet have just reached the ground, the momentum acquired by the head and upper extremities would compress the elastic pad, and diminish the distance between each two vertebræ. At this moment, if the upper part of the body had the least tendency to obliquity in its downward movement, the relaxed outer fibres of the intervertebral substance would allow the

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* "Proceedings of the Zoological Society," 1877, pp. 48–50. Read, Feb. 6, 1877.

body of the upper vertebræ to slide upon the one below it (fig. 2), and so diminish the capacity of the spinal canal, as well as the general stability of the column. A forcible attempt to rotate the body upon the spine would, under similar conditions, be also attended by compression of the elastic pad, and considerable rotatory gliding of the vertebræ on one another (fig. 3).

These difficulties are entirely surmounted by the existing mechanism (fig. 4), as may be most satisfactorily demonstrated by the employment of a model composed of two circular disks of wood bound together, with an interval between them, by tapes of similar lengths arranged obliquely and crossing one another, attached to opposite points on the margins of the disks. So connected, no gliding of any kind of the disks upon one another can be produced, and the only movements possible are their approximation either at all points, or at any part where compression is employed (figs. 5 and 6). Page 50.

It may not be out of place for me here to draw attention to one or two points which are associated with the erectness of the carriage of man, in contradistinction to the horizontal and oblique attitudes assumed by lower animals.

The simple curve, concave ventrally, of the vertebral column of the higher Apes was most certainly shared by the human progenitor. In the young child it is found to exist. In its attempts to assume the upright carriage this progenitor must, equally certainly, have thrown the centre of gravity of its body directly above the hips, to do which it was necessary to bend the spine backwards. On account, however, of the thoracic region being rendered rigid by the attachment of its cage of ribs, and the sacrum being unmodifiable from its ankylosis, this flexion of the spine could only occur in the neck and loins; consequently the spinal flexures in man may be explained upon the assumption that the dorsal and sacral ventral concavities are the similar curves of the ancestral type, retained on account of the mechanical obstructions to their removal, whilst the ventral convexities of the yielding cervical and lumbar regions are the means by which the centre of gravity in the erect position is carried to a point directly above the hip-joints.

This assumption of a vertical attitude by a creature originally differentiated for a horizontal position of its body, has produced but marvellously slight inconvenience. If it had resulted in many, man could scarcely have survived. There are one or two, however, which are most clearly traceable to this cause, including the painful tendency to prolapse, antiflexion, and retroflexion of the uterus in women, as well as crural hernia in both sexes, and inguinal hernia in the male.

In mammalian animals with the body horizontal the weight of the uterus is transmitted to the abdominal walls, at the same time that the round and broad ligaments prevent it from leaving the pelvic region. In the Sloths and Bats these ligaments are still more called into play, on account of the peculiar attitudes assumed by them. No more satisfactory mechanism could be desired. But in the human species the condition is very different. The uterus is situated almost directly above the vagina; and the entire absence of any ligaments to suspend it place it in a position of the greatest mechanical disadvantage, especially when congested and depressed by stays. Unsupported, it frequently bends forward or backwards, or even drops into the cavity of the vagina, and there finding nothing to obstruct it, becomes completely prolapsed. Similarly in inguinal hernia, the abdominal walls being abnormally extended in connexion with the lumbar curve, the tendency to rupture in the region of the inguinal canal must be greatly increased, as it must likewise be by the downward tendency of the viscera.

65. NOTES ON THE ANATOMY OF THE MUSK-DEER (*MOSCHUS MOSCHIFERUS*).*

Page 287. In the large collection of living animals brought home by the Prince of Wales from India were two male specimens of the Musk-Deer (*Moschus moschiferus*), nearly adult, from Nepaul, presented to His Royal Highness by Sir Jung Bahadoor, whose sudden death has been so recently announced. As far as I am aware, the only other individual of the species which had been seen alive in this country, was the female presented by Sir Richard Pollock, K.C.S.I., on March 31st, 1869, to this Society, which formed the subject of Professor Flower's valuable memoir published in our "Proceedings" (1875, p. 159).

On Feb. 2nd of this year one of the Prince's specimens died at Sandringham; and His Royal Highness having graciously given permission that a post-mortem might be made upon it, Mr. Clarence Bartlett placed it in my hands.

Pathologically it did not present any features of special interest, Page 288. the only organ which gave any proof of lesion being the psalterium, in which several minute abscesses were found along the attached margins of several of the laminæ.

Zoologically the specimen has given me the opportunity of veri-

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* "Proceedings of the Zoological Society," 1877, pp. 287–292. Read, March 20, 1877.

fying many of the statements both of Pallas in his exhaustive treatise on the animal,* and of Prof. Flower in his memoir above referred to. My own attention having been much devoted of late to the anatomy of the Ruminantia, I was particularly pleased at having the opportunity of dissecting the species, especially as it was of the male sex, and as Prof. Flower has most kindly allowed me to compare its viscera with those of the female specimen in the Museum of the College of Surgeons.

Considering the various organs seriatim, I found that the tongue agreed exactly with that figured by Prof. Flower, as did the epiglottis in being pointed in the middle line, and the stomach in its general configuration.

In the *rumen* the villi were shorter than in most of the Cervidæ and more sparsely scattered. There were no traces of any special glandular pouch on the anterior wall of the viscus.

In the *reticulum* the shallow cells were peculiar in being comparatively small, and more numerous than is generally the case.

The *psalterium* did not differ, except in the number of its laminæ, from the description given by Pallas; and it appears to me that Prof. Flower, at the same time that he was the first to lay proper stress upon its non-typical nature, hardly read correctly the account given by the earlier observer; for in the College specimen, although the rows of papillæ are particularly feeble, nevertheless it might be said of them "inter majores laminas rugæ intercalares, vel lamellulæ accessoriæ angustiores." In the stomach under consideration they are much more conspicuous. The organ is therefore dupliciplicate, and differs from that of any other Ruminant examined by me, as I have elsewhere shown,† in that the laminæ are arranged more closely than is usually the case, and at the same time there is a great deficiency in minor folds, and an excess of those of higher degree.

Pallas counted 23 or 25 major laminæ in the psalterium of his specimens: Prof. Flower, 19 in his; there were 21 in the specimen now under consideration.

The small intestine was 24 feet 2 inches in length, the large intestine measuring 11 feet 9 inches, and the cæcum 5½ inches. There were three and a half double turns in the colic coil, which is one more than is generally found in larger species, and two more than is frequently observed in smaller ones. Both the cæcum and the colon were curiously mottled from the collection of fat in the course of the vessels traversing their surface, as is mentioned by Pallas, and shown in his figure of the former organ.

With reference to the peculiar dilatation of the colon in the region

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* "Spicilegia Zoologica," fasciculus xiii. (1779).

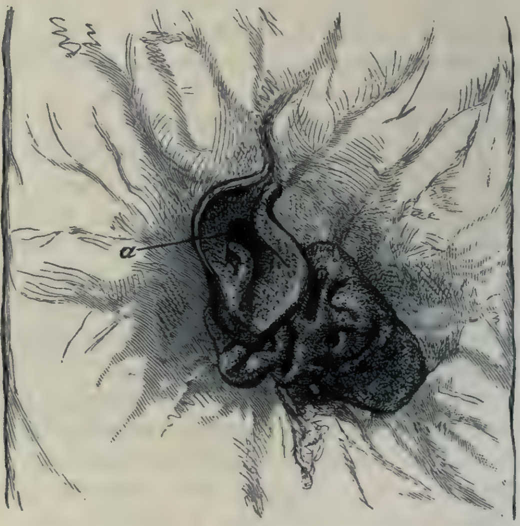
† (*Suprà*, p. 394.)

of the ileo-cæcal valve, this is produced by the considerable development of a glandular surface, which is quite as well marked in the Page 289. Giraffe (*Camelopardalis giraffa*), as was first pointed out by Dr. T. S. Cobbold, in his article "Ruminantia," in the Cyclopædia of Anatomy and Physiology,* where it is excellently figured, as it is also by the same author, although much less accurately, in the "Proceedings"† of this Society. I take the present opportunity of depicting its condition in *Moschus*, and have had placed side by side with it a drawing of the homologous gland in the Fallow Deer (*Cervus dama*), where it is comparatively smaller (figs. 1, 2). This gland is probably to be found in other members of the Order; but I regret that till quite recently, not having had my attention specially called to it, I have not taken the opportunity of looking for it. In future I will do so, and will inform the Society of the results of my search.‡ I could find no Peyer's patches.

Fig. 1.

Ileo-cæcal gland of ***Moschus*** : *a*, orifice of small intestine.

Fig. 2.



Ileo-cæcal gland of *Cervus dama* : *a*, orifice of small intestine.

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* Vol. v. p. 540, fig. 363.

† "Proceedings of the Zoological Society," 1860, p. 104, Plate LXXVIII.

‡ Since this paper was read I have examined the ileo-cæcal region of the colon in *Alces machlis*, where the gland is large and very much like that of the Giraffe—in *Cervus virginianus*, where it is oval, made up of shallow glands, and an inch long—and in *Tragelaphus scriptus* and *Oryx beisa*, where it agrees with that in *C. virginianus*.

The liver was more elongate and not so deep as that figured by Prof. Flower. The gall-bladder was lodged in a shallow fossa, its fundus not nearly reaching the free margin of the organ. The caudate lobe was lateral, and far from large. The Spigelian lobe was absent—a fact which demonstrates, what specimens of *Cephalophus pygmæus* and *Camelopardalis giraffa* had previously taught me, the variable Page 290. nature of this small hepatic appendage, even in the same species.

With reference to the generative organs, Pallas records the existence of Cowper's glands and a filiform termination to the urethra, of some length. I take the opportunity of figuring the glans penis, as the drawings given by Pallas, although particularly instructive, are too small to exhibit some of its characteristics (fig. 3). The glans, on the whole, is more like that in the genera *Gazella* and *Addax** than in *Ovis*, *Capra*, *Cephalophus*, and *Camelopardalis*, in all of which there is a filiform termination to the urethra. The Cowper's glands were about the size and shape of haricot beans, one on each side. The vesiculæ seminales were each an inch long, and of a fairly uniform breadth of $\frac{1}{4}$ inch. The urethral ends of the vasa deferentia were considerably dilated for a little more than an inch and a half.

Fig. 3.

Glans penis of ***Moschus***.

As has been clearly described by Pallas, the musk-sac opens a short distance in front of the preputial opening; its size is nearly that of an ordinary orange. In the specimen under consideration it was filled with a dark-brown, chocolate-coloured powder, possessing, most powerfully, the characteristic odour. Its minute orifice was a little more than half an inch in front of the opening of the prepuce, from which latter a few stiff hairs, about half an inch long, projected forwards and downwards. The two orifices were included within a common sphincter muscle, the skin over which was covered with fine hairs, all radiating towards its centre. The slightly convex cutaneous surface included within the sphincter was devoid of hair. This account agrees with that of J. F. Brandt and J. C. T. Ratzeburg in 1839;† and my specimen in no way differs from the excellent figures of the musk-sac given by those authors.

In my paper on the visceral organs of the Ruminantia,‡ I have

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* (*Vide suprà*, p. 397, fig. 18.)

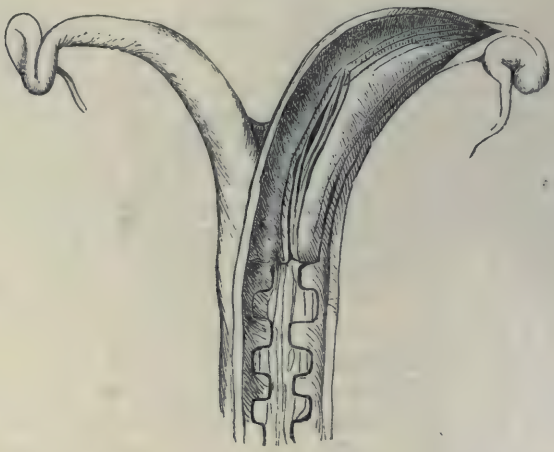
† "Medicinische Zoologie" (Berlin, 1839), Band i. pp. 41–51, Plate VIII.

‡ (*Suprà*, p. 399.)

drawn special attention to the nature of the internal surface of the uterus in the Order, having given strong reasons for the surmise that the Cavicornia are characterized by having numerous cotyledons on the placenta, on which account they are termed *Polycotyledontophora*, whilst in the Cervidæ (therefore termed *Oligocotyledontophora*), the cotyledons are very few in number. It occurred to me that the nature of the interior of the uterus or the placenta would throw much light on the very disputed point as to the affinities of *Moschus*. Of the placenta Pallas tells us* that "*cotyledones* et respondentes *placentulæ* Page 291. oblonga, plana figura gaudent et in series fere digeruntur. Extrema secundinarum attenuata, in cornua uteri filo protensa; at versus orificium uteri chorion utrinsque anastomosi tubulari cohæret." At the same time he tells us that there were two fœtuses in the uterus.

Prof. Fower has kindly allowed me to examine the uterus of the specimen of *Moschus moschiferus* in the College-of-Surgeons Museum, which was about 2½ years old. From it fig. 4 is taken. It will be seen that there are no cotyledonary papillæ at all, the mucous membrane being disposed in narrow longitudinal folds, six in number, of very little depth, running nearly the whole length of the cornua, slightly broken here and there, but nowhere developing from their free edges the tongue-like processes which form the cotyledonary papillæ in ordinary Deer, or the characteristic linearly arranged elevations

Fig. 4.



Uterus of *Moschus moschiferus:* the left cornu is opened up longitudinally.

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* *Loc. cit.* p. 41.

of the Bovidæ. This condition differs from any I have seen in other Ruminant animals; and I can find no reference to it by other authors.

I do not think that my account of the organ is at all incompatible with that of Pallas, who has laid special stress on the linear nature of the cotyledons. Neither in the Cervidæ nor the Cavicornia have I ever found an arrangement which can be compared with it. I do not feel justified in regarding it as indicating a nearer relationship to the one than to the other; for the number of the plications is opposed to Cervine affinities, whilst their size militates against their polycotyledonary nature.

When we consider the genus *Moschus* in its relations to the other Ruminants, it seems to me that to call it a Deer is altogether against Page 292. the tendency of the facts at our disposal. No known Deer has a gall-bladder, or a filiform termination to its urethra. How can we place with the Cervidæ, therefore, an animal which possesses both?

66. NOTES ON THE ANATOMY AND SYSTEMATIC POSITION OF THE GENERA *THINOCORUS* AND *ATTAGIS*.*

THROUGH the kindness of Mr. Edward Gerrard I have become Page 413. possessed of an adult specimen of *Thinocorus rumicivorus*, and of a nestling of *Attagis gayi*, in spirit, from Chili; and I take the present Page 414. opportunity of bringing before this Society my notes on their structure. Of the former of these species Mr. Eyton has fully described the visceral anatomy and the osteology in the "Zoology of the Voyage of the 'Beagle,'"†; and in his "Osteologia Avium"‡ will be found an account of the skeleton, together with a figure of the sternum, of the latter. By Mr. Eyton, in his account of *Thinocorus*, these birds are referred to the order Gallinæ; but in his more recent work they are included with *Chionis*, to constitute the Chionididæ, which are by him placed after the Otidæ (comprising the Otinæ and Tinaminæ), and before the Charadriidæ, as families of his order Littores. By Mr. G. R. Gray, in his "Hand-list of Birds," they are separated from the Chionididæ, between which and the Glareolidæ they stand as a

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* "Proceedings of the Zoological Society," 1877, pp. 413–8. Read, May 1, 1877.

† Part iii. p. 155.

‡ p. 177, and Plate XXI. fig. 3.

division of the Grallæ. This is much the same position as that in which they are located by Messrs. Sclater and Salvin in their "Nomenclator Avium Neotropicalium." Nitzsch, as Burmeister tells us, was disposed to place them in his group of the Alectorides, along with *Chauna*, *Otis*, *Cariama*, *Psophia*, and *Grus;* whilst Wagler placed them with the Pteroclidæ; but Burmeister himself is of opinion that "this remarkable bird (*Thinocorus rumicivorus*), which Wagler very improperly compares with the Sand-Grouse (*Pterocles*), is in every particular an aberrant Scolopacine form, related to *Glareola* in exactly the same way as *Chionis* to *Hæmatopus*, or *Dromas* to *Recurvirostra*."*

As far as pterylography goes, not much of importance with reference to the position of the Thinocorinæ can be learnt. In that they possess a tufted oil-gland they differ from the Pteroclidæ and Columbæ, in both of which families it is nude. On the whole the pterylosis is typically Limicoline.

With reference to the alimentary canal, the tongue is simple and triangular, occupying most of the space between the rami of the mandible. The œsophagus is not large, but develops a capacious and well-defined globose crop, situated just above the furcula. The gizzard is muscular, not large, and it possesses simple triturating pads like those in the majority of non-carnivorous birds.

In the specimens of both *Thinocorus* and *Attagis* under consideration the intestines are 12·5 inches in length; but it must be remembered that the *Attagis* is a nestling. The colic cæca in the *Thinocorus* are 2·25 and 2·5 inches long; in the *Attagis* they are both 3 inches.

Myologically, the ambiens muscle is present, although slender. Both the femoro-caudal and its accessory head exist, of equal breadth. The semitendinosus, together with the accessory semitendinosus are of average size, whilst the semimembranosus is peculiarly slender. The myological formula, therefore, in conformity with the nomenclature adopted in my paper "On the Muscular System of Birds," in the Society's "Proceedings" for 1874 (p. 111),† is A B, X Y.

The vastus externus covers the biceps cruris; and in the foot the Page 415. deep plantar tendons are arranged as in *Apteryx* and many other birds in which the hallux is small, the flexor longus hallucis blending with the flexor digitorum profundus, at the same time that a slender slip is sent off from the inner side of the conjoined tendon to the hallux.‡

In the patagium of the wing a slender muscular fasciculus runs

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* Nitzsch's "Pterylography," Ray Society's translation, p. 139.

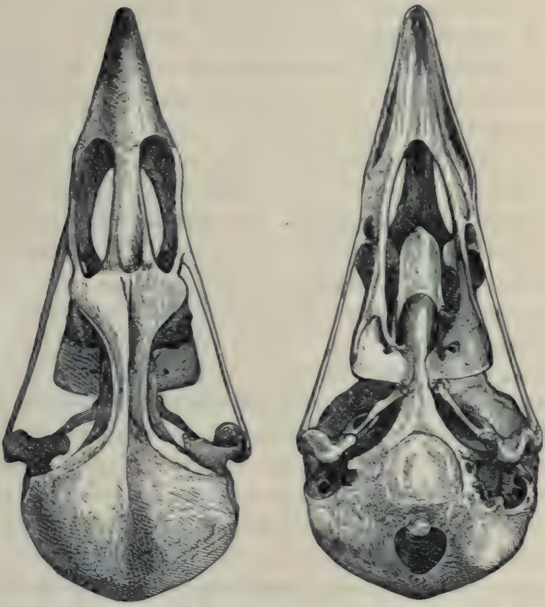
† (*Suprà*, p. 208.)

‡ *Vide* "Proceedings of the Zoological Society," 1875, p. 341. (*Suprà*, p. 291.)

from the biceps to a little above the middle of the tendon of the tensor patagii longus—the tendon of the tensor patagii brevis being in two parts, of which the outer is the broader and stronger. Where this latter joins the extensor carpi radialis longus a fan-shaped fibrous expansion is sent off to the middle long patagial tendon, as in the Limicolæ generally.

The obturator internus muscle is very small and oval in shape.

Both the right and left carotid arteries are developed in the two genera, which agree exactly in their myology.



Skull of *Attagis gayi*.

The lower larynx is simple, a slender muscle on each side running to the fourth bronchial half-ring, which, like the three above it, is deeper than the other bronchial half-rings, and more like a split tracheal ring.

Osteologically the Thinocorinæ present many features of interest. In his more recent communication "On Ægithognathous Birds" (part II., read before this Society in February 1876, and not yet published), Professor Parker has fully described and beautifully figured the skull of *Thinocorus rumicivorus*, and has drawn special attention to the spuriously Ægithognathous nature of the palate, with its peculiarly broad vomer, rounded in front, and there intimately connected with the nasal cartilages in a manner which much resembles the Page 416.

arrangement in Passerine birds. In the accompanying figure (p. 419) the palate of *Attagis gayi* is represented from a specimen most kindly lent me by Mr. T. C. Eyton, the sternum of which is that referred to above as figured in the "Osteologia Avium."

By comparing it with Mr. Parker's figure of *Thinocorus rumicivorus*, the almost exact identity of the two is rendered certain. In the same memoir Mr. Parker also directs attention to the nature of the anterior osseous nares, which, as he remarks, are much the same as in the Turnicidæ. Both these genera agree with the birds termed Schizorhinal by me in a previous paper,* resembling the Limicolæ, Pteroclidæ, Columbæ, and their allies in this respect—although, on account of the shortness of the face, as in the Pteroclidæ, their schizorhinal nature is not quite so conspicuous as in such genera as *Grus*, *Ibis*, and *Scolopax*. The superior aspect of the skull of *Attagis gayi* is also represented *suprà* (p. 419).

In more than one peculiarity the skulls of *Thinocorus* and of *Attagis* differ from those of *Turnix* and *Hemipodius*.† The maxillo-palatines, instead of being slender throughout and simply squared off at their free ends, which are situated considerably nearer the middle line than are the inner margins of the palatine bones at the parts which they oppose, are broad, short, and swollen apically, where they scarcely project beyond the median borders of the palatines. The Turnicidæ also possess an extensive articulation between the middle of each pterygoid bone and the basisphenoid rostrum—no traces even of processes for such an articulation being present in the Thinocorinæ, in which latter subfamily also the supraorbital glands, although not largely developed, leave a small crescentic depression on the superior surface of the upper margin of the bony orbit, not present in the former group.

Continuing the comparison with the Turnicidæ, it may be mentioned that in them the left carotid artery is alone developed (in *Hemipodius tachydromus* and *Turnix lepurana* at least), whilst the accessory femoro-caudal muscle, as well as the slip to the patagium from the biceps of the arm, are wanting, at the same time that the obturator internus is large and fan-shaped, not oval and small.‡ The colic cæca, also, never exceed $1\frac{1}{2}$ inch in length, in which, as well as all the above-mentioned characters, they differ from the Thinocorinæ.

That *Turnix* and *Thinocorus* are not intimately related may be

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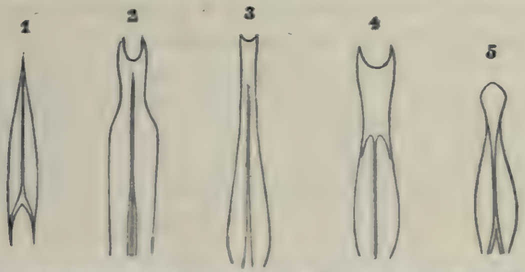
* "Proceedings of the Zoological Society," 1873, p. 33 *et seqq.* (*Suprà*, p. 124.)

† For most instructive figures and descriptions of the skulls of *Turnix* and *Hemipodius* see Prof. Parker's paper "On Ægithognathous Birds," part i., "Transactions of the Zoological Society," vol. IX. Plate LIV. and p. 294.

‡ *Vide* "Proceedings of the Zoological Society," 1876, p. 195. (*Suprà*, p. 325.)

therefore considered certain, notwithstanding the partial resemblance of their vomers. Page 417.

Next with reference to *Chionis*. By De Blainville this genus has been located close to *Hæmatopus**; and his view has been accepted, to a greater or less extent, by many. Nevertheless, although these birds are both strictly schizorhinal, their skulls give indications of a very different affinity. *Hæmatopus* possesses supraoccipital foramina, as well as pterygoid articulations with the basisphenoid, together with a bifid vomer, as represented in fig. 2. The similarly formed vomer is extraordinarily broad in *Recurvirostra avocetta*, which is shown in fig. 4, agreeing with the restricted Limicolæ; whilst in *Chionis* the vomer is blunt (fig. 5), and the basisphenoid rostrum, as well as the pterygoids, are entirely free as far as articulating facets are concerned. In the Bulletin of the United States National Museum† Dr. E. Coues and Mr. Kidder, after a most careful study of the whole anatomy of the genus, *Chionis minor* especially, remark, "We find in *Chionis* a connecting link, closing the narrow gap between the plovers and gulls of the present day. In our opinion this group represents the survivors of an ancestral type from which both gulls and plovers have descended."‡ A separate division, termed Chionomorphæ, is established for them, comparable with the Geranomorphæ and the Cecomorphæ of Prof. Huxley.§ My dissections of both *C. alba* and *C. minor* are quite in favour of this Larine affinity. That the genus deserves to be located in a separate division, however, as Dr. Coues suggests, I cannot agree. The Cecomorphæ of Prof. Huxley include the Laridæ, Procellariidæ, Colymbidæ, and Alcidæ; and it is now known that neither the Procellariidæ nor Colymbidæ come near the Laridæ and Alcidæ, which two last-named families are related one to



Anterior extremity of vomer in :—1. *Sterna hirundo*; 2. *Hæmatopus ostralegus*; 3. *Numenius arquatus*; 4. *Recurvirostra avocetta*; 5. *Chionis alba*.

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* "Annales des Sciences Naturelles," vi. 1836, p. 97.

† No. 3, p. 85, Washington, 1876.

‡ *Loc. cit.* p. 114.

§ "Proceedings of the Zoological Society," 1867, p. 457.

the other most intimately, and differ from one another to almost exactly the same amount as the Chionididæ do from either. I should **Page 418** place the Chionididæ, the Laridæ, and Alcidæ in sequence as members of the Limicolæ*; and such being the case, their intimate affinities with the Thinocorinæ scarcely need further notice. The bifid vomer of *Numenius arquatus*, as shown in fig. 3, p. 419, closely resembles that of most of the Limicolæ proper. The vomer is always sharp-pointed in the Larinæ, as in *Sterna hirundo* (fig. 1, p. 419), with which *Chionis* generally agrees.

In *Cursorius* and *Glareola* the vomer is not expanded laterally. In them, however, there is an absence of pterygoid facets for articulation with the basisphenoid rostrum, together with a general resemblance between their palates and those of the Thinocorinæ. In their myology these genera do not differ in any essential points from *Thinocorus* and *Attagis;* and it is with these that I cannot help thinking that *Thinocorus* and *Attagis* are most allied. Not in any of these genera are the pair of supraoccipital foramina to be found, which are present in nearly all the Charadriidæ and the Gruidæ.

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* *Vide* "Proceedings of the Zoological Society," 1874, p. 123. (*Suprà*, p. 221.) I may here mention that Dr. Coues's account, in the above-quoted paper, of the myology of *Chionis minor* is incomplete as far as the varying muscles are concerned; and I may add that in both species the ambiens muscle is of fair size, the external vastus covers the biceps cruris, the femoro-caudal with its accessorius and the semitendinosus with its accessorius are well developed. The internal obturator is oval; and there is a slip from the biceps humeri to the patagium. There are two carotid arteries, and intestinal cæca, 5 inches long in *C. alba,* 6 inches in *C. minor.*

67. NOTE ON AN ANATOMICAL PECULIARITY IN CERTAIN STORKS.*

The Ciconiidæ, whilst presenting great uniformity in their myology, Page 711. differ among themselves in one feature which seems to me to be of sufficient interest to deserve special record, as it may aid those who study their external characters to arrive at a more satisfactory determination of their affinities among themselves.

The following are the species I have had the opportunity of dissecting:—

Ciconia nigra.
—— *alba.*
—— *boyciana.*
—— *maguari.*
Abdimia sphenorhyncha.
Xenorhynchus australis.
—— *senegalensis.*
Leptoptilus crumeniferus.
—— *argala.*
Tantalus ibis.

In all these birds, with the exception of *Abdimia sphenorhyncha* and *Xenorhynchus senegalensis*, I have found the ambiens muscle, which courses obliquely through the front of the capsule of the knee, present, although never large; whilst in the two last-named birds, Page 712. both from Africa, it is absent on both sides of the body. Such being the case, it seems to me highly probable that the relationship between *Abdimia sphenorhyncha* and *Xenorhynchus senegalensis* is more intimate than that between *X. senegalensis* and *X. australis;* and this view is favoured by their geographical distribution.

The tendency of the ambiens muscle to vanish in certain of the birds so closely allied as the Storks under consideration, in certain Psittaci, as well as in some of the Columbæ, is one which our knowledge of their habits does not enable us to explain. It can have no relation to the habits or bulk of the species; for this muscle is present in the Ostrich as well as in the smallest Cuckoo, whilst it is absent in the Cassowaries and the Passeres. The fact that it is not found in certain Storks makes its total loss in the Ardeidæ less surprising than it would otherwise be.

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* "Proceedings of the Zoological Society," 1877, pp. 711, 2. Read, Nov. 6, 1877.

68. NOTES ON THE ANATOMY OF THE CHINESE WATER-DEER (*HYDROPOTES INERMIS*).*

Page 789. SINCE the discovery by Mr. Swinhoe of the Chinese Water-Deer, which in the "Proceedings" of this Society† he named *Hydropotes inermis*, naturalists have been anxious to obtain information upon its visceral anatomy, together with other features not ascertainable from adult skins or from the skeleton. At Tours our Corresponding Member M. J. Cornély has succeeded in breeding the species,‡ the Society having allowed him the loan of its male specimen, and his example being of the opposite sex. One of the three young ones, a female, having died shortly after its birth, M. Cornély forwarded it to Mr. Sclater, who has kindly placed it in my hands for description; and it is my notes upon this specimen which I take an opportunity of laying before the Society.

From the tip of the nose to the base of the tail the specimen is 16 inches, the tail being an inch long. From the top of the shoulder to the tip of the hoof of the fore limb it measures 12 inches. The colour of the hair, after being in spirit for some days and then dried, is a dark greyish brown, which is redder along the back than at the sides. The abdomen, as well as the throat, is a dirty white, as are the hairy inner surfaces of the ears.

The fawn is spotted with white.§ The spots are not numerous or pronounced. They run in longitudinal lines from the neck to the tail, with a median area about 1·5 inch broad unspotted. There is one line, the upper, fairly defined and uninterrupted; two others, lower down, are irregular and shorter. The spots are not distinct, Page 790. because they are not produced by the presence of hairs which are white throughout, but by dark reddish hairs tipped with white for not more than one-sixth of their length.

The nipples are four in number. The crumenal glands are quite small. No supraorbital glands were recognizable. In the fore limb the interdigital skin is inflected but slightly, and there is no special

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* "Proceedings of the Zoological Society," 1877, pp. 789–792. Read, Nov. 20, 1877.

† "Proceedings of the Zoological Society," 1870, p. 89.

‡ See M. Cornély's article in "Bull. Soc. d'Acclim." 3e sér. t. iv. p. 417; and note, "Proceedings of the Zoological Society," 1877, p. 533

§ In the Society's "Proceedings," 1872, p. 817, Mr. Swinhoe remarks, "I learn from Mr. Russell that the fawn is spotted with dark brown spots all over the hind quarters." I could not detect any trace of these.

gland differentiated, although the surface of the skin is apparently studded with minute gland-openings. In the hind limb the interdigital skin forms a deep pocket, which almost completely separates the toes, except that they are joined by a thin transverse skin-fold along their posterior edges. The included skin is studded with small glands. I can find no trace of any metatarsal glands.

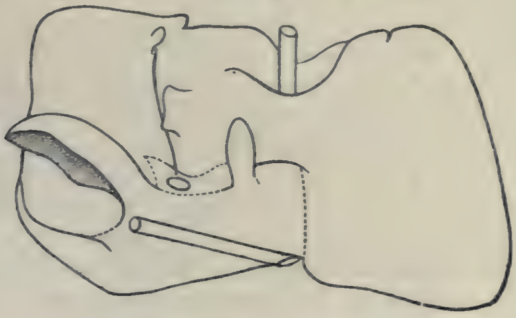
The muffle is as deep as broad, and extends one half up the outer margin of the narial orifice.

In the new-born female the milk-incisors and lower canines are cut, as is the sharp small upper canine. The milk-molars are in place, partly disguised by a layer of mucous membrane covering them. The anterior portion of the palate is covered with the ordinary transverse ridges, running outwards from the middle line; posteriorly it is smooth.

The tongue shows but little of the intermolar eminence. The fungiform papillæ are numerous, and stand out conspicuously. Postero-laterally they develop into lines of papillæ circumvallatæ.

The stomach is not favourable for study, because of its being so little developed. The villi on the rudimentary paunch look like the pile on thick-set velvet. The hexagonal cells in the reticulum are conspicuous though not high-walled. By the aid of a magnifying glass the psalterium is seen to be quadruplicate—in other words, to have its laminæ arranged in four powers, there being ten primary laminæ, with secondary smaller folds between them, on each side of which are smaller laminæ, with linear rows of papillæ (rudimentary laminæ) between them, of the fourth power. The large abomasum is not peculiar.

Fig. 1.



Liver of *Hydropotes inermis* (still-born).

The spleen is circular, flat on its gastric, and convex on its parietal surface. Page 791.

The liver (fig. 1) has no gall bladder, therein being quite cervine.

There are one or two minor lobules so situated as to develop a spurious cystic fossa; and what is still further interesting is, that in that fossa there is a white fibrous cord which runs from the transverse fissure nearly to the ventral margin of the abdominal surface of the right lobe, exactly in the situation of a gall-bladder. Once previously in a Deer (*Cervus virginianus*, I believe) have I seen a similarly situated fibrous cord, which I can hardly believe to be any thing else than an atrophied gall-bladder, although I was not able to trace its connection with the bile-duct on account of the bad state of preservation of the specimen.

The Spigelian lobe is proportionally well developed, being tongue-shaped (or rusiform) as in the genus *Rusa*. The caudate lobe is of fair size. The umbilical fissure is shallow, the left hepatic lobe being slightly smaller than the right, both being of a square shape.

The intestines measure 9 feet 8 inches, the small intestines 7½ feet long, the large 2 feet 2 inches. The cæcum is 1½ inch long. No trace is visible of an ileo-cæcal gland. There are 2½ colic coils, there being an irregular reversed half-loop in the returning portion of the spiral.

In the bicorn uterus of this new-born animal the cotyledonary papillæ are as manifest as in that of the pregnant adult. There are four in one cornu and three in the other, the highest of these in the latter being particularly large. I have, in my paper on the visceral anatomy of the Ruminantia ("Proceedings of the Zoological Society," 1877, p. 12),* mentioned that in a pregnant uterus of *Hydropotes*, which was lent me kindly by Mr. Ewart, of University College, there were three cotyledons in one cornu and five in the other, which agrees very closely with the specimen under consideration.

The brain is very much like that of the Pudu Deer (*Cervus pudu*) figured by Professor Flower,† mainly differing in that the hippocampal gyrus is much less conspicuous upon the superior aspect. It is considerably more convoluted than that of *Moschus moschiferus*, upon the typical Ruminant pattern. I take the opportunity of figuring it (*vide* fig. 2, p. 425) from above.

Reviewing the above-described anatomical features, the differences between the visceral anatomy of *Hydropotes inermis* and *Moschus moschiferus* clearly indicate the slightness of their relationship. In the former we find a fairly convoluted brain, a quadruplicate psalterium with 10 primary laminæ, no ileo-cæcal gland, no gall-bladder, two and a half colic coils, and an oligocotyledontophorous uterus; whilst in the latter the brain is comparatively smooth, the psalterium is duplicipli-cate, with 20 or so primary laminæ, a large ileo-cæcal gland, a gall-

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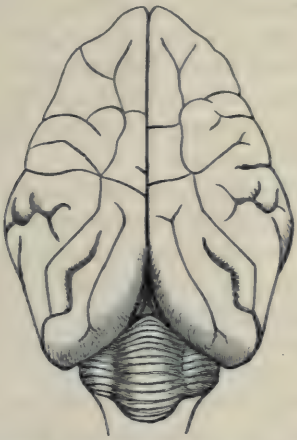
* (*Suprà*, p. 400.)

† "Proceedings of the Zoological Society," 1875, p. 177.

bladder, three and a half colic coils, and a specialized linear cotyledonary arrangement. In other words, *Hydropotes* is typically Cervine, whilst *Moschus* is any thing but so.

To what group of the Cervidæ *Hydropotes* is most allied there is still considerable uncertainty. That it is not allied to the New- Page 792. World type is evident from its vomer not extending downwards to join the osseous palate posteriorly. That it is not Cervuline is equally certain on account of its tarsal cuneiform bones being free from the naviculo-cuboids. Its large hepatic Spigelian lobe favours the view suggested by Sir Victor Brooke,* that it is most closely allied to the Rusine Deer.

Fig. 2.



Brain of *Hydropotes inermis* (still born).

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* "Proceedings of the Zoological Society," 1872, p. 525.

69. NOTE ON THE POSSIBLE CAUSE OF DEATH IN A YOUNG SEAL.*

Page 792. On October 1, 1877, Mr. G. Mellin presented to the Society a female Common Seal (*Phoca vitulina*), which died on the 9th of the same month. He obtained it from the Scilly Islands on September 27th, when it had attached to it the rudiments of the umbilical cord, which dropped off on the 30th, three days later. It must therefore have been born only a few days. When in the Society's Gardens it sucked milk freely from a baby-feeding bottle, and exhibited no pathological symptoms. As it did not take kindly to the water, it remained almost entirely on land.

On post-mortem examination it was found to be three feet two inches in length from the tip of its nose to the end of its tail, along the back. The lungs were of a dark red colour, collapsed, containing scarcely any air, and scarcely floating in water, otherwise also resembling
Page 793. those of a suffocated new-born child. The kidneys were dark on section being made in the cortical portions, and quite white at the apices of the cones.

It is the heart which was peculiar, in that neither the ductus arteriosus nor the foramen ovale was obliterated, and they appeared to be as patent as they could ever have been in fœtal life. The question then suggests itself as to whether the animal suffered from cyanosis, of which it died, or whether in the Pinnipedia the semi-fœtal circulation continues for longer after birth than in other mammals.

The creature having lived for nine days in the Society's Gardens, and having lost the umbilical rudiment a day before it arrived, was probably about a fortnight old when it died, and ought, according to analogy with the human infant, to have lost all traces of the fœtal cardiac peculiarities; whereas the ductus arteriosus and the foramen ovale were not even beginning to be obliterated. This can hardly have been otherwise than pathological, which leads me to the inference that it died morbidly cyanotic, perhaps because it lacked its normal maternal milk, and so was not in a condition to repair its fœtal imperfections.

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* "Proceedings of the Zoological Society," 1877, pp. 792–3. Read, Nov. 20, 1877.

70. ON THE SYSTEMATIC POSITION OF THE *MOMOTIDÆ*.*

Page 100. In my paper on certain muscles of birds and their value in classification†, I have made an error, which I desire to correct, with reference to the systematic position of the Momotidæ. I there included them with the Coraciidæ as part of a single family, characterized among the Anomalogonatæ by the possession of a nude oil-gland, together with colic cæca. Since the time my paper appeared, I have had the opportunity of dissecting several species of Momotidæ, thanks to the kindness of Mr. O. Salvin, including *Momotus lessoni*, *M. æquatorialis*, *M. brasiliensis* (a specimen which had lived in the Society's Gardens), *Hylomanes gularis*, and *Eumomota superciliaris;* and I find that in none of these are colic cæca present.

Page 101. Further, in *Hylomanes gularis* and *Eumomota superciliaris* I find a minute tuft on the apex of the oil-gland, although in the several species of *Momotus* there is no trace of any tuft; in fact they have lost it, evidently since the family was differentiated off.

Such being the case, the Momotidæ must be placed with the Piciformes, as defined by me, instead of with the Passeriformes; and the amended arrangement may be thus tabulated, the Todidæ and Momotidæ almost certainly forming a single family, as has been suggested by many, and which is confirmed by the observation made by Dr. Murie that in the Todidæ the beak is serrate.‡

ANOMALOGONATÆ.

Aves Piciformes.	*Aves Passeriformes.*
Bucerotidæ.	Coraciidæ.
Alcedinidæ.	Steatornithidæ.
Momotidæ.	Caprimulgidæ.
Todidæ.	Galbulidæ.
Ramphastidæ.	Meropidæ.
Capitonidæ.	Trogonidæ.
Pici.	Bucconidæ (?).
	Passeres.

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* "Proceedings of the Zoological Society," 1878, pp. 100–2. Read, Jan. 15, 1878.

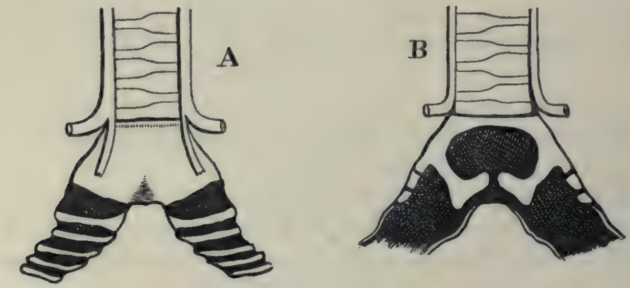
† "Proceedings of the Zoological Society," 1874, p. 123. (*Suprà*, p. 222.)

‡ "Proceedings of the Zoological Society," 1872, p. 671.

In further favour of the inclusion of the Momotidæ with the Piciformes may be mentioned the pterylographic peculiarity found in them all, namely that the outer pectoral branch of the inferior tract is separated almost entirely from the inner branch, with which it blends for nearly its whole distance, or entirely, in the Passeriformes.

From a skin, I have been able to determine that the deep flexor tendons of the leg of *Todus viridis* are arranged on exactly the same plan in it as in the Momotidæ,* and that its tensor patagii brevis also terminates in exactly the same manner as it does in them.†

The syrinx of the Momotidæ has never been fully described, so far as I am aware. I therefore exhibit a figure of it as it appears in *Momotus lessoni*, which resembles that of the other species which I have examined. Fig. A is the anterior view; B, the posterior.



Syrinx of *Momotus lessoni.*

Page 102. The large cartilaginous three-way piece, in which the trachea terminates inferiorly, is compound, being formed of several fixed rings. It is complete in front, being represented behind by a hooked process on either side, extending inwards towards the middle line, where the two nearly meet. The lateral muscles of the trachea extend down to the upper margin of this peculiar syrinx; and a few of their anterior fibres continue onwards to the surface of the cartilaginous box, where they terminate, sometimes higher and sometimes lower, but always before reaching its inferior margin.

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* *Vide* "Proceedings of the Zoological Society," 1875, p. 344. (*Suprà*, p. 294.)

† *Vide* "Proceedings of the Zoological Society," 1876, p. 511. (*Suprà*, p. 359.)

71. NOTE ON THE GIZZARD AND OTHER ORGANS OF *CARPOPHAGA LATRANS.*[*]

In the collection of birds preserved in spirit by H.M.S. "Challenger" is the body, after the skin had been removed, of a single specimen of *Carpophaga latrans*, together with the gizzard of a second individual of the same species, obtained at Kandavu, Fiji. These form the material for the present communication. Page 102.

In his note-book Mr. John Murray makes the following remarks on the species[†]: "Stomach contained the fruit of some tree unknown to me. The coat of the stomach had hard papilla-like ossifications of a circular form, two or three rows. . . . These indurations are composed of a horny substance"—from which it is seen that Mr. Murray was the first to recognize the existence of the strange arrangement to be here described.

The thin-walled and capacious crop contained only one thing in its interior—a complete fruit, which has been identified for me by Mr. W. T. Thiselton Dyer, as that of *Oncocarpus vitiensis*. In the gizzard was also found a portion of a second example of the same fruit.

Oncocarpus vitiensis is a tree belonging to the natural order Anacardiaceæ, which, according to Dr. Seemann[‡], is "about sixty feet high, bearing large oblong leaves and a very curious corky fruit, somewhat resembling the seed of a walnut." The tree is included among those which are poisonous by the Fijians; and its sap produces an intense itching of the skin, when brought into contact with it, whence the native name Kau Karo or itch-wood.

For the crushing of this very hard fruit a special anatomical modification of the gizzard-walls of this Fruit-pigeon is developed, which is peculiarly interesting and tends to prove the plasticity of organs when aberrant forces come into play.

The gizzard is not developed to anything like the extent that it is in the Gallinæ or Anseres, but, as in most Carpophagine birds, is small, and has its muscular walls comparatively ill-developed. No stones of any kind were found in it. Page 103.

It is the epithelial lining which is so peculiar in *Carpophaga*

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[*] "Proceedings of the Zoological Society," 1878, pp. 102–5. Read, Jan. 15, 1878.

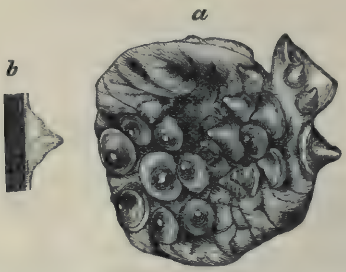
[†] *Vide* "Proceedings of the Zoological Society," 1877, p. 737.

[‡] Seemann's "Mission to Viti," p. 334.

latrans. Instead of being smooth, or folded into plications, as is usually the case, its surface is raised into horny cones which closely resemble in appearance the tubercles for the attachment of the spines of the Echinoderm genus *Cidaris.* In fig. 1, *a*, the interior of the gizzard is represented; fig. 1, *b*, is a section of one of the cones resting upon the muscular gizzard-wall.

These conical processes are corneous throughout, are erect, and are quite transparent when cut into sections. There are twenty-three of them, large and small, in each of my specimens. The larger cones, which are the more numerous, average seven millimetres in diameter at their bases, their axial length being about four millimetres; the smallest cone is four millimetres across and of nearly the same height.

Fig. 1.



Interior of the gizzard of *Carpophaga latrans.*

The cones are arranged, close to one another, in a fairly regular manner upon the two muscle-masses, being distributed in rows of three, counting either transversely or longitudinally. This disposes of eighteen of the twenty-three cones. The remaining five are found on the tendinous intermuscular walls of the organ, in longitudinal rows, two in one row, three in the other.

A section of any one of the cones demonstrates that it is not in the least ossified, but corneous throughout, and of about the density of ox-horn. It is also seen that the attached surface of the epithelium does not participate in the undulations of the free surface, being quite smooth. Neither does it send any processes into the cones. Between the cones the epithelium is yielding, and only semicorneous.

A still further exaggeration of this abnormal condition of the Page 104. epithelium of the gizzard of *Carpophaga latrans* has been described by MM. Jules Verreaux and O. Des Murs in *Phœnorhina goliath*[*] of New Caledonia, which "se nourrit de graines de *semicarpum*." In this

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[*] "Revue et Magasin de Zoologie," 1862, p. 168.

bird "le gésier, déjà on ne peut plus musculeux par lui-même, a sa surface intérieure régulièrement recouverte . . . de pointes véritablement osseuses, rappelant la forme de celles qui se voient à la surface du corps de la *Raia* bouclée, ou *Clavel*, ou *Clavelade*. Ces pointes, en cône aplati, ont leur base plane de 5 millim. de diamètre, d'une hauteur de 5 à 6 mill., sont légèrement inclinées sur elles-mêmes, et quelquefois recourbées par la dessication, l'extrémité en étant mousse." A central fibrous peduncle is also said to run through each osseous element.

Phænorhina goliath, from what has been said above, therefore differs from *Carpophaga latrans* in having the cones of the gizzard proportionally longer, at the same time that they are ossified (which necessitates the presence of vessels in the ossification, which appear after death as the fibrous cord) and oblique. There is, however, a great similarity between the two organs.

I am informed by the Rev. S. J. Whitmee that *Carpophaga pacifica* in the Samoan Islands feeds on nutmegs, from which it is highly probable that in that species the gizzard-epithelium is modified in a manner similar to that of the Fiji or New Caledonian species. Specimens of *C. pacifica* preserved would therefore be of special interest for the determination of this point.

Fig. 2.

Syrinx of *Carpophaga latrans*.

With reference to the other parts of *Carpophaga latrans*, the intestine is very capacious, only nine inches long, and transversely sacculated from the contraction of its outer longitudinal muscular coat, this producing the appearance of thirty bold transverse folds on the mucous surface. There are no colic cæca; and, as in the genus *Carpophaga*, generally,* the gall-bladder is well developed. The liver-lobes are equal in size.

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* *Vide* "Proceedings of the Zoological Society," 1874, p. 258. (*Suprà*, p. 239.)

Page 105. The syrinx (fig. 2, p. 431) is Columbine, with its lateral muscles attached inferiorly to the membrane between the penultimate and antepenultimate tracheal rings. The trachea is composed of rings which are very yielding in the middle line posteriorly. As can be seen in the figure, the musculi sterno-tracheales, which are independent of the intrinsic muscles, are not quite symmetrically attached.

The furcula, as is the rule in the subfamily, is very slender, but complete, wherein this species differs from *Phœnorhina goliath*, in which it is cartilaginous at its symphysial end, according to MM. Verreaux and Des Murs.*

Myologically, the ambiens is to be found, not large; the femoro-caudal with its accessory head are well developed; the semitendinosus and its accessorius are the same.

There are two carotids; so that in this as well as all the other features above mentioned *Carpophaga latrans* agrees with my definition of the division of the Columbidæ into which it naturally falls, its gizzard differing, however, from that of all but one of the species which have been examined.

72. NOTES ON THE ANATOMY OF *TOLYPEUTES TRICINTUS*, WITH REMARKS ON OTHER ARMADILLOS.†

Page 222. THE Society purchased, on the 3rd of October 1877, a young female living specimen of the Apar (*Tolypeutes tricinctus*), which was the first example of the species exhibited alive in the Gardens, and probably the first ever brought alive to this country. It was in bad health on its arrival, and, never recovering, died, without any visible lesion, on the 27th of December following. Its death has given me an opportunity of determining some of the most important points in its anatomy, which may be accepted as a supplement to Dr. Murie's valuable and elaborate memoir on *Tolypeutes conurus* in the "Transactions of the Linnean Society."‡

The measurements of the specimen under consideration are as follows:—

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* *Loc. cit.* p. 140.

† "Proceedings of the Zoological Society," 1878, pp. 222–230. Read, Febr. 19, 1878.

‡ Vol. xxx. p. 71.

	inches.
From tip of nose to base of tail	12·55
Length of head	2·8
Length of tail.........................	2·1

from which it is evident, on comparison with the table of measurements of the specimens in the national collection given below, that the individual was not adult, but fairly grown.

The differences between the two known species of the genus *Tolypeutes* are so slight that it may be worth while referring to them before going further. It is to M. Geoffroy Saint-Hilaire that we owe the discovery of the second species (*T. conurus*); and his most lucid description is to be found in the "Comptes Rendus" for 1847.[*] Therein the history of the Apar is fully expounded, references being given to all previous important accounts of the animal.

It is in the central portion of the cephalic shield that the most important peculiarities are to be seen. The marginal plates of the posterior two-thirds of this shield form a regular series, and enclose other larger plates—namely, a posterior median plate, followed anteriorly in *T. tricinctus* by a pair of plates, in front of which, again, is **Page 223.**
another smaller pair.

In *T. conurus* the posterior median plate is followed by a single larger plate, and that by a pair of plates the transverse breadth of which is greater than that of the second median plate behind and in contact with it. In fig. 1 (p. 434), *a* and *b* exhibit these features, as well as their effect in causing the characteristic difference in the general shape of the cephalic shield of the two species—that in *T. tricinctus* being triangular, with its greatest breadth opposite the posterior of the pairs of plates, that in *T. conurus* being oval, with its greatest breadth opposite the single pair of plates.

On referring to the beautiful illustrations given by Dr. Murie of the animal dissected by him,[†] the cephalic shield of which is here reproduced in outline (fig. 1 [p. 434], *c*), it is evident that it does not correspond with either of those above described; and I may mention that there is a skin in the national collection (Brit. Mus. spec. 140 *a*) which agrees with it. In these the posterior median plate is followed by a second larger median plate, as in *T. conurus*, and that, more forward, by a small median plate in association with two small lateral plates. The difference makes me feel justified in establishing a third species of *Tolypeutes*, based upon Dr. Murie's figure, together with the skin in the national collection above referred to, for which I would suggest

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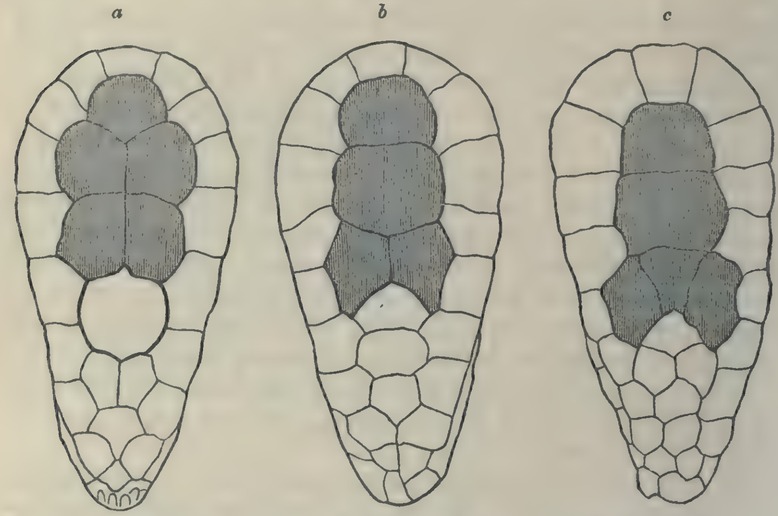
[*] Vol. xxiv. p. 572.

[†] "Trans. Linn. Soc." vol. xxx. pl. xxxi. fig. 3.

Page 224. the name *Tolypeutes muriei*, after the author who has so well described its structure. Dr. Murie's figure, being based upon a photograph of the specimen, is thoroughly reliable.

Fig. 1.



a. T. tricinctus. *b. T. conurus.* *c. T. muriei.*

Cephalic shields of *Tolypeutes.*

M. Is. Geoffroy St.-Hilaire has so well differentiated *T. tricinctus* and *T. conurus* that it will be necessary for me only to mention that in the former there are five toes on the fore feet (as in the Society's specimen in my possession), whilst in *T. conurus*, following the account of the discoverer of the species, there are " trois doigts seulement, avec le rudiment d'un quatrième, aux pattes antérieures (ce rudiment represente le doigt interne). Point de doigt externe." The same remarks apply to *T. muriei;* for in the specimen in the British Museum there are four toes on each fore foot, whilst in Dr. Murie's example the pollex was not present.

The tail, with its infundibuliform armature, is distally covered with four pairs of small rows of plates, arranged in longitudinal lines, there being one superior and one inferior pair, one supero-lateral and one infero-lateral. In *T. tricinctus* the whole organ is flattened from above downwards; in *T. conurus* and *T. muriei* it is not so. Two and a quarter inches appear to be its extreme length along its dorsal curve in all but the largest individuals, where it may reach two and a half inches. I do not find that the different species differ in the length of this appendage, which is correlated, as far as its length goes, with the length of the head, on the right side of which it always lies when the animal is rolled up.*

I can find no important differences among the species in the anterior portion of the carapace. In the three free transverse semizones *T. conurus* and *T. muriei* agree, and differ from *T. tricinctus* in that the terminal or marginal lateral scutes of each zone (which with the scute above on each side of each zone are less tuberculated than the rest, to reduce the friction when the animal rolls itself up) are more detached from the second scute, are more rounded, and are smaller proportionately.

In the posterior moiety of the carapace of *T. conurus* and *T. muriei* fifteen, sixteen, seventeen, or eighteen rows of scutes can be counted along the middle line from before backwards if the marginal scutes are included in the numeration; in *T. tricinctus* I never find more than thirteen or fourteen rows.

In *T. tricinctus* only there is a triangular area composed of small scutes, with its apex directed downwards, and basally in contact with the cephalic shield, which interpolates itself between the eye and ear on each side.

The following measurements of the specimens of the different species in the national collection may prove of service in determining the proportions of each. They demonstrate that the head is decidedly shorter than the anterior moiety of the carapace in *T. tricinctus*, whilst in *T. conurus* and *T. muriei* it is nearly always longer; that in *T. tricinctus* the head is more than half the length of the posterior moiety of the carapace, whilst in the two other species it is not so much as half that measurement.

	T. tricinctus.	*T. tricinctus.*	*T. tricinctus.*	*T. conurus.*	*T. conurus.*	*T. conurus.*	*T. conurus.*	*T. muriei.*	*T. muriei.*
	in.	in.	in.	in.	in.	in.	in.	in.	in.
Length of cephalic shield	3	2·9	2·9	2·75	2·75	2·75	3	3·1	?
Length of anterior shield	3·2	3·3	3·4	2·75	2·55	2·65	3·1	2·8	2·65
Length of posterior shield	5·8	5·75	5·7	5·5	5·75	5·8	6·75	6·3	6·3
Length of tail (upper aspect).	?	2·25	2·25	2·2	2·2	2·2	2·5	?	?
	B.M. 49, 3, 12, 1.	B.M. no. 140 *b.*	B.M. no. 140 *c.*	B.M. no. 140 *h.*	B.M. 52, 8, 24, 10.	B.M. 46, 9, 28, 35.	B.M. *e.*	B.M. no. 140 *a.*	Dr. Murie's specimen.

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* Dr. Murie figures the tail on the left of the head (*l. c.*)—the photograph from which the drawing was made not having been reversed, most probably.

It should also be mentioned that in *T. tricinctus* there is much more hair on the carapace at the posterior margins of the scutes than in the two other species, and that it has only eight teeth on each side of each jaw, whilst both in *T. conurus* and in *T. muriei* there are nine.

All the specimens of the genus *Tolypeutes* agree, as far as my experience goes, in the manner in which their cervical vertebræ ankylose—the atlas, together with vertebræ 5, 6, and 7 alone being free.

Concerning the geographical distribution of the genus *Tolypeutes*, the localities whence both Dr. Murie's and my specimen were obtained cannot be determined, they having been both purchased of dealers.

The specimen 140 *a* in the British Museum, of *T. muriei*, was presented by Burnett and Fitzroy, and therefore must have probably come from some part of the coast of La Plata or Patagonia.

A national specimen of *T. conurus* is marked as having come from Bolivia. Another of the same species, in the museum of the Royal College of Surgeons, was presented by Mr. Darwin.

The type specimen of *T. conurus* was obtained in the province of Santa Cruz de la Sierra, Bolivia; and for a cast of its cephalic shield, from which I have been able to determine the correctness of the nomenclature above adopted, I have to express my very best thanks to Professor Alphonse Milne-Edwards.

The species described by Burmeister[*] from Buenos Ayres is *T. conurus*.

Azara found a four-toed species in Paraguay; it was therefore not *T. tricinctus*.

The brain of no species of *Tolypeutes* has been described, Dr. Murie having met with an accident with his specimen. By Gervais a cast is
Page 226. figured of the interior of the skull, which demonstrates the large size of the olfactory lobes,[†] together with its general proportions, and but little more.

Our knowledge of the brain of the Dasypodidæ has been much increased by a paper from the pen of Prof. Turner in the first volume of the "Journal of Anatomy and Physiology"[‡] on the brain of *Dasypus sexcinctus*, in which the bibliography of the subject is fully given.

The general appearance of the brain of *Tolypeutes tricinctus* differs but little from that of *Dasypus sexcinctus*, whilst in surface-markings it much more closely resembles that of *Tatusia peba*, as figured by

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[*] "Annales del Museo Publico de Buenos Ayres," 1871, tom. ii. p. 117.

[†] "Les formes cérébrales des Edentates," Nouv. Archiv. du Muséum, 1869, tom. v. pl. ii. fig. 8.

[‡] 1867, p. 313.

Rapp,* being comparatively simple in its gyration. There is not that difference in the breadth of the anterior and posterior portions of the cerebral hemispheres which is found in *Dasypus sexcinctus.*

The Sylvian fissure is only represented by an open and very shallow angle, above which, on the surface of the hemisphere, is a slight, partly encircling, shallow groove of some length, separated from it by a very short distance (*vide* fig. 2, *c*).

Fig. 2.

Brain of *Tolypeutes tricinctus.*

The large olfactory lobes are much broader than they are deep.

On the surface of each cerebral hemisphere there are two sulci. One of these, the anterior, is horizontal, and divides the frontal lobe into an upper and a lower part. Its outer extension is nearly to the lateral margin, not going backwards more than one fifth the length of the hemisphere. Internally it ceases on the flat interhemispheral surface as far backward as its outer end (*vide* fig. 2, *a*).

The second sulcus is upon the superior cerebral surface, running from behind forwards and inwards. Posteriorly it commences at the outer posterior angle of the hemisphere a short distance from its extremity. Page 227. It does not, therefore, turn round the posterior end of the hemisphere to become continuous with the fissure of the hippocampus, as it does in *Dasypus sexcinctus.* Anteriorly it ceases in the middle of the superior surface of the frontal lobe, a short distance behind the convex margin of its upper moiety, and at about the transverse level of the ends of the anterior sulcus. The general direction of this sulcus is horizontal when viewed from the side, it being slightly curved, with its convexity downwards.

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* "Edentaten," tab. viii. fig. 3.

The sulcus present on the superoparietal cerebral surface of *Dasypus sexcinctus* is entirely absent in *Tolypeutes tricinctus.*

The internal cerebral surface very closely resembles that of *Dasypus sexcinctus* as figured by Professor Turner. The corpus callosum is short, pointed in front, inclined obliquely upwards and backwards, being rounded and thick posteriorly, where it becomes continuous with the psalterium of the fornix. The anterior commissure is well developed. The sides of the corpus callosum are very much upturned. The calloso-marginal sulcus is feebly represented, being of about the length of the corpus callosum, and situate at a level a little anterior to it (*vide* fig. 2, *d*, p. 437).

The corpora quadrigemina are large, and separated by a deep longitudinal fissure, the pineal gland being extremely small. In the natural position of the spirit-preserved specimen it was quite impossible to cover the testes by the posterior margins of the cerebral hemispheres, which leads me to think that Professor Turner is hardly justified in his correction of Tiedemann, Cruveilhier, and Stannius, who all say that the corpora quadrigemina are uncovered by the cerebrum (in part at least) (*vide* fig. 2 *a*, p. 437).

The median and lateral lobes of the cerebellum are nearly equal in size. The medulla is very large, and the fifth nerve is enormous. The optic nerves and commissure are insignificantly small. I could not see any corpora albicantia.

With reference to the visceral anatomy of *Tolypeutes tricinctus*, the *tongue* was 2¼ inches long in my specimen, and ·4 inch broad at the base. It is soft and elongate-triangular (lanceolate) in shape, flattened above. No circumvallate papillæ are visible, the others being inconspicuous and uniformly distributed. On the *palate* there are nine larger and smaller transverse ridges on each side, the interval between the last pair of molar teeth being smooth. The number of teeth is eight above and seven below, on each side.

The epiglottis is slightly indented by a notch in the middle line; and the soft palate embraces it, so that the rima glottidis opens into the posterior nares, as in so many mammals, during ordinary respiration. A tonsilitic pit exists on each side of the fauces.

The *lungs* are divided into four lobes on the right side, and two on the left. In most Dasypodidæ there are three lobes on the left side; but in the animal under consideration the two upper were blended. This is said by most authors to be the number of lobes of the right lung; but I always find a fourth azygos lobe as well, hidden behind the heart, in the genera *Dasypus* and *Xenurus*, absent in *Tatusia*. Dr. Murie's figure of the lungs scarcely differs, Page 228. except in the absence of division of the left upper lobe, from my specimen.

The *stomach* is of the ordinary shape, with but a short lesser curvature. It is muscular, but not powerfully so, at its pyloric end. Along its greater curvature, when laid out flat, it measures $6\frac{1}{4}$ inches.

The liver has the lateral fissures deep, whilst the umbilical fissure is comparatively insignificant. The gall-bladder is partly, but not deeply, embedded in the abdominal surface of the right central lobe. The Spigelian lobe forms a short rounded cone, very broad at its base. According to the method elsewhere suggested by me,* the formula of the bulk of the lobes is thus expressed—

$$\text{L.L. } 1\tfrac{1}{2} > \text{R.C.} > \text{R.L. } 2 > \text{L.C. } 2 > \text{C.}$$

The small intestines measure 75 inches, the large intestine 6·5 inches. There are no cæca; but there is an abrupt change in the diameter of the alimentary canal at the ileo-cæcal valve, as in *T. conurus* and in the genus *Tatusia*.

The *uterus* is triangular, the fundus being perfectly straight when viewed from in front, and the Fallopian tubes joining it at the extreme upper and outer angles. The conical clitoris is an inch long; and the genito-urinary orifice is a longitudinal slit 0·3 inch from its apex.

Among the various papers on the visceral anatomy of the Dasypodidæ I may refer to Hunter's description of *Tatusia peba*,† Professor Owen's account of the same species, and of *Dasypus sexcinctus*,‡ and Hyrtl's monograph of *Chlamydophorus truncatus*.§ To these I may add my own notes on *Xenurus unicinctus*, together with those upon the other species which have passed through my hands, as an assistance towards the determination of the affinities of *Tolypeutes*.

In *Xenurus unicinctus* the gall-bladder is so deeply embedded in the tissue of the right hepatic lobe that it nearly penetrates to its diaphragmatic surface. This I find to be the case in *Dasypus villosus*, *D. sexcinctus*, and *D. vellerosus;* whilst in *Tatusia hybrida* and *Tolypeutes tricinctus* it is much less sunk. The cystic duct is very much twisted in a corkscrew manner. The proportional bulk of the hepatic lobes is almost exactly the same as in *Tolypeutes tricinctus*. In *Tatusia peba* and *T. hybrida* the right central lobe is the largest, not the left lateral. In *Tatusia* the umbilical fissure is less significant than in *Dasypus*, *Xenurus*, or *Tolypeutes*.

The junction of the large and small intestines in *Xenurus* is as in *Tatusia peba* and *T. hybrida*, there being no cæcal dilatations, as

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* "Proceedings of the Zoological Society," 1875, p. 57. (*Suprà*, p. 274.)

† "Essays and Observations on Natural History," 1861, vol. ii. p. 182.

‡ "Proceedings of the Zoological Society," 1831, pp. 141 and 154, and "Proceedings of the Zoological Society," 1832, p. 130.

§ "Denkschr. der kais. Akad. Wien," ix. 1855.

there are in *Dasypus villosus*, *D. sexcinctus*, *D. minutus*, and *D. vellerosus*.

The following measurements of the intestines demonstrate their relative lengths :—

Page 229.

	Tatusia peba, adult ♂.	*Tatusia peba*, adult ♀.	*Xenurus unicinctus*, ♂.	*Dasypus villosus*, ♂.	*Dasypus minutus*, ♀.	*Dasypus vellerosus*.
	ft.	ft.	ft.		ft.	ft.
Small intestine ..	16·3	14·6	18·5	11·5	5·1	4·3
Large intestine ..	1·5	1·5	1·6	1·25	7·0	0·66

In *Xenurus unicinctus* the vesiculæ seminales are not present, the distal ends of the ureters being enlarged. Cowper's glands and a prostate are present; and the apex of the glans penis is not trilobed as in *Tatusia*, but simple, as in *Dasypus* and *Tolypeutes*. The penis itself is huge. In *Tolypeutes*, according to Dr. Murie, the vesiculæ seminales are also absent.

In *Tatusia peba* and *T. hybrida* the vesiculæ seminales are large, and there is a pair of lateral lobes to the apex of the glans penis. The whole penis is proportionally smaller in *Tatusia* than it is in *Dasypus*, as is the clitoris. In these respects *Tolypeutes* and *Xenurus* agree with *Dasypus*, my experience being, as far as the male organs of *Dasypus* are concerned, confined to *D. sexcinctus*.

In *Dasypus*, *Tolypeutes*, and *Xenurus* there are only a pair of nipples, in *Tatusia* there are two pairs. In *Xenurus unicinctus* the uterus is triangular, as in *Dasypus* and *Tolypeutes*.

The brain of *Xenurus* is intermediate in its form and surface-markings Page 230. between *Dasypus* and *Tolypeutes*. The hemispheres, when viewed from above, are considerably broader posteriorly than anteriorly, as in *Dasypus*. The olfactory lobes are large; and the corpora quadrigemina are completely covered. The oblique sulcus on the back part of the superior surface of each hemisphere, which runs forwards and outwards, is present, as in *Dasypus*, but it is very short. The two other sulci are well developed, that in the frontal portion being longer than in either *Dasypus* or *Tolypeutes*. The upper or second sulcus runs from in front—near the anterior internal angle of the superior surface of the hemisphere—backwards and outwards for some distance, but not nearly as far as the posterior margin of the cerebrum, it ceasing a little behind the level of the outer extremity of the posterior oblique sulcus. In this respect it resembles *Tolypeutes* and differs from *Dasypus* (*vide* fig. 3).

Fig. 3.

Brain of *Xenurus unicinctus*.

It is to Professor Owen that we are indebted for our knowledge of the great differences between the colic cæca and female generative organs of the genera *Tatusia* and *Dasypus*. These facts, when taken in association with other characters above brought forward and referred to, may be thus tabulated:—

Dasypus.	*Tolypeutes.*	*Xenurus.*	*Chlamydophorus.*	*Tatusia.*
Ears apart.	Ears apart.	Ears apart.	Ears apart.	Ears approximate.
Nipples 2.	Nipples 2.	Nipples 2.	Nipples 2.	Nipples 4.
Uterus triangular.	Uterus triangular.	Uterus triangular.	Uterus pyriform.	Uterus pyriform.
External genitalia enormous.	External genitalia enormous.	External genitalia enormous.	External genitalia small in female.	External genitalia not excessive.
Glans penis simple.	Glans penis simple.	Glans penis simple.	?	Glans penis trilobed.
Vesiculæ seminales absent.	Vesiculæ seminales absent.	Vesiculæ seminales absent.	?	Vesiculæ seminales present.
Lateral colic cæca present.	No colic cæca.	No colic cæca.	Lateral colic cæca present.	No colic cæca.
Azygos lobe of lung present.	Azygos lobe of lung present.	Azygos lobe of lung present.	Azygos lobe of lung present (Hyrtl).	Azygos lobe of lung absent.

Thus we may infer that the genera *Dasypus*, *Tolypeutes*, and *Xenurus* resemble one another more than any of them do *Tatusia*. *Chlamydophorus*, in other respects so different from them all, is like *Dasypus* alone in its colic cæca, like *Dasypus*, *Tolypeutes*, and *Xenurus* in most respects, and like *Tatusia* only in the shape of its uterus.

73. NOTES ON THE VISCERAL ANATOMY OF *LYCAON PICTUS* AND OF *NYCTEREUTES PROCYONIDES*.*

Page 373. HAVING had the opportunity in my prosectorial capacity of dissecting a male specimen of *Lycaon pictus*, as well as several, both male and female, of *Nyctereutes procyonides*, I take the present opportunity of giving the results at which I have arrived.

Lycaon pictus.—This canine animal, so different from its allies in its digitation, is not at all aberrant in its visceral anatomy, which has not been previously described, so far as I am aware. The following are some of the most important details:—

The anterior portion of the palate is black, the pigment extending back as far as half an inch, on to the soft palate, of which the posterior one and a half inch is unpigmented. There is no uvula, a median shallow notch occupying its position. The tonsils are elongate, lunate, and vertical in position.

On the tongue the filiform papillæ are all small; and among them small papillæ fungiformes are sparsely scattered. The circumvallate papillæ on each side, increasing in size from before backwards, and converging posteriorly, form the normal V. There is no trace of a lytta.

Of the salivary glands the compact submaxillaries are slightly larger than the irregularly shaped parotids. The zygomatic glands are as big as small chestnuts. The accessory submaxillary (or sublingual) glands are situated nearly in contact, in the middle line of the floor of the mouth.

The thyroid gland is formed of two parts, each of the size of a sheep's kidney, these being joined at the inferior internal angle by a narrow isthmus of thyroid tissue. The superior thyroid artery is enormous.

The stomach presented no differences from that of *Canis familiaris*. The following are the lengths of the intestines:—

	ft.	in.
Small intestine..................	9	1
Cæcum	0	7
Large intestine..................	1	3

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* "Proceedings of the Zoological Society," 1878, pp. 373–7. Read, March 19, 1878.

The cæcum is quite caniform, its curves being exactly represented in that of *Canis familiaris*.* Page 374.

The liver is deeply fissured, upon the same plan as in all the Canidæ—and all the Carnivora, in fact,—the cystic fissure being very deep, which allows the fundus of the gall-bladder to appear on the diaphragmatic surface of the organ. The left lateral lobe is the largest, the right central and right lateral being slightly smaller. These last are half as large again as the caudate and left central, which are at least four times the bulk of the Spigelian, upon which latter there is a small accessory lobule.

In the generative organs, as in all Canidæ, the prostate is large, whilst Cowper's glands and the vesiculæ seminales are absent. The os penis is large, quite straight, four inches in length, and deeply grooved, as in all the Canidæ, along its lower surface.

In the lungs there are three lobes to the left, and four to the right, one of the latter being azygos. The median lobes of both sides are the smallest; the inferior the largest. The fissures between the lobes are all deep.

The brain of *Lycaon pictus* is perfectly dog-like, resembling that of *Canis lupus* (as figured by Leuret and Gratiolet †) in almost every detail, the division of the posterior limb of the gyrus third above the Sylvian fissure extending as far forward on the superior cerebral surface as in that species, or even further, the anterior superior angle of the gyrus next below it being rather more strongly developed. The sulcus between the uppermost (or fourth) gyrus and the third is parallel to the great longitudinal fissure between the hemispheres.

In *Nyctereutes procyonides* the tongue is covered with filiform papillæ smaller in size than in *Lycaon pictus*, allowing the proportionally larger fungiform papillæ to appear more conspicuously among them. These latter posteriorly become the papillæ circumvallatæ, five on each side, larger posteriorly, and arranged in a V-manner.

There is no uvula; and the soft palate embraces the upper end of the larynx with facility.

The stomach is not peculiar, except that it is more than usually muscular at its pyloric end.

In an adult male which died on the 2nd of February last, the father of a litter of six born on May 2nd 1877, the small intestines

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* *Vide* "Proceedings of the Zoological Society," 1873, p. 748, fig 13. (*Suprà*, p. 223).

† "Anatomie comparée du Système Nerveux" (Paris: 1839–1857), pl. iv. fig. Loup.

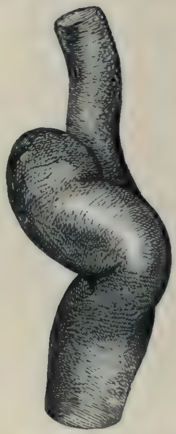
measured eight feet; the large, one foot and an inch, the cæcum being two inches long, rounded at the end, and slightly turned to the left side apically. It is figured in the accompanying sketch.

In three other specimens, not adult, the following were the intestinal lengths:—

Page 375.

	♀, half-grown.	♀, a month old.	♀, a month old.
Small intestine..........	4·25 feet.	5·75 feet.	7·3 feet.
Large intestine..........	6 inches.	8 inches.	8 inches.
Cæcum	1·25 inches.	1·5 inches.	2 inches.

There is evidently not much constancy in the length of the viscera, even in specimens of the same age and sex.



Cæcum of *Nyctereutes procyonides.*

The liver differs from that of *Lycaon pictus* and other Canidæ in the great size of the Spigelian lobe. In this the accessory lobule, referred to above, is enlarged to form part of the lobe itself, which is, by its presence in a semi-independent condition, rendered bifid apically. In the depth of the cystic fissure, and all other respects, it is quite caniform.

The lungs are not peculiar, the fissure between the left upper and middle lobes only being less developed than in many of its allies. The azygos lobe is present on the right lung.

The prostate is well developed; Cowper's glands are absent, as are the vesiculæ seminales. The os penis is three inches in length, straight, and deeply grooved inferiorly to transmit the urethra. The glans penis is bluntly conical, the urethra opening terminally, much as in the American Cervidæ.

In *Ny tereutes procyonides* the brain is perfectly caniform. The posterior limb of the third convolution is bifurcate, the bifurcating sulcus not being lengthy, going upwards and forward without having any extension directly onwards to the anterior extremity of the hemisphere. There is scarcely any tendency in the second gyrus to form an antero-superior angle; and the sulcus between gyri three and four is not quite parallel to the great longitudinal fissure, it diverging slightly from the middle line as it goes forward. In these respects the brain more resembles that of *Canis vulpes*[*] than those of *Canis familiaris* or *C. lupus*. Page 376.

In the peritoneal cavity of the adult male *Nyctereutes* (which, like the half-grown female, had excessive atheroma of all its larger arteries) I found an immense number of parasitic worms, collected especially about the abdominal surface of the liver and the stomach.

These worms had "heads" much like those of the *Bothriocephali*, but larger. My friend Mr. F. G. Penrose has most kindly made sections of them, and has demonstrated the existence of a most peculiar cavity in each. This cavity is coiled up within the ovate "head;" its lumen is small; and its walls are plicated very extensively, the magnitude as well as the number of the folds being great. It opens externally at its proximal extremity by one of its ends only. The "body" is tænioid in its proportions, and is not segmented. It is about two and a half inches in total length, the "head" being about the size of a hemp-seed or a little smaller.

There are a few general remarks suggested by the above recorded facts.

First, with reference to the colic cæcum in the Canidæ, I have on a previous occasion noticed the aberrant form of that appendage in *Canis cancrivorus*,[†] where it is nearly straight. Two other specimens of the species have since passed through my hands, which have been entirely confirmatory of my earlier observation. In *Nyctereutes procyonides* the cæcum is slightly more caniform than in *C. cancrivorus;* it is a little broader also.

From the examination of other Canidæ, I find that the cæcum, in its twistings, resembles that of *Canis familiaris* in being turned about twice and a half upon itself in *C. laniger*, *C. lagopus*,[‡] *C. anthus*, *C. fulvus*, *C. antarcticus*, *C. azaræ*, *Otocyon lalandii*, and *Lycaon pictus*.

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[*] Leuret and Gratiolet, *loc. cit.* pl. iv. fig. 2, Renard.

[†] "Proceedings of the Zoological Society," 1873. p. 748. (*Suprà*, p. 223.)

[‡] *Vide* Flower, "Hunterian Lectures," "Medical Times and Gazette." London, June 1st, 1872, p. 622.

In *Canis aureus* I have found the terminal twist wanting, the apex of the cæcum turning down as in *C. famelicus*.

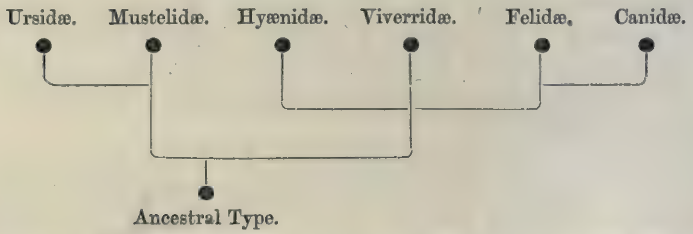
In *Canis cancrivorus* and in *Nyctereutes procyonides* the cæcum is nearly straight.

Secondly, with reference to the brain, Prof. Flower has done much to condense and classify the facts to be arrived at from the study of the convolutions,* which latter, in my estimation, throw much light upon the mutual affinities of the Fissiped Carnivora.

It seems to me that the typical major convolutions of the Carnivorous brain form three complete and uniformly broad gyri round the Page 377. Sylvian fissure, which in the Mustelidæ and the Genets remains as such, notwithstanding that these two latter groups had otherwise diverged before the brain began to modify. From the Musteline animals (the Arctoid ancestral type) the Ursidæ seem to have diverged, the superior or third cerebral convolution broadening and tending to divide, whilst the others persist unmodified.

Those Viverridæ which are more modified than the genus *Genetta*, acquire a broadening of the lowest of first circum-Sylvian convolution, especially in its posterior limb, in which a perpendicular sulcus is formed; and this peculiarity is more strongly marked in *Hyæna*, as well as in *Proteles*. In the Felidæ the anterior as well as the posterior limb of this first circum-Sylvian gyrus broadens, and becomes perpendicularly bisected to such an extent that if in them there were a longitudinal sulcus developed in the upper median portion of the gyrus, a complete secondary gyrus would appear. Such a gyrus, evidently thus originating, is found in the Canidæ, in which the extra convolution is therefore a reduplication of the first, dependent on the differentiation off of its outer moiety.

On the assumption of the correctness of this hypothesis, the classification of the Fissiped Carnivora might be represented thus:—



By Prof. Flower,† after a most careful analysis of their cranial and other peculiarities, the Canidæ are placed between the Arctoidea

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* "Proceedings of the Zoological Society," 1869, p. 482.

† "Proceedings of the Zoological Society," 1869, p. 4.

and Æluroidea; but from the same facts Mr. H. M. Turner[*] placed the three major groups in the same order of sequence that the brain-markings indicate, namely Ursidæ, Felidæ, and Canidæ, which makes it evident that such an arrangement is not opposed to the teachings of the parts other than the cerebral hemispheres.

74. ON THE TRACHEA OF *TANTALUS LOCULATOR* AND OF *VANELLUS CAYENNENSIS*.[†]

In his "Beiträge zur Naturgeschichte von Brasilien," Maximilian, Prince of Wied,[‡] describes briefly and figures the lower end of the trachea of *Tantalus loculator*. A male specimen of the species having recently died in the Society's Gardens, I take the opportunity of more minutely pointing out its peculiarities and of comparing it with *T. ibis*, the windpipe of which, with its elaborate convolutions, I have had the opportunity of bringing before the notice of the Society upon a previous occasion.[§] Page 625.

In *Tantalus loculator* the trachea is not elongated as it is in *T. ibis;* nevertheless it is peculiarly modified, and differs in detail from that of any bird with which I am acquainted, although its plan of construction is perfectly Ciconiine.

The seventy-eight lowermost rings of the trachea are those which are modified, the rings above them being quite typical, of average depth, notched in front as well as behind, and overlapped to produce the well-known zigzag markings on the surface.

With the exception of the last one, all the modified rings are much reduced in depth; and of them the sixty-one upper rings are compressed from side to side and bent sharply in front, whilst the lower seventeen are somewhat flattened from before backwards and sharply bent laterally, the general effect of which is to produce a lateral flattening and an anterior carination of the whole tube opposite the fifty-one rings, as well as an antero-posterior flattening with a lateral carination in the part below. The change from the superior unmodified tube to the laterally compressed portion is somewhat abrupt, as is

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[*] "Proceedings of the Zoological Society," 1848, p. 83.

[†] "Proceedings of the Zoological Society," 1878, pp. 625–9. Read, May 21, 1878.

[‡] Band iv. p. 687, tab. 1. figs. 7 and 8.

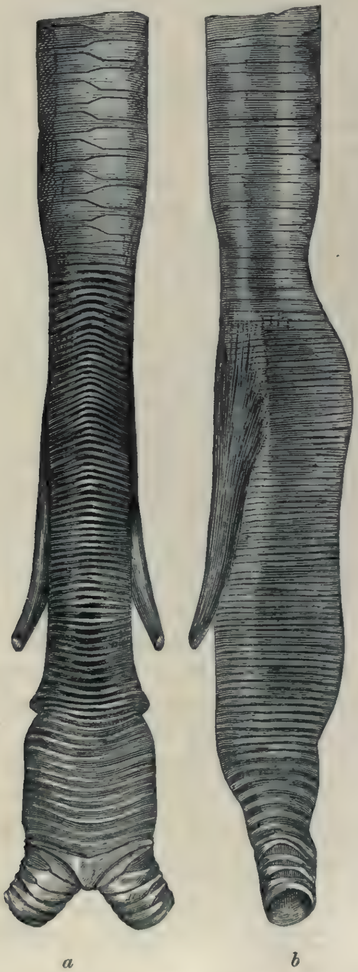
[§] "Proceedings of the Zoological Society," 1875, p. 298. (*Suprà*, p. 286.)

that between the two differently modified parts. In figure 1*a* the front view of the lower end of the trachea is represented, figure *b* giving a side view of the same.

The powerful sterno-tracheal muscles leave the windpipe opposite the middle of the laterally flattened portion of the tube; and a few muscular fibres from their anterior margin are continued downwards for a short distance, but not nearly to the last ring, they being lost upon the sides of the trachea.

Page 626.

Fig. 1.



Lower end of the trachea of *Tantalus loculator* ♂.
a. View from the front ; *b*. View from the right side.

The arrangement above described is only an exaggeration of what is found in *Ciconia alba*, in which species the lowermost nine-and-twenty tracheal rings are extremely shallow and slender, the fifteen above the bifurcation of the bronchi being antero-posteriorly flattened, the fourteen above them being in no wise peculiar except for their slenderness. In *C. alba* there is, however, a small prolongation upwards of the lateral portions of the three lowermost tracheal rings, which forms a consolidated triangular process on each side, overlapping the next few rings, and looking extremely like rudiments of the similarly situated *processus vocales* of the Passerine tracheophone syrinx, which resemblance is increased by the thinness of the neighbouring rings and their being flattened from before backwards. **Page 627.**

In *Tantalus loculator* there is no trace of these triangular processes. Its last tracheal ring, or three-way piece, is not enlarged, as it is in so many birds; and the rings of the bronchi for some considerable distance are complete as in the Ciconiidæ generally, which is so very seldom found to be the case in the Class. In this last feature the Storks agree with the Cathartidæ, and the general arrangement of the bifurcation of the Stork's windpipe would require but little change to pass into a Cathartine type.

The uppermost bronchial rings are thinner on the outer side of each bronchus than they are internally, which consequently leaves greater gaps between them along the outer margin of the tubes. Ring four on one side and ring three on the other are partly reduplicated, the extra processes ending freely in the bronchial membrane.

From this description it is evident that these two *Tantali* differ greatly in the arrangement of their windpipes, whilst a recent comparison of specimens makes it evident to me that what I thought on seeing *T. loculator* might have been an error in my account of *T. ibis*, namely the *posterior* carination of the windpipe, is correct, in which, as well as in the relative lengths of trachea, the two species differ so much.

In other anatomical characters *Tantalus loculator* agrees with *T. ibis*, and is perfectly ciconiiform. In both the great pectoralis muscle is formed of two layers, as in the Steganopodes, Procellariidæ, and Cathartidæ only. The ambiens muscle is slender; the femoro-caudal is minute, without any accessorius; and the semitendinosus, as well as its accessorius, are not large. There is no great gluteus muscle, nor any muscular slip from the biceps of the wing running to the patagium.

The small intestine measures six and a half feet, the cæca half an inch, and the large intestine nearly three inches. The stomach is capacious, with but a small muscular development. The tongue is an inch long and arrow-head shaped. The sub-equilobed liver has a gall-bladder.

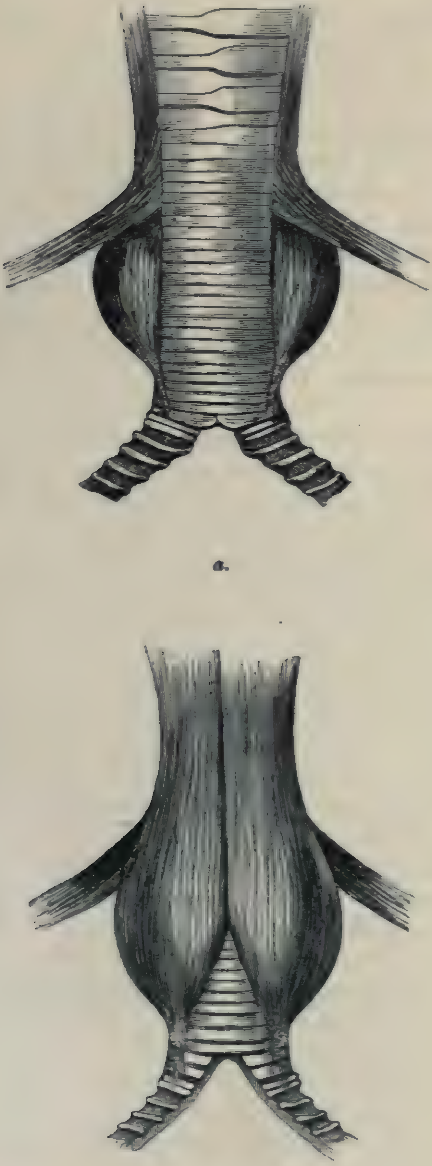
In *Vanellus cayennensis* there is an exaggerated development of the intrinsic muscles of the trachea a short way above its bifurcation in both sexes that is quite worthy of special note, because the amount of muscular fibre there present is proportionately as much as in any bird with which I am acquainted.

There is nothing peculiar about the windpipe itself or the bronchi, which are represented in the accompanying figure (p. 451). The uppermost two bronchial semirings are not like those which succeed them, but are like halves of tracheal rings. The third and fourth semirings are closely united, whilst those which follow are not modified in any way.

The sterno-tracheal muscles are powerful, and besides springing directly from the side walls of the windpipe opposite the spot where Page 629. they run off, their upper fibres are continuous up the trachea itself in front of and in contact with the intrinsic muscles. These latter, one on each side as usual, meet in the posterior middle line of the trachea, but are not unusually near in front; they are of considerable size throughout. Near their lower ends they increase immensely in bulk to form, combined posteriorly, a large subglobose mass which is situated opposite the twenty-four lowermost rings of the trachea, which are considerably shallower than those above them and consequently occupy a much less space than if they were of the same depth, as is the case in *Tantalus loculator*. There is a consolidation of the last few rings in adult birds, with which the first two bronchial semirings fuse to form a compound three-way piece, and it is to the lower elements of this that the powerful lateral muscles are attached (as well as to the third and fourth bronchial semirings slightly) by a broad fibro-tendinous continuation of their muscular substance, which fixes itself on each side along nearly the whole length of the semirings, especially the second, of which the extremities are alone free.

So far as I can find out by watching the living birds, there is nothing peculiar in their note to lead one to surmise so large a muscular supply for their lower larynx. They make a powerful screech, with no modulation in it; and it can hardly be possible that the extra muscular development has not some other function to perform. What that may be it is not easy to surmise.

Fig. 2. Page 628.



Windpipe of *Vanellus cayennensis*.
a. Anterior aspect; *b*. Posterior aspect.

75. ON THE ANATOMY OF THE MALEO (*MEGACEPHALON MALEO*).*

Page 629. Besides being a Megapode, *Megacephalon maleo* is interesting as a peculiar form; I therefore take the opportunity of bringing before the Society the results of my dissection of three specimens of this bird which have died in the Gardens.

Pterylosis.—In the distribution of its feather-tracts the Maleo is somewhat different from the typical Gallinæ. Nitzsch briefly records what he found in a bad specimen of *Megapodius rubripes*, mentioning that the tracts were not different from those in allied birds, and that the oil-gland was tufted. This is all we know of the pterylosis of the group.

In *Megacephalon maleo* the anterior surface of the neck is covered, not thickly, with feathers, which only tend to divide opposite the furcula into the two pectoral tracts, each of which descends, strong and uniform in breadth, to opposite the middle of the carina sterni, where it ceases obtusely. The ventral tract does not exist over the anterior or upper part of the pectoral region, but commences narrow close to and opposite the middle of the carina sterni, dilating opposite the abdomen, near the middle line of which it descends parallel to its fellow, to just above the anus, where the two meet. The skin over the
Page 630. carina and in the middle line of the abdomen is hard and scaly. The hypopteral tract is but feebly represented, and the termination of the pectoral tract is some distance from the commencement of the abdominal tract, the angle between the direction of the one and the other being about 25°.

A strong tract traverses the middle dorsal line of the neck, with a space on each side of it. This does not bifurcate in the scapular region, but ceases abruptly a little below the level of the shoulder-joints, undilated. Over the rump and the inferior scapular region the dorsal tract is diffused and indefinite, ceasing before the *nude* oil-gland is reached. There is no ephippial space. There are sixteen rectrices. The lumbar tract is only well developed over the tibia-head and for a little way behind it. The humeral tract is not in any way peculiar. I counted nine primary and sixteen secondary remiges, the first and second secondary feathers being considerably shorter than those which follow.

Down-feathers are generally distributed. The after-shaft is weak,

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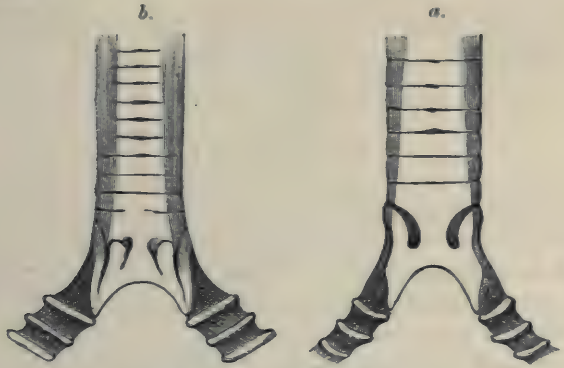
* "Proceedings of the Zoological Society," 1878, pp. 629–31. Read, May 21, 1878.

and the rhachis of each feather is not swollen, except in some of the smallest size.



Lower larynx of *Megacephalon maleo.*
a. From the front; *b.* From behind.

Visceral Anatomy.—The tongue is simple and fleshy; a well-developed crop is present, situated between the limbs of the very open furcula; the proventriculus is zonary, the gizzard powerful; the small intestine is four and a half feet long, the simple cæca five and a half inches, and the large intestine five inches in length.

There is only one carotid artery, the left, as in all the Megapodidæ.

In its *myology* the bird is perfectly gallinaceous, the third pectoral muscle being found beneath the much larger second of the same name, the femoro-caudal and semitendinosus with their accessories, the ambiens, and gluteus maximus, being all present. The obturator internus is triangular; a vinculum joins the two deep flexors of the foot, and the biceps of the arm sends a fasciculus to the patagium. The expansor secundariorum muscle ends by running to the scapula at the same time that it sends a slip of tendon to the first rib.

The lower end of the trachea is represented in the accompanying Page 631. figures, from the front and from behind. It differs in arrangement from all other of the Gallinæ with which I am acquainted. To the terminal tracheal three-way ring is fused the first bronchial semiring by its extremities, its bowed free portion being upturned with its limbs almost perpendicular. In the middle line posteriorly the penultimate tracheal ring fuses with the what may be compound three-way piece, in the posterior aspect of which a small upward-directed tongue of cartilage developes from its upper border. The sternotracheal muscles are minute and the intrinsic tracheal muscles form thin broad sheets which almost cover the tube and end on the outer surface of the first bronchial semiring and in the semicartilaginous large membrane between it and the unmodified following semiring.

76. ON THE GRAVID UTERUS AND PLACENTA OF *HYOMOSCHUS AQUATICUS*. (Written in conjunction with Prof. WILLIAM TURNER, M.B., F.R.S.)*

(Plate XXIX.)

Page 682. AN adult female of *Hyomoschus aquaticus* having come into our hands, it was with no small pleasure that on eviscerating it we found it far advanced in pregnancy; for it enables us to give an account of the placenta, the nature of which has, till now, only been surmised from what is found in *Tragulus*.

In his valuable memoir on the Tragulidæ,† M. Alphonse Milne-Edwards briefly describes and also figures the fœtus with the placenta of *Tragulus stanleyanus*. He makes no mention of the uterus, of which, in an allied species, John Hunter tells us‡ that it "soon divides into two horns, which are pretty large and not long, having none of the buttons for the cotyledons."

In his paper on the visceral anatomy of *Hyomoschus aquaticus*,§ Prof. Flower describes the female generative organs in the following words:—"The vagina was 5 inches in length; the uterus 3·5 inches to the point of bifurcation, sharply bent back on itself near the upper end, and terminated in a pair of rather short, closely curled cornua."

In our gravid specimen the single hairless fœtus which, from tip of nose to end of tail, measures 8·5 inches, the tail being an inch long, is lodged on the left side.

The uterus consists of two horns communicating with a common corpus uteri. The horns are united together in the greater part of their extent, not more than about 1·5 inch of the tip of each horn being free. The line of union is marked externally by a groove, and internally by a broad partition, the septum uteri, which extends longitudinally backwards and terminates in a well-defined semilunar free border, behind which the two horns are fused together into the common corpus uteri. The free ends of the cornua are curled backwards, and together with the Fallopian tubes and ovaries are situated upon the anterior part of the superior wall of the uterus. Owing to the fœtus being developed in the left horn, this cornu is much more dilated than

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* "Proceedings of the Zoological Society," 1878, pp. 682–6. Pl. XLIV. Read, June 18, 1878.

† "Annales des Sciences Naturelles," 5th series, vol. ii. 1864, pp. 49–167.

‡ "Essays and Observations," edited by Prof. Owen, 1861, vol. ii. p. 135.

§ "Proceedings of the Zoological Society," 1867, p. 960.

the right; but the latter is considerably more capacious than in the non-gravid uterus. The corpus uteri communicates by a constricted os with a passage which may perhaps be regarded as a cervix, though some might look on it as only the specially modified anterior end of the vagina. This part of the genital passage is $1\frac{3}{4}$ inch long and very much constricted. Its mucous lining is longitudinally folded; and the folds are at intervals so projecting as to give the appearance of transverse constrictions. The passage and the os are blocked up by a whitish viscid mucus. Behind the most posterior transverse constriction the vagina undergoes a considerable dilatation, and the mucous lining exhibits faint longitudinal folds. Page 683.

The uterine walls are slightly thinner than those of the human stomach. The cavity of the two cornua and of the corpus uteri is lined by a well-defined mucous membrane, from which the fœtal chorion can readily be separated. This mucous membrane forms the maternal portion of the diffused placenta characteristic of *Hyomoschus.* The mucosa of both cornua is not elevated into folds, except in close proximity to the openings of the corresponding Fallopian tubes; and the mucous lining of the corpus uteri is longitudinally folded only in proximity to the os uteri. The free surface of the mucous membrane, both in the cornua and corpus and on both surfaces of the septum uteri, is soft and velvety and pitted with multitudes of minute depressions just visible to the naked eye. These depressions are the crypts in which the villi of the chorion are lodged when the chorion is *in situ.* The crypts are distributed with almost equal regularity over the surface of the mucosa in the several divisions of the uterus; but on the more convex part of the impregnated left cornu the mucosa is not quite so thick, so that the crypts are shallower, and over a limited area the free surface of the mucous membrane is almost, if not quite, free from crypts. We did not, however, see any depressed circumscribed smooth areas surrounded by crypts such as one of us has described elsewhere* in the Pig and Lemurs, or polygonal areas occupied by crypts and bounded by ridges free from crypts, such as are to be seen in the gravid uterus of the Mare. In the regular diffusion of the crypts over the surface of the mucosa, the gravid uterus of *Hyomoschus* much more closely resembled what has been described in *Orca gladiator*† than it did the uterine mucosa of the Pig, Mare, and Lemurs.

We then carefully stripped portions of the mucous membrane off the subjacent muscular coat, and soaked them in glycerine for some

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* Turner, Lectures "On the Comparative Anatomy of the Placenta," Edinburgh, 1876, and "Transactions of the Royal Society," London, 1876.

† Turner, "Transactions of the Royal Society, Edinburgh," 1871.

days, in order to render the membrane as translucent as possible. When the mucosa thus prepared was examined microscopically, the openings of the uterine glands on the surface of the membrane could be seen. Sometimes these openings were found on the slender raised folds of mucosa separating adjacent crypts from each other; at other times they opened into the crypts, and at other times on smoother portions of the membrane where the crypts were shallower or almost absent; but in no case were the mouths of the glands specially localised in smooth circumscribed areas of the mucosa, as is the case in the Pig and in the Lemurs. The gland-orifices were directed obliquely to the plane of the free surface of the membrane; and it was not uncommon to see an epithelial plug projecting through the mouth.

Additional views of the relation of the glands to the crypts were Page 684. obtained by making vertical sections through the mucosa. This membrane consisted of a gland layer and a crypt layer. The gland layer was next the muscular coat, and consisted of elongated tubular glands, somewhat tortuous and occasionally bifurcating. In the vertical sections the glands were cut across so that the tubes were sometimes transversely, at others obliquely, at others longitudinally divided, and here and there the stem of a gland could be seen passing obliquely through the crypt-layer to open on the surface in the manner already described. The glands were lined by a columnar epithelium, and possessed a central lumen. The glands were neither so numerous nor so distinct, neither did they bifurcate so frequently as do the utricular glands in the Pig and the Cetacea.

The crypt layer contained the numerous depressions already referred to for the lodgment of the villi of the chorion. The epithelium lining the crypts had, as a rule, disappeared; so that it was only in exceptional localities that it could be seen *in situ*, where it appeared to consist of cells, the type form of which was columnar, though modifications of that shape occurred. The subepithelial connective tissue contained a large proportion of corpuscles, some of which were fusiform, others polygonal, others of the rounded form of white blood-corpuscles. This tissue was more compact where it formed the walls of the crypts; but deeper in the mucosa, as it approached the glandular layer and the muscular coat, it had an areolated character. The vessels of the uterus were not injected; but there can be no doubt that, if they had been so, the walls of the crypts would have been seen to contain an abundant freely anastomosing network of capillaries, such as exist in the corresponding crypts in the Cetacea, the Mare, the Pig, and the Lemurs. In sections through the wall of the uterus, that had been stained with hæmatoxylin, a well-defined band, coloured with the blue pigment, marked the junction of the deep surface of the mucous membrane and its glands with the muscular coat. This band in all probability was the muscularis mucosæ. In *Hyomoschus*, as in other animals possessing a diffused placenta, the uterine glands have no relation, as regards numbers or termination, to the crypts. The crypts are infinitely more numerous than the glands, and are not to be regarded as formed by dilatation of their mouths, but are new formations during pregnancy, due to hypertrophy and folding of the mucous membrane so as closely to adapt it to the irregular villous surface of the fœtal chorion.

The chorion extended from the tip of the left uterine cornu, through the corpus uteri, to the tip of the right uterine cornu. The left horn of the chorion, which contained the fœtus, was longer and much more capacious than the right horn. The tip of each horn of the chorion was in close relation to the orifice of each Fallopian tube; and close to the tip the free surface of the chorion was over a very limited area smooth and non-villous. That part of the chorion situated in the corpus uteri, immediately opposite the os uteri, presented a circular non-villous surface about the size of a shilling. This surface, though without villi, was folded so as to adapt it to the corresponding folds of the uterine mucosa in the same locality. A portion of the chorion corresponding to the more convex part of the gravid uterine **Page 685.** cornu was thinly covered with villi, and, indeed, in one or two very limited areas was non-villous—these bare or thinly covered patches being in contact with those portions of the uterine mucosa (already described) where the crypts are either shallow or absent. In all other localities the free surface of the chorion was as thickly studded with villi as the uterine mucosa was with crypts; so that it furnished an excellent and characteristic example of a diffused placenta. In the absence of villi from those parts of the chorion which were situated in relation to the three uterine orifices, *i.e.*, the os uteri and the two Fallopian tubes, the chorion of *Hyomoschus* corresponded with what one of us has elsewhere described in *Orca*, the Narwhal and the Mare.

The villi were arranged in small tufts, separated from each other by very narrow intervals. The tufts varied in size; and the villi of which they were composed were short and branched, usually in the form of filamentous processes. The basal substance of each villus and of the chorion itself consisted of a delicate corpusculated connective tissue. The epithelium on the free surface of the chorion was partly shed; but considerable patches of it were seen in many localities.

The amnion formed a capacious bag, which extended to within half an inch of the tip of the left horn of the chorion. It occupied the rest of this horn and the part of the chorion situated in the corpus uteri, but did not extend into the right horn of the chorion.

The sac of the allantois occupied the whole of the right horn of the chorion, extending as far as its tip; and its wall was in close apposition by its attached surface with the deep surface of the chorion. The sac of the allantois was also prolonged into the left horn of the chorion to within half an inch of its tip: but in other respects its distribution in this horn was limited; for instead of being in contact with the whole extent of the deep surface of the chorion, it formed only a circumscribed tubular prolongation attached to that part of the chorion which was opposite the belly of the fœtus. The remaining part of the deep surface of the chorion in this horn was in contact with the attached surface of the amnion, which membrane extended as far as the edge of the non-villous circular spot opposite the os uteri. The amnion was also prolonged over the tubular prolongation of the allantois which extended into this horn. The amnion enveloped the umbilical cord up to the abdominal wall of the fœtus. The amniotic investment of the cord was studded with numbers of small stunted whitish sessile corpuscles, which did not, however, project from the free surface of the amnion, where it was in contact with the chorion and allantois. These bodies resembled in form and size the bodies projecting from the umbilical cord in the Cetacea. They had not, however, the yellowish-brown colour of the corresponding corpuscles in *Orca* and the Narwhal, but like them they were developed in relation to the deep surface of the amnion and caused an elevation of that membrane by their growth.

The umbilical cord was 3¼ inches long. It contained two arteries and two veins; and a slender tubular prolongation of the sac of the Page 686. allantois could just be traced into the chorionic end of the cord. Some injection was passed into the vessels of the cord, which filled the principal vessels of the chorion; but as the specimen had been for some time in spirit before the injection was made, it did not enter the vessels of the villi. Slender vessels, however, traversed the non-villous spot opposite the os uteri, and some also were seen subjacent to the amnion where it was in contact with the wall of the tubular prolongation of the allantois situated in the left horn of the chorion.

EXPLANATION OF PLATE 29. (XLIV.)

Fig. 1. Fœta membranes of *Hyomoschus aquaticus*, opened into and fœtus removed; reduced from natural size. *Ch.* Villous chorion of the fœtal horn. *Ch*¹. Villous chorion of the opposite horn. *Al.* Sac of allantois in the non-fecundated cornu, the communication of which with the tubular prolongation in the fœtal horn is seen to the right of the letters. *Am.* Sac of the amnion; the letters are placed on the amnion where it is in contact with the chorion. *u.* The umbilical cord; the letter is placed on the amnion

where it is in contact with the allantois. *o.* The non-villous surface of the chorion opposite the os uteri. *s.s.* The smooth non-villous parts of the chorion in relation to the Fallopian tubes.

2. Magnified view of the free surface of the uterine mucous membrane of *Hyomoschus*, showing the crypts in which the villi of the chorion are lodged. At *a* the mouth of one of the uterine glands is shown.

The drawings have been kindly made for us by Mr. J. D. Dunlop.

77. NOTES ON THE ANATOMY OF *INDICATOR MAJOR*.*

Page 930. THROUGH the kindness of Mr. R. B. Sharpe I have had the opportunity of examining a spirit-preserved specimen of *Indicator major*, from Fantee, which enables me to lay before the Society some fresh facts in its anatomy confirmatory of its non-Cuculine affinities.

In his contributions to Orr's edition of Cuvier's "Animal Kingdom" (1840), the late Mr. E. Blyth referred the Honey-guides to the Woodpeckers as their nearest allies;† and this idea was expanded by him two years later in the Journal of the Asiatic Society of Bengal.‡ In "The Ibis" for 1870,§ Mr. Sclater brought forth fresh facts in proof of the non-Cuculine affinities of the genus, and proposed to place it next to the Capitonidæ, with which, or with the Coliidæ, Mr. Blanford also in the same year showed it had its nearest relationships.‖

The following observations tend to prove the correctness of the conclusions arrived at by the two last-mentioned ornithologists, and the error of imagining that *Indicator* is related to the Cuculidæ.

Page 931. *Pterylosis.*—This has been recorded by Nitzsch in his "Pterylography;" and it seems more than strange that the characteristically Picine distribution of its feather-tracts did not lead that able ornithologist to recognize its true relationships. He retained it among the Cuculidæ.

My study of Pterylography has led me to look upon the nature of the dorsal tract as all-important in determining to which great group of Birds, the Homalogonatæ or Anomalogonatæ,¶ any doubtful family belongs. When the dorsal tract develops a fork *between* the

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* "Proceedings of the Zoological Society," 1878, pp. 930–5. Read, Nov. 19, 1878.

† *Loc. cit.* p. 215.

‡ Vol. xi. p. 167, 1842.

§ p. 176.

‖ "Observations on the Geology and Zoology of Abyssinia," 1870, p. 308.

¶ *Vide* "Proceedings of the Zoological Society," 1874, p. 116, for definition of these terms. (*Suprà*, p. 213.)

shoulder-blades a bird is homalogonatus; when the tract runs on unenlarged to near the lower ends of the scapulæ, then it is anomalogonatous. Again, among the Anomalogonatæ, when the pectoral tract bifurcates into an outer and an inner branch just after commencing on the chest, then the bird is one of the Piciformes, and has a tufted oil-gland; when the pectoral tract does not bifurcate at all, or only at the lower end of its pectoral portion, but is only increased in breadth instead, then the bird is Passeriform,* and has a naked oil-gland. Exceptions to these rules scarcely exist.

In that the dorsal tract of *Indicator* does not form a fork, but remains narrow, between the shoulder-blades, it is anomalogonatus—the Cuculidæ being homalogonatous; in that it possesses a free outer pectoral band to the anterior tract, it is a Piciform bird. The oil-gland is also tufted.

A careful examination of the skin proves that the genus agrees more closely in its feather-tracts with the Picidæ, Capitonidæ, and Ramphastidæ than Nitzsch's figures would tend to prove. To me it is evident that there is a communication between the thoracic extremity of the inferior neck-tract and the upper extremity of the humeral tract, as in the Picidæ, Capitonidæ, and Ramphastidæ. Again, in the three groups just named there is a great weakness or an entire disappearance for a short distance of the dorsal tract towards the lower extremity of the interscapular region. In *Indicator* this same weakness exists; so that, with the exception of a single feather in the middle line, the appearance of the region in question is much more like the arrangement in *Ramphastos* than in Nitzsch's figure of the genus. On the ventral surface of the fleshy tail I find a median subcircular space surrounded by feathers, as in the Picidæ and Ramphastidæ, as well as in the Capitonidæ apparently. The caudal termination of the dorsal tract agrees with the account given by Nitzsch. I could find no trace of a duplication of the lumbar tract. In the possession of twelve rectrices *Indicator* differs from the Capitonidæ and Ramphastidæ, which have ten, like the Picidæ.

Skeleton.—The specimen of the skull of *Indicator* examined by Professor Huxley† at Mr. Sclater's request was too imperfect for exact description. The considerable interval between the maxillo-palatines is recorded by him. I am now able to add that the vomer Page 932. is but little different from that of the Capitonidæ. The palate of *Megalæma asiatica* is described and figured by Professor Parker in the "Transactions of the Linnean Society." ‡ It is truncated in front

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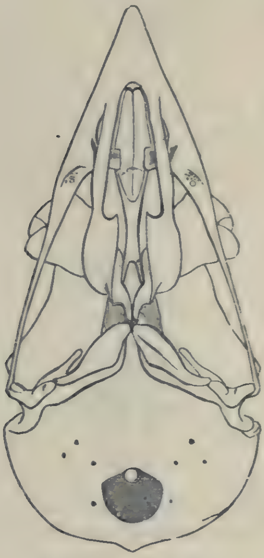
* *Vide* "Proceedings of the Zoological Society," 1874, p. 119. (*Suprà*, p. 217.)

† "Ibis," 1870, p. 179.

‡ 2nd series, "Zoology," vol. i. p. 122, and pl. xxiii.

and strongly bifid, the cornua running forward to blend with the maxillo-palatines. These last-named inward-directed processes of the maxillary bones blend with the mid-nasal septum in some specimens of *Megalæma asiatica*, whilst in others they remain free from one another, separated by an inconsiderable interval. In *Pogonorhynchus bidentatus* and *Tetragonops ramphastinus* they completely blend across the middle line, without the nasal median septum persisting in front of the junction. So these two last-named species, and most probably all the species of the genera, are genuinely desmognathous.

Fig. 3.



Palate of *Indicator*.

The point in which the truncated vomer of the Capitonidæ most differs from that of the order Passeres is that in the former the truncation occurs behind the line joining the posterior angles of the maxillo-palatines, whilst in the latter the truncation occurs some way in front of the same transverse line. The limbs of the forked vomer in the Capitonidæ run forward to meet the posterior angles of the maxillo-palatines; in the Passeres they continue, often in cartilage alone, to the nasal labyrinth.

In *Indicator* the vomer is less ossified than in the Capitonidæ above mentioned, and is smaller; the fork is slenderer and has longer limbs, which, however, quite typically join the well separated maxillo-palatines (which advance but slightly beyond the inner margins of the palatine bones) at their posterior angles. Page 933.

As the Ramphastidæ have to be mentioned so frequently in connexion with the genus under consideration, it may be useful to refer to the vomer of this family. By Prof. Huxley it is included among his Coccygomorphæ, in which the vomer, if present, is pointed anteriorly. Prof. Huxley further remarks[*] that in *Ramphastos* "the antero-internal angles of the palatines not only meet, but are united by bone." But close examination demonstrates *a large tabular truncation* of the anterior extremity in the Ramphastine vomer, which I cannot help thinking Prof. Huxley interpreted as a median osseous bridge formed by the (supposed) blending of the antero-internal angles of the palatines. Figure 2 represents the vomer of *Ramphastos ariel*, freed from its surroundings. It does not send forward limbs to join the maxillo-palatines [which are those of the desmognathous Capitonidæ inflated], but helps by its terminal expansion to complete, by contact or ankylosis with the palatine on either side, the posterior wall of a cavity in the dried skull, bounded laterally and superiorly by the inflated and infused maxillo-palatines, anteriorly by the nasal septum together with ossifications in the nasal cartilages associated with it.

Fig. 2.

Palatal aspect of the truncated vomer of *Ramphastos ariel*, with the posterior parts of the palatine bones retained in union with it.

In the "Transactions" of the Linnean Society[†] Prof. Parker describes the vomer of *Ramphastos toco* as double, it being composed of a smaller posterior and a larger anterior bone, the truncated nature of which I am not able to infer from the account given.

The Capitonidæ, the Ramphastidæ, and *Indicator* are intimately associated, therefore, so far as the vomer is concerned. Nevertheless the proportionally great length of the limbs of the vomerine fork in the last-named form, and the considerable separation of its small Page 934. maxillo-palatines, are characters which tend to bring it nearer than either of the others to the Picidæ.

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[*] "Proceedings of the Zoological Society," 1867, p. 444.

[†] "Linn. Trans." 2nd ser. vol. i. p. 127.

The pterygoid bones of *Indicator* are much flattened from above downwards, with thin outer and inner margins, which are curved, a triangular groove on the palatal surface running from end to end. In the Capitonidæ and Ramphastidæ these bones are much more cylindroid, the superior surface alone being thin-edged, whilst in the Picidæ they are thin, as in *Indicator*, but differ in possessing a large anteriorly directed process springing from the superior surface of each.

In *Indicator* there is a small notch in the middle of the superior margin of the osseous orbit, no trace of which exists in any of the other birds above referred to. In its external osseous nares, also, there is no tendency towards the Ramphastine position of those orifices, such as is so well marked in *Tetragonops;* the alinasal ossification that tends to divide each of the nares into an anterior and a posterior moiety is likewise far less considerable than in *Megalæma.*

As is known, and well illustrated in Mr. Sclater's figure of the bone ("Ibis," 1870, p. 178), the sternum agrees most closely with that of the Capitonidæ and Ramphastidæ; and this is especially the case in the imperfect development of the posterior extremity of the median xiphoid process, which in the Picidæ continues further onwards to reach the level of the ends of the lateral xiphoid processes, at the same time that the manubrial rostrum of the last-named family only of the group is bifid. As to the posterior sternal notches, the inner is the deeper; and the same is the case in *Gecinus viridis*, whilst in *Picus*, the Capitonidæ, and Ramphastidæ the outer is the deeper.

In its soft parts *Indicator* agrees with the Capitonidæ, Ramphastidæ, and Picidæ, and differs from the Cuculidæ, in the following particulars:—There is only one carotid artery, the left; the ambiens and the accessory femoro-caudal muscles are absent (the latter of these is wanting in the Tree-Cuckoos); there are no colic cæca. The femoro-caudal, semitendinosus and accessory semitendinosus are present, as is the large gluteus. The tensor patagii brevis muscle of the wing is inserted into the extensor metacarpi radialis longus exactly as in the Capitonidæ, Ramphastidæ and Picidæ, and as in no other birds.* As in these three groups also (and in the Galbulidæ, but not in the scansorial Cuculidæ and Psittaci), the deep plantar tendons are distributed peculiarly—the flexor profundus digitorum supplying the third digit only, whilst the flexor longus hallucis sends slips to digits I. II. and IV., as well as a vinculum to its companion muscle.† The trachea at its lower end (fig. 3, p. 464) consolidates

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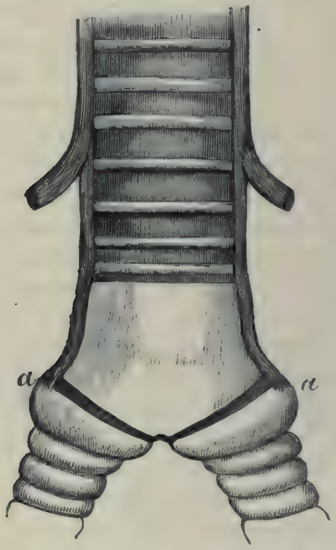
* *Vide* "Proceedings of the Zoological Society," 1876, p. 508, Pl. XLVIII, fig. 1. (*Suprà*, p. 356. pl. 21.)

† *Vide* "Proceedings of the Zoological Society," 1875, p. 346. (*Suprà*, p. 296.)

into a bony box, formed by the fusion of the lowermost rings. To the enlarged uppermost bronchial half-ring (*a a*) the single slender intrinsic muscle of each side fans out to be attached at its middle.

Summing up the results of the above analysis, it may be stated that, among the Piciform birds, pterylosis, osteology, myology, and Page 935. visceral anatomy place the Picidæ, *Indicator*, the Capitonidæ, and the Ramphastidæ in one great group of subordinal importance (if the peculiar hammer skull of the Picidæ be omitted from consideration). In this suborder the Picidæ constitute one main division—a family; whilst I, for one, cannot separate off the Capitonidæ from the Ramphastidæ by any well marked differences, the two subfamilies graduating into one another.

Fig. 3.



Syrinx of *Indicator major* (enlarged); anterior aspect.

Indicator must, in my opinion, also be placed in this family, from all members of which it differs in possessing an extra pair of rectrices. No one, however, objects to keeping all the Momotidæ together because of a similar difference in some of its genera; why remove *Indicator* therefore from its allies? Nevertheless *Indicator* is not exactly like a Capitonine bird in certain details, so may be placed as a subfamily by itself, the Indicatorinæ; and the whole series may be thus tabulated.

Order.	*Suborder.*	*Family.*	*Subfamily.*
Piciformes.	Pici.	Picidæ. Capitonidæ.	Indicatorinæ. Capitoninæ. Ramphastinæ.

78. NOTES ON POINTS IN THE ANATOMY OF THE HOATZIN (*OPISTHOCOMUS CRISTATUS*).*

Professor Newton having most kindly placed in my hands for dissection Page 109. three specimens of *Opisthocomus cristatus* preserved in spirit, I am able to add a few details to the accounts which have already appeared on the structure of this peculiar bird.

In his valuable paper in this Society's 'Proceedings,†' "On the Classification and Distribution of the Alectoromorphæ and Heteromorphæ," Professor Huxley describes in detail the skeleton of Page 110. *Opisthocomus*, concluding, as the result of his study of the bird, that it should constitute a group (the Heteromorphæ) by itself, which sprang direct from the main stem of Carinate descent, later than the Tinamomorphæ, Turnicomorphæ, and Charadriomorphæ, but before the Gallinaceous birds, Sand-Grouse, and Pigeons were developed.

Since then, in our "Transactions,"‡ Mr. J. B. Perrin has published a myological account of the species, in which he, however, compares it with few other birds. One of Mr. Perrin's figures§ very excellently represents the form and situation of the immense crop, as well as the situation, in the unfleshed bird, of the expanded margin of the short carina sterni, from which an accidental error made by Nitzsch, who evidently had an imperfect skin to work upon, may be corrected. Nitzsch, in his "Pterylography," figures (and the drawing is reproduced Page 111. in Mr. Perrin's memoir), the outline of the furcula and sternum, and does it as if the bird were not peculiar in the pectoral region. But as the crop occupies almost all the upper part of the breast, and by its magnitude distorts the furcula and sternum, the outline is quite incorrect. What is more, there is in the bird itself an oval area, about ·75 inch long from above downwards, and ·25 inch in breadth, of dense naked skin, covering the surface of the expanded upper cutaneous surface of the carina sterni. This is omitted in the drawing. The area surrounding this is unfeathered, although I find well-developed plumes *in the middle line* above it, and no trace of any longitudinal median space of any kind over the surface of the crop or neck.

Opisthocomus is one of those birds in which the pterylosis is not

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* "Proceedings of the Zoological Society," 1879, pp. 109–14. Read, Febr. 4, 1879.

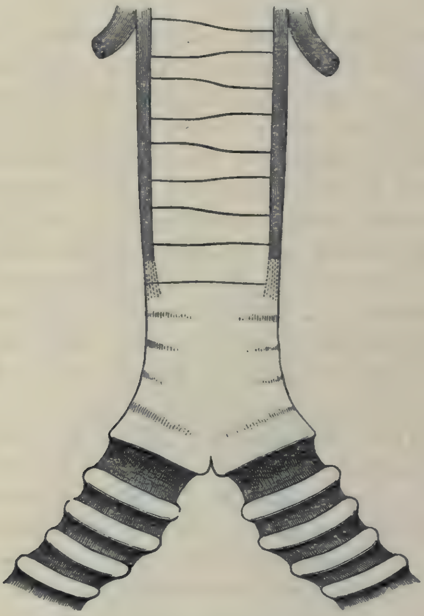
† "Proceedings of the Zoological Society," 1868, p. 294.

‡ "Transactions of the Zoological Society," vol. IX. p. 353.

§ *Loc. cit.* pl. lxiii. fig. 3.

so decisive of its affinities as in many cases, the reason being that so great an amount of the unfeathered spaces is protected by semiplumes. May not these semiplumes in many instances be degenerated feathers? This question has never been decided, so far as I am aware.

Fig. 1.



Trachea of *Opisthocomus* (front view).

To our knowledge of the osteology of the Hoatzin I have no fresh
Page 112. facts to add. I may, however, mention that it is only in the Cracidæ, among allied birds, that the vomer runs so far forward in the palate at the same time that it is tumefied at its anterior extremity. In *Ortalis albiventris* this is most strikingly the case.

The alimentary canal has been so fully described by L'Herminier,[*] that it is quite unnecessary for me to enter into detail with reference to it.

Johannes Müller[†] has noted one or two points concerning the windpipe. Figs. 1 and 2 represent its anterior and posterior aspects. The lowermost four tracheal rings are consolidated together, and

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[*] "Comptes Rendus de l' Acad. des Sciences," 1837, vol. v. p. 435.

[†] "Berichte Akad. d. Wissenschaft. z. Berlin," 1841, p. 177.

the first pair of bronchial semirings with them, to form a box-like three-way piece, the pessulus posteriorly running up to join the middle of the penultimate ring. The second pair of bronchial semirings does not articulate with the first, they in all respects resembling those nearer the lungs.

Fig. 2.

Trachea of *Opisthocomus* (back view).

It is possible that what is above considered to be the first pair of bronchial semirings may be the last tracheal ring. That there is a small notch interrupting the continuity of the inferior mid-anterior margin of the tube formed by the consolidated rings, and that the ring above the lowest segment of the consolidated tube is incomplete behind, are, however, facts in favour of the former view.

Among the Gallinæ the only genera which at all approach *Opisthocomus*, as far as the lower larynx is concerned, are those of the Megapodidæ.

The two carotid arteries of *Opisthocomus*, where they meet in the front of the neck, become bound together much more intimately than in most birds, although at the part where it is impossible to dissect away the one vessel from the other, a cross section proves that the two tubes are still quite separate.

Myologically, the great gluteus (tensor fasciæ of my earlier papers) completely covers the biceps cruris superficially. The fifth gluteus, which runs from the ilium a short distance behind the acetabulum, and covers with its triangular tendon the trochanter of the femur, is present, but small. The semitendinosus and its accessorius are both large, as are the femoro-caudal and its accessorius. The myological formula,* as far as these muscles are concerned, is therefore AB. XY. The ambiens muscle is present and small; but its slender tendon, in every case but one of the six knees I have examined, is lost upon the capsule of the front of the knee. In the one instance it traversed the fibrous tissues of the quadratus-tendon, as in other birds where it is present, to join the digital flexors in the back of the leg. A similar imperfection in the development of the ambiens is sometimes found in *Sula bassana*, *Stringops habroptilus*, and in the species of the genus *Œdicnemus.* The obturator internus is triangular in shape, as in the Gallinæ.

In the deep tendons of the foot, the flexor hallucis longus sends a Page 113. strong vinculum downwards to that of the flexor digitorum profundus before it runs on to supply the hallux itself.† The determination of this point the late Prof. C. J. Sundevall much desired,‡ as in the only specimen he had the opportunity of examining, and that imperfectly, the apparent absence of the vinculum favoured its Passerine affinities. As, however, is stated above, the vinculum is present and large in the individuals dissected by myself.

In the upper limb, the great pectoral muscle is much reduced at its furcular and manubrial origins, over which the crop is placed. It is thicker lower down. The fibres of the second pectoral descend as far as the lower margin of the sternum; and there is a small third pectoral covered by it, as in all Gallinæ, although in *Opisthocomus* it is reduced in size. The biceps humeri muscle sends a peculiarly large fasciculus to the tendon of the tensor patagii longus, which reaches it opposite the middle of the patagium.§ This slip I never find developed in the Cracidæ; but it is present in the closely allied Megapodidæ, and in all the other Gallinaceous birds.

The above-mentioned myological facts throw some light on the affinities of *Opisthocomus.* The presence of two carotid arteries, an ambiens muscle, an accessory femoro-caudal, and a deep plantar vinculum place its non-passerine nature beyond a doubt. Adding the tufted oil-gland and the inch-long colic cæca, the bird could only be

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* *Vide* "Proceedings of the Zoological Society," 1874, p. 111. (*Suprà*, p. 208.)

† *Vide* "Proceedings of the Zoological Society," 1875, p. 341. (*Suprà*, p. 290.)

‡ "Methodi Naturalis Avium disponendarum Tantamen." Stockholm, 1873, p. 156.

§ *Vide* "Proceedings of the Zoological Society," 1876, pp. 195, 199. (*Suprà*, pp. 324, 329.)

related to the Tinamidæ, Gallinæ, or Rallidæ, from which it will be remembered the Cuculidæ differ in that they lack the oil-gland tuft, and the Musophagidæ in that they have no colic cæca. *Opisthocomus* being holorhinal,* can have nothing to do with the Charadriiform birds. In the Rallidæ there is only a single posterior notch on each side of the carina sterni, at the same time that a crop is never developed. These features, when correlated with the peculiarities of the palate, remove them from the necessity of further consideration.

Opisthocomus must therefore, from what has been just shown, be a Gallinaceous bird, or form a group by itself. As there is *no* Gallinaceous bird without a direct articulation between the pterygoid bones and the basisphenoidal rostrum, it is hardly possible to include the Hoatzin along with them; and yet it resembles them most closely, as it does the Cuculidæ, in the length of its colic cæca and the number of its rectrices. It is not far removed from the Musophagidæ as well. All these facts can be expressed as follows:—

Page 114.

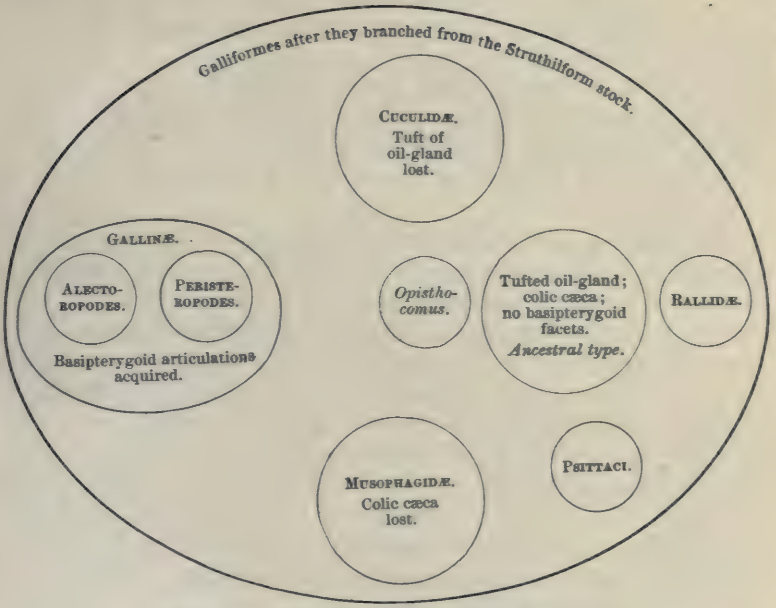

Diagram to show the position of *Opisthocomus.*

This diagram indicates that the Galliform ancestor, besides giving rise to the at this moment irrelevant Rallidæ and Psittaci, varied also in a strictly Gallinaceous direction, the ancestor of *Opisthocomus*

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* "Proceedings of the Zoological Society," 1873, p. 33. (*Suprà*, p. 124.)

leaving the parent stem very shortly before the true Gallinæ first appeared, and at about the same time as the independent pedigree of the Cuculidæ and Musophagidæ commenced. That the Musophagidæ and the Cuculidæ are very closely related to the Gallinæ is proved by facts brought forward by me in an earlier paper;* and the anatomy of the Hoatzin seems to still further favour this hypothesis, by showing that there exists a bird which helps to fill the gaps between them.

79. NOTES ON THE VISCERAL ANATOMY OF THE TUPAIA OF BURMAH (*TUPAIA BELANGERI*).†

Page 301. On February 8th, 1875, the Society received as a present from the Hon. Ashley Eden, C.S.I., a male Burmese specimen of *Tupaia belangeri*, which died, without any perceptible organic lesion, on December 18th, 1876.

Not much is known of the anatomy of the Tupaiidæ, the most important account of the viscera with which I am acquainted being that by Dr. Cantor on *Tupaia ferruginea*.‡

Subjoined are the notes on the anatomy of the Society's specimen of *T. belangeri*.

The parotid and submaxillary glands are of about equal size, flattened and subcircular, a little less than half an inch in diameter, the duct of the former coursing superficially near the lower border of
Page 302. the powerful masseter muscle. The duct of the latter opens by the side of its companion, at the tip of a small and slender pointed papilla situated just behind the symphysis of the lower jaw. The sublingual glands form a linear chain along the floor of the mouth.

The tongue, which is rounded at its tip, is 1·3 inch in length and ·35 inch broad, having its margins nearly parallel. Its upper surface is covered with filiform papillæ, among which are scattered papillæ fungiformes, very much in the same proportion as in the Ruminantia. There are three conspicuous circumvallate papillæ, arranged in the usual V-shaped manner.

A rudimentary unfringed sublingua exists, which is lanceolate in contour, just free at its margins, and with a strongly marked median

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* "Proceedings of the Zoological Society," 1874, p. 121. (*Suprà*, p. 220.)

† "Proceedings of the Zoological Society," 1879, pp. 301–5. Read, March 18, 1879.

‡ "Journ. Asiatic Soc. of Bengal," vol. xv. 1846, p. 189.

raphé. It much resembles the same structure in *Cheiromys*.* Dr. Cantor says of the same organ in *Tupaia ferruginea*† that "on the lower surface of the tongue the frænum is continued to within a short distance of the apex, in a raised line, on either side of which the skin is thickened, fringed at the edges, and thus presenting a rudimentary sublingual appendage, somewhat similar to that observed in *Nycticebus tardigradus*, though in *Tupaia ferruginea* the fringes of the margin only are free, the rest being attached to the tongue, but easily detached by a knife."

The palate is transversely grooved, presenting upon its surface seven strong curved ridges, convex forward, and a small median incisor pad at its anterior end. The soft palate is smooth and lengthy, with no indication of the existence of a uvula.

The œsophagus has no free course in the abdominal cavity, being embraced by the diaphragm quite close to the cardiac orifice of the stomach.

The stomach is subglobose, with the cardiac and pyloric extremities approximate. When laid out flat its circumference is 6·2 inches, the interval between the axis of the œsophageal tube and that of the commencing duodenum being 0·9 inch. The squamous epithelium of the œsophagus does not enter the stomach, but ceases at its orifice, as in man. The gastric walls are simple, except that there are somewhat larger glands, in patches, on the anterior (ventral) surface.

The liver has no umbilical fissure, whilst both lateral fissures are strongly marked. There is a cystic fissure, at the bottom of which the fundus of the gall-bladder reaches the diaphragmatic surface of the organ. The *left lateral*, with its irregular inner margin, is the largest of the lobes; next comes the *right central*, on the visceral surface of which the imbedded gall-bladder lies diagonally. The *right lateral* lobe is slightly larger than the left central, and the caudate lobe is but little smaller, whilst the Spigelian is a small subcircular mass of hepatic tissue supported on a very slender stem. The bile and pancreatic ducts open together into the duodenum half an inch from the pylorus.

The walls of the intestines are thin. The small intestine is 29·25 inches in length, and 0·8 inch in circumference. The large intestine Page 303. measures just over 3 inches, the conical and blunt-tipped cæcum not exceeding 0·7 inch in length. In Dr. Cantor's specimen of *Tupaia ferruginea* the small intestine is longer, reaching 40 inches. The mesenteric arteries form loops before they finally distribute.

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* Owen, "Transactions of the Zoological Society," vol. V. Pl. XXIV. figs. 8 & 9.

† "Journ. Asiatic Soc. Bengal," 1846, p. 189, vol. xv.

The kidneys are smooth, with a single calyx. The testes appear large proportionately, the particularly big epididymis alone descending into the rudimentary scrotum. The prostate is bilobed, Cowper's glands being of fair size. The glans penis is elongately filiformly conical, and terminally a little blunted.

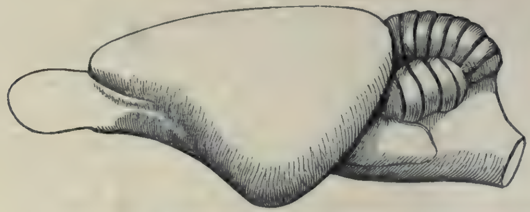
The aortic arch divides as in man, giving off a right innominate, a left carotid, and a left subclavian. There are two independent innominate veins, right and left.

The lungs are deeply divided into three main lobes on each side, whilst on the right the extra azygos triangular lobe is also found, not so large as any of the others.

Through the kindness of our President, I have had the opportunity of dissecting a female specimen of *Tupaia tana*, where there is a feebly developed sublingua, a less globose stomach, a lengthy thin-walled small intestine, *no trace of a cæcum*, and a thick-walled large intestine 3·25 inches long, quite easily distinguishable as such. The caudate lobe of the liver is much larger proportionately than in *T. belangeri*. In that there is no umbilical fissure, whilst that of the gall-bladder is very deep, the two species agree.

Dr. Günther has also permitted me to eviscerate a Bornean specimen of *Tupaia splendidula* in the National Collection. Its liver is constructed on a plan identical with that of the two other species, the left lateral lobe being much the largest, the umbilical fissure nearly obsolete, the cystic fissure deep, and the Spigelian lobe bifid. The caudate lobe, however, is long and narrow. The colon was very much distended, and with it the cæcum, so that the ileo-cæcal valve appeared to be situated at the side of the dilated colon, near to the blind extremity. If there had been no enlargement I should infer, from inspection, that the cæcum is normally less than half an inch in length.

Fig. 1.



Brain of *Tupaia belangeri*; lateral aspect.

The brain of *Tupaia belangeri* is smooth on its surface, and other-
Page 304. wise much resembles that of *Solenodon*,* *Rhynchocyon*, *Petrodromus*,

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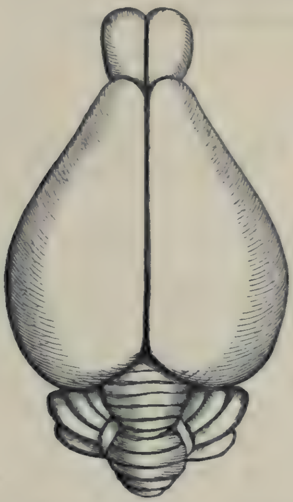
* "Ueber die Säugethiergattung *Solenodon*," pl. ii., "Abhandlungen der k. Akad. der Wiss. zu Berlin."

and *Macroscelides*, as figured by Dr. Peters.* It is broadest a little behind its middle, from which it narrows gradually in front, more rapidly behind, so as to be pyriform in general outline when seen from above. No trace of any convolutions can be detected. The olfactory lobes are considerable in size, longer than broad. Each hemisphere is very slightly convex from before backwards, its outline forming the base of the triangular side view of the organ, the two other sides of which are of nearly equal length, so that its deepest part is at about its middle.

Fig. 2.



Brain of *Tupaia belangeri;* superior aspect.

Fig. 3.

Brain of *Tupaia belangeri;* mid-longitudinal section.

The corpus callosum is thin and nearly straight. It continues forward to within one-sixth of the length of the hemisphere from its

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* "Reise nach Mossambique," 1852, pl. xxiv. figs. 10, 12, 13.

Page 305. anterior margin. The corpora quadrigemina are large, especially in front.

The cerebellum is just overlapped at its anterior border by the back of the cerebral hemispheres; otherwise it is quite posterior.

The several lemurine resemblances of *Tupaia* make the simplicity of the cerebral surface somewhat surprising.

80. NOTES ON THE ANATOMY OF *HELICTIS SUBAURANTIACA*.*

(Plate XXX.)

Page 305. A SPECIMEN of *Helictis subaurantiaca*, from China, purchased by the Society on Nov. 26, 1874,† having died on Nov. 29, 1878, I take the present opportunity of recording some of the most important facts in its visceral anatomy, more on account of the rarity of the animal in this country, than because it presents peculiarities of any kind.

It may first be noticed that the skins of this species collected by Mr. Swinhoe, and now in the national collection, seem to have faded much in their underparts, which, quite in opposition to that naturalist's original account of his species, are a pure white. It may further be mentioned that *Helictis* is extremely Badger-like in its proportions, gait, and odour.

On comparing the skull of the Society's specimen with the small collection of skulls of the genus in the national collection, I found no small difficulty in detecting any intimate resemblance to any. In most of its measurements it agrees exactly with those of *H. moschata*, as recorded by Dr. Gray.‡

In the Society's specimen the skull retained no trace of any sutures, and the lower jaw was considerably diseased, apparently in association with decay of the teeth. I hardly think, however, that extreme old age will account for the peculiarities of the individual under consideration. It differs from other specimens of *H. moschata* and *H. subaurantiaca*, and much more resembles *H. nipalensis* and *H. orientalis*, in that its zygoma is massive, the premaxillary region short as well as comparatively broad, and the mid-parietal area between the upper margins of the temporal muscular origins decidedly broad. The pre-

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* "Proceedings of the Zoological Society," 1879, pp. 305–7. Pl. XXIX. Read, March 18, 1879.

† *Vide* "Proceedings of the Zoological Society," 1874, p. 666.

‡ Catalogue of Carnivorous, Pachydermatous, and Edentate Mammalia in the British Museum, 1869, p. 143.

molar and molar teeth are heavier than in *H. moschata* and *H. subaurantiaca*, lighter than in *H. nipalensis* and *H. orientalis*, with the two former of which species it most agrees in the size of the zygomatic foramen, with the two latter in its situation.

The following were the measurements taken a few hours after death :— Page 306.

	inches.
Tip of nose to base of tail................	14·25
Tail................................	6·9
Ear................................	1·4
Tip of nose to occipital ridge	3·8

Sex, female.

The two pairs of inguinal nipples are widely separate, forming the four corners of a square.

The clavicles are reduced, each ·3 inch long, the scapular extremities remaining.

The tongue is covered with small, similar, retroverted filiform papillæ, with a fair scattering of fungiformes. The papillæ circumvallatæ, two on the left, three on the right, and one in the angle, form the usual V.

The right lung has four lobes, one being the azygos. On the left side there only two lobes.

The stomach is exactly like that of *Arctictis binturong* (as figured by me*) and nearly all Carnivora when contracted. The small intestine is seven feet in length, the large intestine six inches and three quarters. There is no cæcum; but an abrupt change in the nature of the mucous membrane from thin and villous to thick and smooth indicates the junction of the tubes.

The liver conforms completely to the carnivorous type, the right central lobe being largest, with a deep cystic fissure, and a gall-bladder so deeply imbedded that its fundus is seen on the diaphragmatic surface of the organs. The left lateral lobe comes next in size, the right central, and then the caudate following, after which the left central lobe, and the small Spigelian last.

The pancreas is seven inches in length, its left terminal two inches being in relation with the narrow spleen (two and three quarters inches in length).

There is a pair of pea-sized anal glands, opening into the rectum near the sphincter, in a linear transverse orifice on either side.

The uterus is strongly bicorn; the vulva much enlarged, with a well developed gland on each side of the orifice of the meatus urinarius.

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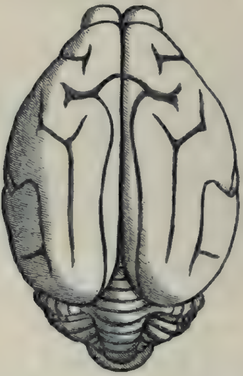
* "Proceedings of the Zoological Society," 1873, p. 198. (*Suprà*, p. 154.)

The brain conforms to the Musteline Carnivorous type, not to that of most of the Arctoidea. In Prof. Flower's excellently concise definitions of the three different arrangements of the cerebral convolutions in the Carnivora,* he tells us that "in the *Arctoidea* the fissure of Sylvius is rather long, and slopes backwards; the inferior gyrus has the limbs long, corresponding with the length of the Sylvian fissure, the anterior rather narrower than the posterior (especially in the true Bears); the middle gyrus is moderate and equal-limbed, the upper one large, very broad in front, and distinctly marked off from the second Page 307. posteriorly as far as near the lower border of the temporal lobe (‡). The crucial fissure is long and oblique, and situated further back than usual." In the footnote (‡) we read, "Except in the smaller numbers of the genus *Mustela*, where the sulcus separating the superior from the middle gyrus is less produced posteriorly than in others of the group. In *Galictis vittata*, however, the brain is quite a miniature of that of a Bear; but the middle convolution is united with the upper one at its superior anterior angle."

Fig. 1.



Brain of *Helictis subaurantiaca;* superior aspect.

Fig. 2.

Brain of *Helictis subaurantiaca;* lateral aspect.

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* "Proceedings of the Zoological Society," 1869, p. 482.

In *Helictis*, as also in *Ictonyx zorilla*, the superior gyrus ceases at the superior posterior angle of the hemisphere, as in *Mustela*. The anterior limb of the inferior gyrus is extremely narrow, especially near its upper end, where it becomes almost hidden by the corresponding part of the posterior limb of the same gyrus. A small sulcus tends to divide the transverse part of the middle gyrus from its posterior limb.

Most peculiarly, in *Helictis* there is no crucial fissure, *because the hippocampal gyrus appears upon the superior aspect of the brain.* This is the case in no other carnivorous animal with which I am acquainted, but occurs in *Moschus*, *Cervus pudu*, and other smaller Ruminantia.

81. ON THE CONFORMATION OF THE THORACIC EXTREMITY OF THE TRACHEA IN THE CLASS AVES. PART I. THE GALLINÆ.*

INSPECTION of the windpipes of several species of allied birds makes it evident that the bifurcation of that tube to form the bronchi is brought about in different ways in almost every case, by various alterations of greater or less degree in the proportionate development of the several rings and semirings entering into the composition of the organ. In the case of the non-oscinine Passeres, Johannes Müller has proved the great importance of the study of the "lower larynx" or syrinx in the determination of the affinities of the species. In the present communication it is my desire to continue his line of investigation to other families of the class, laying more stress on the cartilaginous structures, and less on the muscles moving them. Opportunities are specially in favour of my studying the Gallinæ at the present time; therefore this first fasciculus is an account of the bifurcating windpipe in those species of the Order which it has been my good fortune to examine. Page 354.

By C. J. Temminck, in his valuable "Histoire Naturelle Générale des Pigeons et des Gallinacés",† several of the windpipes of the Gallinæ are figured. These will be mentioned when the respective species are discussed.

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* "Proceedings of the Zoological Society," 1879, pp. 354–80. Read, April 1, 1879.

† Amsterdam, 2 vols., 1813 and 1815.

It is in the Peafowl that the thoracic terminations of the trachea is less complicated, as far as my experience goes, than in any other Gallinaceous bird; and the arrangement is so simple that it is not easy to imagine one much more so.*

In the chick (a month old) of *Pavo spicifer* (figs. 1, 2) the antepenultimate tracheal ring is free, and agrees with those above it in that the interannular intervals are reduced to a minimum, at the same time Page 355. that anteriorly it is slightly bent downwards in the middle line, to assist in the changes of form connected with the bifurcation of the tube. The penultimate ring, from its position, is more pronounced in this respect, whilst posteriorly the pessulus runs up to blend with it, not at its inferior margin, but by a wedge-shaped cartilaginous expansion, the apex of which touches the lower margin of the ring above. That this is so is proved by the existence of two oblique indented lines, one on each side, converging superiorly, where they nearly meet to form the apex of the just-mentioned wedge. The last tracheal ring anteriorly sends down an obtuse median process, the inferior margin of which constitutes the summit of the notch between the divaricating bronchi, whilst its posterior surface forms the anterior attachment of the pessulus. Posteriorly this ring is incomplete, the two obliquely truncated ends being separated by a considerable interval occupied by the pessulus in the middle line, and laterally by the commencement of the membranous inner walls of the bronchi.

Fig. 1.

Front view.

Fig. 2.

Back view.

Pavo spicifer (adult).

N.B.—This and all the subsequent diagrams are drawn to one scale, and have no relation to the actual size of the structures.

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* *Vide* Temminck, *loc. cit.* pl. i. fig. 2.

In the middle of the upper border of the penultimate ring anteriorly a white line is seen sending a limb down on either side, beyond the ring itself, on to the next, at the lower margin of which it ceases at the root of the obtuse median process. Such an appearance indicates that in the older bird fusion of the two rings will occur at the spot, as an inspection of the part in the adult verifies. From the above description it will be also seen that the pessulus—a slender cylindroid bar, expanded and flattened at each end—is anteriorly attached to the last, and posteriorly to the penultimate ring of the trachea. The last tracheal ring, it must not be forgotten, is incomplete behind.

Page 356.

The first bronchial semiring—for in no Gallinaceous birds are any of the bronchial rings complete—articulates at both its extremities with the last tracheal, anteriorly along the side of the oblique median process, posteriorly with the lower angle of its square-cut termination. Both ends are slightly expanded and obliquely truncated, their acute upper angles being their articulating spots. The lower margin of the last tracheal ring being concave downwards and slightly uptipped laterally, whilst the first bronchial semiring descends slightly from its attachments outwards, a considerable membranous interannular interval is left. The second bronchial semiring is simple, free, and slightly expanded posteriorly. In front the third was bifurcated in both bronchi, on one side each branch being further subdivided. The depth of the bronchial interannular membranes is about the same as that of the semirings themselves.

Between the membranous inner wall of one bronchial tube and the same part of the other there is a dense fibrous band of union, a short distance below the bifurcation of the windpipe, and generally on the level of the two or three semirings below the second. This band is, I believe, always to be found in birds (it will be termed the *bronchidesmus* in this communication) developed to a greater or less extent. Being of fibrous tissue and connected with the membranes of the neighbourhood, anatomists have removed it whilst dissecting the organ for examination. Its importance, however, is more considerable than might be at first imagined; and I only regret that in many of the subjoined descriptions I took no note of it. In birds like the Tetraonidæ the bronchidesmus is so strong that it cannot escape special observation.

The adult female presents no modifications of importance. The penultimate and last tracheal rings are relatively a little smaller and have blended in front in the middle line, whilst all trace is lost of the shape of the posterior termination of the pessulus. The articulating surfaces of the first bronchial semiring have become slightly more considerable.

The adult (male) *P. nigripennis* differs in that the antepenultimate tracheal ring blends anteriorly with the penultimate, at the same time that there is a greater fusion between the penultimate and last rings, all three apparently blending behind as well. The interannular interval between the last tracheal ring and the first bronchial semiring is reduced to little more than a line, and the bronchial interannular intervals are very small.

It is to be specially noted that in the genus *Pavo* the second bronchial semiring, by not articulating with the one above it at either end, does not participate in the formation of the specialized lower larynx. This is a feature indicating non-elaboration of the organ. No other Gallinaceous bird with which I am acquainted resembles *Pavo* in this respect.

In *Caccabis rufa* the thoracic extremity of the trachea is perfectly
Page 357. simple, and all the rings are in contact with those contiguous to them throughout their circumference. The lower margin of the penultimate ring faces slightly outwards on either side, whilst in the middle line in front it fuses with the ring below it, a well-defined semiellipsoid ossification developing in the region, upwards as far as the upper margin of the penultimate ring, and downwards to the median point of bifurcation of the last ring, from which it extends laterally a short distance. The pessulus is attached as in *Pavo*. It is ossified, the anterior termination being the ossification just described; the posterior is a triangular extension into the middle of the posterior surface of the penultimate ring, the apex of which reaches its superior margin. The first bronchial semiring is concave upwards, and in front forms a

Fig. 3.

Front view.

Fig. 4.

Back view.

Caccabis rufa.

sharp inturned angular process at the spot where it articulates with the anterior extremity of the second semiring. Posteriorly its articular upward-directed process is more developed—so much so that the contour line of the posterior extremity of the last tracheal is continuous with that of the ring under consideration and the next as well. The second bronchial semiring differs but little from those which follow it, except in that it articulates with the one above. Its extremities are somewhat more expanded, and articulate freely with the angles of the first ring. Anteriorly it sends inwards a pointed angular process, which advances further towards the middle line than does the similar angle of the semiring above, with which it closely articulates. The semirings which follow have also pointed anterior ends, running **Page 358.** inwards almost as much as does the second, in a manner very characteristic of all the genera in which the second semiring is pointed and prolonged. There is no trace of any interval between the penultimate and last tracheal rings. Between the last and the first bronchial semiring the interval is a capacious ovoid. That between the first and second bronchial semirings is elongate and shallow, not deeper than the lower bronchial intervals. *Caccabis saxatilis* agrees with *C. rufa*, except that in the former there is a slight development of anterolateral interannular intervals between the lower tracheal rings, as in *Argus*, the account of which follows.

In *Argus giganteus* the lowermost tracheal rings are separated by narrow intervals in front, where in the middle line the last three fuse

Fig. 5.

Front view.

Fig. 6.

Back view.

Argus giganteus.

and ossify into a mass whose lower border descends but little below the level of the inferior margin of the unmodified last ring for the articulation of the anterior extremities of the first bronchial semirings. Posteriorly the pessulus joins the penultimate ring, the two hinder ends of the last ring being well separated. The first bronchial semiring is large and strongly convex downwards from the development at each of its ends of upturned articulating processes, at the junction of which with the horizontal portion of the tube the second semiring articulates along its lower border. The interval between each lateral element of the last tracheal ring and its corresponding first bronchial semiring is considerable, tending to a quadrate form, whilst
Page 359. that between the first and second semiring is much narrower and meniscoid. The second semiring itself is strongly convex downwards, articulating behind by its extreme end with the ring above, but in front continuing onwards as a triangle beyond the articular point into the internal bronchial membrane a short distance. The anterior terminations of the few lower bronchial semirings are similarly pointed; and posteriorly they run inwards (especially the fourth and fifth) considerably more than do semirings one and two.

Polyplectron chinquis so closely resembles *Argus* in all respects that no description of it is needed. The first and second bronchial semirings are proportionately a little stronger; the antepenultimate tracheal ring does not actually fuse with the penultimate, and in one specimen the pessulus, instead of blending with the penultimate ring behind, runs upwards cuneately between the separated ends of that ring to touch the lower margin of the antepenultimate ring. From this and other facts pointing in the same direction, to be mentioned subsequently, it may, with much probability, be inferred that this arrangement just mentioned is the typical one, consolidation of the pessulus with the posterior extremities of the penultimate tracheal ring having occurred in those cases where, among the Gallinæ, that bar is found connected with it.

In *Ithaginis geoffroii* (♂ adult) there is a transversely fusiform median interannular interval between the lower tracheal rings anteriorly, entirely absent behind. The antepenultimate and penultimate rings are slightly separated throughout, most at the sides, whilst between the penultimate and last rings—fusing though they do in the middle line anteriorly—there is a slight elongated oblong interval on either side of the fused isthmus, extending outwards as far as the lateral margin of the tube, but not further backwards. The pessulus gives no indication of separation from the penultimate tracheal ring posteriorly, whilst anteriorly it springs from the last ring, between which and the first bronchial semiring there is a considerable interval. This semiring is somewhat squared, sending up processes (an anterior and a posterior) of no great length to articulate with the last tracheal ring, the second semiring (scarcely differing from the third) just touching its two angles sufficiently for it to be said that it does articulate with it. In this species the lateral sterno-tracheal muscle terminates inferiorly in a peculiar manner. It is constituted of two parts, an outer and an inner. Of the inner, which is also divided below into two, the median portion ceases at the twelfth ring from the bifurcation, opposite which spot its outer moiety sends downwards a special thin extra broad fasciculus to join the undivided outer main element of the muscle just before it leaves the windpipe, opposite its antepenultimate ring. The nerve to these lower fibres is not small; and from being superficial—resting as it does on the muscles under consideration as they descend—it disappears behind the special fasciculus above described at the spot where that begins to run inwards towards its fellow, which it does not meet.

In *Lophortyx californicus* (adult male) there are no interannular intervals on the posterior aspect of the intrathoracic portion of the Page 360.

Fig. 7.

Front view.

Fig. 8.

Back view.

Lophortyx californicus.

windpipe [as in so many of the birds under consideration, and dependent, no doubt, upon the proximity of the œsophagus]; but anteriorly the lowermost twelve rings are thinned in such a way that the intervals are uniform and deeper than the rings forming them, at the same time that their breadth is half the circumference of the tube itself, they continuing across the middle line, except in the case of the lowermost three, which are divided up by median junctions of the rings, narrow and not fused between the antepenultimate and the one above it, broad and blended in the two below it. There is a narrow medio-anterior vertical fibrous bond between all the upper thinned rings, taking the place of the lower cartilaginous isthmuses. Posteriorly the penultimate and antepenultimate rings blend in the middle line, the pessulus joining the former in the usual manner. The last ring is typical and incomplete behind. The first bronchial semiring is large Page 361. and concave upwards. It develops a considerable angle on its convex border in front, at the spot where the next semiring meets it. Behind it is peculiar from its inconsiderable thickness, it meeting the corresponding extremity of the last tracheal ring for some distance, opposite which part it is so narrow that the expanded hinder end of the second semiring does not manage to reach it, and remains separated by a small interval. The second semiring meets it in front, and sends inwards beyond the articulating spot a pointed process of some length. The lower bronchial rings are similarly pointed and prolonged in front.

The bronchidesmus is powerful, at the same time that its posterior margin is the place of insertion of the pair of contiguous powerful muscles that runs down the back of the windpipe, and spreads laterally so much as to be just seen in the anterior view of the organ.

The windpipe of *Oreortyx pictus* differs in detail from that of the bird just described. The penultimate and last rings of the trachea blend in the mid-anterior and posterior line; whilst behind the antepenultimate does so also, articulating in front. The next four rings anteriorly are lozenge-shaped in the middle line, the six above which are uniformly thinned; but the intervals between them are much less considerable than in *Lophortyx californicus*. Posteriorly there are no interannular intervals at all. The bronchial semirings, the posterior muscles, and the bronchidesmus are as in *Lophortyx*.

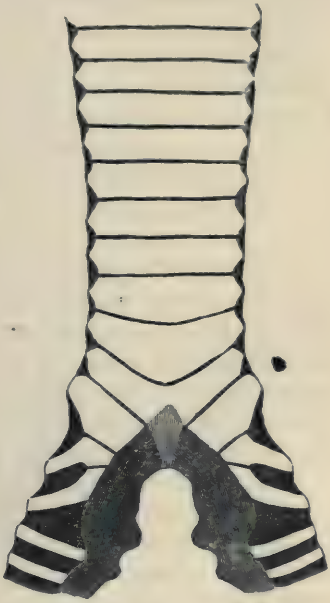
In *Arboricola atrogularis* the bifurcating portion of the windpipe most closely resembles that of the American Quails. With no posterior interannular intervals, those in front are deep and twelve or so in number, being interrupted, in the case of that between the last and penultimate rings, by a large medio-anterior lozenge-shaped ossification which unites them, but continuous above except that a fine fibrous band runs up the tube, as in *Lophortyx*, previously described. The thinned antero-lateral element of the last ring has a slight special downward curve towards its inner end. In *Oreortyx* there is an indication of the same. The second bronchial semiring is prolonged inwards pointedly in front, and posteriorly *does* meet the first semiring to articulate slightly with it.

In *Coturnix communis*, with which *C. coromandelica* agrees in every respect, the posterior surface of the intrathoracic portion of the trachea is seen to be formed by rings between which no interannular intervals exist, except as transverse lines. Anteriorly, however, the rings are very much thinner, becoming so abruptly at the side of the tube, and the intervals between them are nearly twice their depth, even more than that towards the bifurcation of the tube. Narrow medio-anterior perpendicular isthmuses of fibrous tissue connect the lowermost six rings. Laterally the penultimate ring is slightly upturned, more behind than in front. The antero-lateral thin portion of the circumference of the last ring is decidedly convex downwards, as is also the first bronchial semiring and the second. The last tracheal ring sends downwards a medio-anterior oblong process, ossified in the adult, to the lower angles of which the first semirings articulate by their **Page 362.**
equally lengthy extensions inwards beyond the short articular pro-

Fig. 9.

Front view.

Fig. 10.



Back view.

Coturnix communis.

cesses for the second semirings. The posterior articulations of the incomplete last tracheal ring with the first semiring, and of that with the second on each side, are considerable, and much the same in detail as in *Caccabis*. The pessulus blends with the penultimate ring behind. The lateral intervals between the penultimate and last rings are plano-convex, the plane side being uppermost; those between the last ring and the first bronchial semirings are meniscoid, very deep, and concave upwards. Between the first and second semiring the interval is small, elongate, and curved like the one above it.

Ptilopachys ventralis differs very little from *Coturnix* in this part of its windpipe.

Rollulus coronatus closely resembles the Ortyges and Quails. There are five fairly deep antero-lateral interannular intervals between the lowermost six tracheal rings, these same rings meeting in the middle line in front as well as through all the posterior moiety of the circumference. Ossification extends through the median fused anterior portions of the penultimate and last tracheal rings, as well as a short Page 363. distance posteriorly into the middle of the lower border of the penultimate ring from the fair-sized bony pessulus. The last tracheal ring sends downwards a thick short process from its hinder end on either side, to articulate with the equally developed upturned posterior extremity of the first bronchial semiring, the anterior upward- and inward-directed terminal limb of which is proportionately long, at the same time that the angle it makes with the main element of the ring is very abrupt. The second semiring is nearly in contact superiorly with the first throughout its length. Anteriorly it ends in a point, as do the lower semirings, which extends a short distance into the inner membranous wall of the bronchus. Posteriorly it is slightly enlarged and rounded, ceasing a short distance outside the posterior angle of the semiring above, with which it is in contact.

Turning to the genus *Euplocamus*, in *Euplocamus swinhoii* the last four tracheal rings become slightly enlarged from above downwards. Between the simple antepenultimate ring and the one above it there is a slight interval, except in the middle line behind, where a general fusion of the last three rings occurs, as in all *Euplocami*. The penultimate ring sends downwards a narrow tongue-shaped median process anteriorly, which touches, but does not join, the upper margin of the there indented terminal tracheal ring. Its upper margin is also slightly irregular. The last ring is peculiar in front. Besides the shallow and broad concavity in the middle of its upper border, it sends downwards a deep and transversely considerable semiovoid process, notched at its apex, which is lowermost, to form the median element of the actual bifurcation of the tube. On either side of this notch, just beyond it, the anterior extremity of the first bronchial semiring articulates by its triangularly expanded end, the lower angle of which is jointed with the not much specialized second semiring, which posteriorly articulates by its somewhat expanded termination with the first semiring also. The hinder extremity of the first semiring fuses with the last tracheal, as does the posterior termination of the pessulus, to form a continuous cartilage along the back of the tube as high as the upper border of the antepenultimate tracheal ring. Antero-laterally the annular interval between the penultimate and last rings is well developed, and bent downwards near the middle line on account of the presence of the process and notch above described. The interval between the last tracheal ring and the first bronchial semiring is very large and deep on account of the great size of the descending process of the former. The interval between the first and second semirings is ovate and slightly deeper than those which follow. The pessulus is narrow.

Euplocamus prœlatus, *E. nychthemerus*, and *E. albocristatus* differ from *E. swinhoii* in that anteriorly the median process from the lower border of the penultimate ring blends with the upper border of the last tracheal, as does the upper border, but by a more slender isthmus, with the antepenultimate. In *E. nychthemerus* and *E. albocristatus* there is a further fusion of the anterior extremity of the first semiring with the last tracheal at its (should be) articulating spot. Page 364.

The pessulus is broad; and the angle on each side of its posterior blending with the penultimate ring runs a short way into the latter so as to reduce its depth a little at the spot. The interannular intervals are the same as in *E. swinhoii*, except the one between the antepenul-

Fig. 11. Fig. 12.

Front view. Back view.

Euplocamus albocristatus.

timate and penultimate rings, which is interrupted in front by the narrow cartilaginous isthmus between them. Above this the following twelve rings or so touch all round; and they are succeeded by typically interlocking rings in the cervical portion of the tube. It must be also mentioned that whilst the plane of the penultimate tracheal ring is transverse, that of each lateral moiety of the last one, as well as the first bronchial semiring, runs upwards from its more fixed median anterior and posterior parts. The plane of the second semiring makes an angle of some 15° with the first.

In this last respect, as well as others, the genus *Phasianus* differs from *Euplocamus*. In *Phasianus wallichii*, *P. colchicus*, and *P. versicolor* the plane of each tracheal ring, as well as that of the uppermost bronchial semirings, is nearly, if not perfectly, transverse. The whole trachea narrows slightly at its lower end, to expand again opposite the last two or three rings. As in *Euplocamus*, the last three rings fuse in the middle line behind, as do the last two (in *P. wallichii* the last three) in front, whilst in adult birds the anterior extremities of the first and second semirings participate in the blending, as does the pessulus posteriorly. In *P. colchicus* and *P. versicolor* (which differ from *P. wallichii* about as much as *Euplocamus swinhoii* does from its **Page 365.** allies) there is a robustness about the last two tracheal rings and the first two bronchial semirings peculiar to them. Their direct front view always exhibits the posterior articulation of the first bronchial semiring with the ring above and the semiring below, as in no other Gallinaceous bird with which I am acquainted; thus, it includes the whole of the considerable interannular intervals between them, the

Fig. 13.

Front view.

Fig. 14.

Back view.

Phasianus colchicus.

upper ovoid, the lower semi-ovoid, with its convexity downwards. In *Phasianus* there is no interval between the penultimate and last tracheal rings, nor any of importance higher up. In *P. colchicus*, however, above the antepenultimate ring, there are small median intervals, fusiform and elongate in front, minute behind. These shortly become the notches of the interlocking superior rings.

Pucrasia darwini is so like the genus *Phasianus*, as far as the parts under consideration are concerned, that it needs no separate description. Any difference is in the direction of *Euplocamus*, the sides of the last tracheal ring being slightly uptilted.

Returning to *Euplocamus*, a start in another direction brings us to *Thaumalea*, *T. picta* and *T. amherstiæ* being identical, as far as their windpipes are concerned. In this genus the intrathoracic rings (tracheal rings) are in contact all round, as far as and including the penultimate ring, which sends down a short median anterior process to articulate with a small corresponding upward-directed one from the upper margin of the last ring. Posteriorly, in the young bird, the blunted triangular extremity of the pessulus interpolates itself between the two slightly expanded ends of this (therefore imperfect) ring, its extremity meeting and even disrupting the continuity of the lower edge of the antepenultimate ring to a small extent. The last tracheal ring is characterised by the great obliquity of the plane of its lateral moieties, the downturned angle between which is less than 45°. Behind there is a considerable interval between its downward-directed ends, filled up by the pessulus, which is prevented from

Page 366.

Fig. 15.

Front view.

Fig. 16.

Back view.

Thaumalea picta.

touching them by the intrusion of the extremities of the similar parts of the, also incomplete, penultimate ring. In front the middle of the ring is expanded into a large, quadrilateral, square-set cartilage, ossified in the adult, from the superior angles of which the slender oblique side elements of the ring take origin, to the inferior angles of which the first bronchial semiring is articulated in the chick and consolidated in the adult; the middle of the superior margin of which also articulates or blends with (according to the age) the broad median descending process of the penultimate ring. The first and second bronchial semirings are much alike; both are slightly swollen at their extremities, especially the anterior; and their planes of direction are parallel, which is not the case in *Euplocamus*. The lateral intervals between the penultimate and last tracheal rings are like the section of a plano-concave lens with the concavity (formed as it is by the arch of the lateral moiety of the last ring) downwards. The interval between the last ring and the first bronchial semiring is considerable and broadly fusiform; that between the first and second semiring is narrow and lanceolate, or fusiform in the adult, where the two semirings consolidate at their extremities.

Page 367. *Lagopus scoticus* is not far different from *Thaumalea* in certain respects. The lower intrathoracic rings of the trachea are but little modified above the antepenultimate, there being slight median fusiform anterior interannular intervals, whilst posteriorly the ununited rings are keyed together, as in the middle of the windpipe generally. The penultimate ring agrees with the same in *Thaumalea*, even to being incomplete behind, the free ends slightly receding from the ring above. The last ring anteriorly agrees with the same genus in detail, its lateral arched moieties being even more slender and delicate. Posteriorly, however, its ends develop into large fairly equilateral triangular expansions, continuous with the slender lateral arch at its supero-external angle, articulating with the posterior end of the first bronchial semiring at its inferior angle, whilst its supero-internal angle joins a similar development at the side of the pessulus, the hinder part of which expands into a sagittate cartilage, the blunted apex of which is directed upwards to meet the middle of the inferior margin of the antepenultimate ring of the trachea. The main bar of the pessulus is very slender; and all the structures under consideration are built up of a much more yielding cartilage (without ossifying tendencies) than in any non-tetraonine birds. The first and second bronchial semirings are parallel to one another in course throughout,
Page 368. and are more uptilted laterally than in *Thaumalea*. Posteriorly they are not expanded and scarcely touch; anteriorly they expand a little and articulate freely. The interannular intervals in essential points are not different from the preceding genus. The bronchial semirings

below the second are peculiarly lengthy; their extremities turn inwards towards one another, and so slightly intrude into the membranous inner wall of each bronchus. One or more of the semirings may be bifid at their anterior ends. The bronchidesmus is particularly powerful in the Tetraonidæ, including *Lagopus*, and, as it were, pulls the two tubes into nearer relationship than would otherwise appear to be their tendency.

Fig. 17.

Front view.

Fig. 18.

Back view.

Lagopus scoticus.

Lagopus mutus agrees with *L. scoticus* in every respect.

Tetrao urogallus and *T. tetrix* conform to a type which has several important differences from *Lagopus scoticus*, although in common they have the yielding cartilaginous (and never ossified) rings throughout the organ under consideration, as well as the great development in length of the bronchial semirings beyond the second.

In the female of *Tetrao tetrix* the first feature that strikes the observer is the consolidation of all the intrathoracic tracheal rings along the mid-posterior surface into a vertical bar, rendered more than it would be otherwise conspicuous by the considerable thinning of the lateral third or more of each ring on each side, and the consequent formation of lateral interannular spaces slightly deeper than the rings enclosing them. In the adult bird no trace of the transverse lines of junction between the constituent transverse annular elements of this vertical posterior bar can be seen; in the young bird, however, they

are conspicuous. Anteriorly the rings above the antepenultimate are separated by an interval which slightly reduces the lowest of them, and that only, towards the middle line. There is a median semifusion in front, of considerable breadth, between the antepenultimate and penultimate rings, below which a broad cordiform cartilage represents the fused mid-anterior elements of the penultimate and last rings, with which the anterior extremity of the first bronchial ring is blended, and the second articulates, in such a way as to form lateral extensions of its apex. The line constituting the actual angle between the contiguous sides of the bronchi—produced, as just indicated, by the apex of the cordiform cartilage, together with the inferior margins of the lateral expansions, composed of the anterior ends of the first and second bronchial semirings—is less concave downwards than in *Lagopus* (in fact almost straight), and much less so than in the other Gallinæ. It has, in *Tetrao*, a very slight descending protrusion in the actual centre—the apex of the cordiform cartilage. Posteriorly each free end of the last tracheal ring expands and sends downwards and outwards a small process for the articulation and fusion with the similarly enlarged extremity of the first bronchial semiring. Upwards it blends with the base of the vertical posterior cartilage, which is considerably broader opposite the lowermost three tracheal rings than higher up. Into the middle of its base the narrow pessulus is seen to run. There is a great similarity between the depth and shape of all the interannular intervals in the bifurcating portion of the tube, the
Page 369. comparatively great depth of the intervals between the lateral parts of the last tracheal and the first bronchial semiring, observed in *Thaumalea* for instance, not being seen. The first and second bronchial semi-rings themselves, agreeing as they do with those of *Lagopus* in all respects, are of the same thickness as their neighbours both above and below—the result being simplicity of construction a little more apparent than real. Many of the bronchial semirings are bifid at their anterior extremities.

In the male of *Tetrao tetrix* the trachea is most extraordinary. At first sight the deeply situated intrathoracic part appears to have no similarity with that of the female, there being developed, on each side, an immense irregular tumefaction, communicating with its fellow by means of a bridge of fatty tissue which covers the anterior portions of the lowermost tracheal rings. When preserved in spirit this tumefaction shrinks to a comparatively small size, to swell to its original bulk upon its immersion in water. This leads me to suppose that it
Page 370. is composed of "mucous" tissue, like that of the umbilical cord, which it resembles in consistence. The "mucous" tissue in this case is entirely developed between the external fibrous covering of the windpipe and the middle ring-carrying layer, the rings themselves not

Fig. 19.

Front view.
Tetrao tetrix, ♂.

varying in the least, as far as I can detect, from their arrangement in the female.

Tetrao urogallus (a male, not quite full-sized, and without any trace of the cervical loop developed) differs from the female of *T. tetrix*

Fig. 20.

Front view.

Fig. 21.

Back view.

Tetrao urogallus.

only in a few details. All the rings and semirings are thinner, and the interannular intervals greater. The posterior vertical bar is undistinguishable. Anteriorly, however, the lowermost seven tracheal rings are not thinned in the middle line, where they, above the penultimate, articulate above and below to form what becomes almost an anterior vertical bar as well. The corresponding parts of the penultimate and last rings, considerably narrower than in *T. tetrix*, expand and consolidate into an elongate lozenge, with a much shorter one above it, from the lateral angles of which the rings are continued, and from the inferior angle of the lower of which the articulating (and subsequently fusing) surfaces for the anterior ends of the first bronchial rings arise. The second semiring also articulates with the first, as in the allied birds, with, however, a considerably larger interannular interval than in *T. tetrix*. The lateral parts of the first semiring being markedly convex upwards, at the same time that the curved last tracheal ring sends down rather lengthy processes from its posterior extremities as well as the deep lozenge-shaped cartilage in front, the interval between the two agrees with the section of a plano-concave lens. Some of the bronchial semirings are bifid at their extremities: and the bronchidesmus is very strong.

Tetrao cupido is intermediate in its tracheal bifurcation between *Lagopus scoticus* together with *L. mutus* on the one hand, and *Tetrao urogallus* with *T. tetrix* on the other. Page 371. Its cartilages are considerably less yielding than those of either genus; and the lower tracheal rings, instead of fusing behind to form a continuous longitudinal bar supporting the remaining parts of the rings upon each side, remain separate, in close contact, for the posterior half of their circumference. The pessulus interpolates its considerable cuneate posterior end as high as the antepenultimate ring, which it splits up. The lowermost nineteen tracheal rings are considerably thinned in front, the uppermost being least so. Of these, the antepenultimate ring, as well as the one above it, give indications of being bent downwards in the middle line in front. This angulation is more marked in the penultimate ring, and most so in the last ring, where a mid-anterior rhombic cartilage exists, of exactly the same shape as in *Lagopus scoticus*. The first and second bronchial semirings agree precisely with those of the last-named species, convexly *upwards* as they are curved; and, as in all the species of *Lagopus* and *Tetrao*, the bronchidesmus is strong, at the same time that the bronchial semirings almost completely encircle the tubes, leaving a very narrow membranous unsupported wall. The bronchial tubes are comparatively lengthy.

In *Perdix cinerea* the intrathoracic portion of the trachea is quite different from the same in *Caccabis* or any of the birds above described. The last and penultimate tracheal rings are much developed, and blend

to form the considerable three-way piece, which is triangular in front, apex downwards, and horizontally oblong behind. Of the anterior triangle, which is ossified, the two sides are formed by the last ring, whilst the penultimate ring constitutes the base, the intervening interval being filled up with a thin cartilage. The apex of the triangle is continued downwards in cartilage, this latter being deeply notched in the middle line, at the same time that the anterior extremities of the first and second slender and upward-arched bronchial semirings Page 372.
blend with it laterally. Laterally, the separation between the last and penultimate rings is feebly indicated, as it is posteriorly by the non-ossification of the latter, notwithstanding the blending of the two. Posteriorly the oblong ossified cartilage, with its unossified and slightly indented upper margin (the part formed by the penultimate ring), is joined by the slender pessulus in the middle of its lower edge, whilst it is with its lower extreme angles that the simple posterior extremities of the first bronchial half-rings blend, the same parts of the second semirings not participating in the fusion, and being almost if not quite free, as are those below it at both ends. All the upper bronchial semirings are slender, strongly convex upwards, and separated by intervals not greater than their depth. The interval between the last tracheal ring and the first semiring, to which it is united both in front and behind, is fairly deep and crescentic. The antepenultimate ring is very much slenderer than the one below it, from which it is separated by a large interannular interval, deeper in front than behind on account of the obliquity of its plane. Anteriorly it is very shallow and insignificant; and it gradually enlarges as it goes backwards. The ring above it is scarcely different, but slightly less oblique, the interannular interval between it and the fifth from

Fig. 22.

Front view.

Fig. 23.

Back view.

Perdix cinerea.

the end being slightly less than that next lower down. This fifth ring first gives indications of a latero-posterior deepening, with a corresponding reduction of the interannular interval and the formation of an antero-median horizontal fusiform space, the only remains of the interannular interval recognizable higher up, and extending into the cervical portion of the windpipe.

Ceriornis temmincki differs from all other Gallinæ examined by me, except *Francolinus vulgaris*, in that the *third* bronchial semiring articulates with the second, and so participates in the formation of the specialized organ under consideration. None of the tracheal rings are narrowed; and there are consequently no interannular intervals of any kind, if we except the one on each side of a narrow anterior isthmus which runs between the penultimate and the last ring. This interval is guttate in shape, on account of the slight upturning of the lateral element of the last ring, the antero-median part of which is expanded, almost exactly as in *Euplocamus*, into a quadrate cartilage. The pessulus at its posterior extremity is unattached, though situated as usual. Its freedom depends upon the fact that the penultimate as well as the last tracheal ring is incomplete behind, the end of the pessulus filling the deficiency and just touching the lower margin of the complete antepenultimate ring. This may possibly be the normal arrangement, all others resulting from subsequent consolidation. The first and second bronchial semirings are very much alike. The relations of the upper of them to the ring above, as well as those of the lower to the ring below, are almost identically those of *Euplocamus;* whilst posteriorly they consolidate together for one half their length, a small elongate fusiform interval existing external to their anterior fused extremities. With the lower of them the slightly-bowed third

Fig. 24.

Front view.

Fig. 25.

Back view.

Ceriornis temmincki.

semiring articulates at one end, and the other (as does the second in Page 373. *Euplocamus*) with the first. *Ceriornis satyra* agrees exactly with *C. temmincki* in its lower larynx.

My acquaintance with the trachea of *Francolinus* is confined to *F. vulgaris*, an early sketch, too, only of that. Its great peculiarity is that the first *three* bronchial semirings articulate together, the third being decidedly the strongest, the first and second being separated by a greater interval than exists in *Ceriornis*.

In *Crossoptilon mantchuricum* the thoracic end of the trachea is euplocamine in construction. It narrows considerably near its termination, at which it again expands. The only indications of interannular intervals are small medio-anterior fusiform spaces, absent between the antepenultimate and penultimate rings, and replaced by a fusion in the case of the last two, on each side of which the lateral separation between the rings expands into a minute triangular interval, smaller than in *Euplocamus*. The pessulus agrees with that of the *Euplocami*. The interval between the last tracheal ring and the first bronchial semiring is very large, both upper and lower margin being about equally convex upwards, from the shape of the last tracheal ring and the uptilting of the first semiring. The interval between the first and second semirings is scarcely smaller, and is ovoid, the latter semiring being decidedly downturned laterally, bent upwards abruptly near its ends, and particularly strong throughout. On the whole, the organ

Fig. 26.

Front view.

Fig. 27.

Back view.

Crossoptilon mantchuricum.

is more like that of *Phasianus* and *Euplocamus*, its most striking difference from the former being the lateral uptilting of the first bronchial semiring, and the similar tendency in the sides of the last tracheal ring.

In *Lophophorus impeyanus* the lower tracheal rings, which are narrower than those above, are in contact with one another behind; Page 374. but anteriorly they are thinner, leaving considerable intervals, diminishing as they ascend—continuous between the five rings above the penultimate, found also between it and the last, but in that case interrupted by a small median connecting isthmus, which is broader below than above, at the same time that it is continuous with the superiorly broader medio-anterior descending process of the last ring, the two together forming a lozenge-shaped cartilage that receives the extremities of the first semirings at its lower margin. Posteriorly the pessulus is continuous with the penultimate ring, whilst the ends of the last tracheal also blend with it slightly. The second bronchial semiring is slightly larger than the first, and articulates with it in the usual way, as does the first with the last tracheal ring. There is a great uniformity in the depths of all the interannular intervals in the region of the bifurcation of the trachea.

In *Numida cristata*, which may be taken as the type of the very characteristic windpipe of the genus, figured accurately as it is in part by Temminck,[*] the peculiarity is that the lowermost six or so tracheal rings develop antero-lateral fenestræ between them, increasing Page 375. in size from above downwards, and produced by the thinning of the rings alone. In the adult male the four lowest rings blend in the middle line, both anteriorly and posteriorly. Those higher up do not do so. The last ring of the trachea, the whole plane of which is transverse, sends downwards a bluntly triangular medio-anterior process, with the lower margin of which the first bronchial semirings articulate. Posteriorly, in the full-grown bird, the pessulus fuses with the hinder extremities of the same, in such a way as to make it appear to form a continuation of it, as in no other of the Gallinæ with which I am acquainted. The first bronchial semiring sends upwards at right angles a strong anterior articular process, it posteriorly expanding triangularly, so that the upper angle meets the lower margin of the last tracheal ring in the usual situation, the lower angle articulating with the second semiring, whose other end bends up to be jointed to the corresponding part of the first semiring, developed slightly downwards to articulate with it. The interval between the last tracheal ring and the first bronchial semiring is considerable and broadly quadrilateral; that below it is much shallower; and those above are

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[*] *Loc. cit.*, pl. i. fig. 4.

Fig. 28.

Front view.

Fig. 29.

Back view.

Numida cristata.

fusiform, diminishing gradually as they ascend, until the last is quite minute.

N. ptilorhyncha and *N. rendalli* are very similar. They agree with one another, and differ from *N. cristata* in that the extreme lateral edges of the penultimate and last tracheal rings meet and blend, thereby reducing the interannular interval to a guttate form, with the **Page 376.** apex directed outwards. In *N. vulturina* there are as many as ten pairs of lateral tracheal fenestræ.

In *Meleagris gallopavo* the intrathoracic rings are all thinned away in front, whilst posteriorly they are not so, the consequence being that considerable interannular intervals separate them anteriorly, entirely absent posteriorly. The antepenultimate and penultimate rings are alone joined by a median anterior isthmus of cartilage. The former of these is split across behind; the latter is not so, the fairly thick pessulus blending with the mid-posterior margin, its apex apparently producing a protrusion of its upper border between the sides of the fissure in the ring above. The penultimate ring is greater in diameter, and stronger than the rest. *The last tracheal ring is represented only by the posterior extremities of the normal ring,* its lateral and anterior parts having quite disappeared, in the half-grown, and perhaps even younger bird. It will be remembered that its lateral elements are much reduced in *Lagopus*. In *Meleagris* the reduction has gone further, the only remainder being the inverted blunt triangular cartilage that intervenes between the juxta-pessular margin of the penultimate ring and the posterior articulation of the first bronchial semiring on each side of

Fig. 30.

Front view.

Fig. 31.

Back view.

Meleagris gallopavo.

the organ. A minute pointed process of the outer margin of the cartilage under consideration indicates the situation of the posterior root
Page 377. of the lateral portion of the atrophied ring. The first and second bronchial semirings are upturned laterally, and more slender than those below them. The first anteriorly sends upwards and inwards a lengthy process of about three times the thickness of the body of the ring itself, cut away obliquely, so that its upper end looks inwards and a little upwards, nearly to meet its fellow, from which it is separated by a narrow triangular fibro-cartilage, developed at its base from the middle of the antero-inferior margin of the penultimate ring of the trachea. The second semiring is slightly swollen at its ends to articulate with the semiring above. The interval between the penultimate ring and the first semiring is necessarily considerable, and is quadrate as well as slightly biconcave; that between the first and second semiring is meniscoid, convex upwards and shallow. The bronchial semirings below the second are peculiarly lengthy, especially the fifth, and pointed at the ends. Strangely also, semiring three, a short distance external to its anterior termination, articulates by small special facets with those above and below. The bronchidesmus is particularly strong.

By Temminck[*] this windpipe is imperfectly figured.

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[*] *Loc. cit.*, pl. iii. fig. 8.

Gallus bankiva at first sight seems to have the lower end of its windpipe constructed upon quite a different type from that of any of its allies, although I have reason to believe that other species fill up the gaps between it and other Phasianidæ. The lower extremity of the trachea is very much compressed from side to side, whilst it is correspondingly augmented in depth from before backwards. The antero-posteriorly directed pessulus joins in front the base of a considerable median triangular cartilage, which, with upward-directed small-angled apex, reaches as high as the level of the antepenultimate tracheal ring: posteriorly it joins a similar but smaller cartilage, the apex of which does not quite reach the penultimate ring. With the lateral angles of these triangular cartilages, the anterior and posterior extremities of the first bronchial semirings freely articulate. These semirings are large and much curved, with the convexity directed downwards. Anteriorly they meet, but do not articulate with the scarcely modified second semirings, from which they are quite independent behind.

The last tracheal ring is thin and band-like, joining the lower ends of the sides of the anterior triangular cartilage in front, whilst behind its free extremities are separated by a considerable interval, partly occupied by the posterior triangle. The penultimate ring persists as two straight lateral band-like rudiments fixed in the tracheal membrane, and *nearly* reaching both the anterior and posterior triangular cartilages. The antepenultimate ring is still further modified in the

Fig. 32.

Front view.

Fig. 33.

Back view.

Gallus bankiva.

same direction, only the antero-lateral parts persisting as rudiments, not seen, therefore, in the back view of the organ. A short distance above the level of the apex of the anterior triangular cartilage, and some way below the first fairly normal tracheal ring, is a continuous filamentous transverse cartilage, with little extra pieces connected to Page 378. it—incomplete in the middle line behind, supported by the membranous walls of the windpipe. This is evidently the atrophied fourth ring, counting from below. Above this an abrupt change occurs; the rings attain their ordinary depth, with only linear intervals between them. The fifth ring, again counting upwards, differs from those above it in being slightly incomplete behind, with downturned ends. The interval between it and the fourth is about equal to its own depth. It in front, and its superior two or three neighbours behind as well, is slightly V-shaped in the middle line*.

The Cracidæ are particularly uniform in the manner in which the trachea bifurcates. In *Mitua tuberosa* there are no tracheal inter-annular intervals of any kind. The pessulus is united with the penultimate ring posteriorly and with the last ring in front, the latter ring being therefore incomplete behind, as in all the birds above described. Mid-anterior and posterior ossifications extend upwards from the attachment of the pessulus, generally sufficiently high to involve the four lowermost rings, which are therefore consolidated together in the median lines. The lower lateral borders of the last tracheal ring are slightly concave downwards; the medio-anterior descending process being small, whilst by its slightly truncated triangular apex it forms a small portion of the actual margin of the Page 379. bifurcation. On account of the considerable length of the slender first bronchial semiring, which is very concave upwards, the interval between it and the last tracheal ring is conspicuously large and fusiform, one side of the small antero-median process and the *outer* border of the inferior angle of the corresponding truncated posterior termination of the last tracheal ring being its articulating spots. The semiring is not of uniform thickness, small expansions, not unlike the "tubercles" of ribs, occurring at a short distance from both ends, which mark the points at which the next semiring meets it and ceases. The second semiring is simple, except that it is slightly enlarged at its posterior extremity. The interval between it and its neighbours is extremely narrow.

The species I have examined are *Crax globicera*, *C. carunculata*, *Pauxis galeata*, *Mitua tomentosa*, *Penelope jacucaca*, *P. cristata*, *P. superciliaris*, *Pipile cumanensis*, and *Aburria carunculata*. In *Penelope*,

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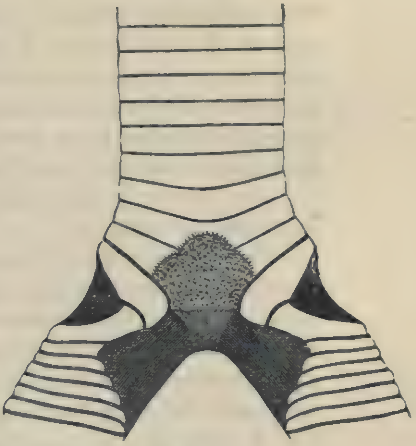
* By Temminck (*loc. cit.*, pl. ii. fig. 4) a different figure of the windpipe of *G. bankiva* is given.

Pipile, and *Aburria* the first bronchial semirings are thicker and stronger than in *Crax* and its near allies, their posterior articulations with the ends of the last tracheal ring being upon what becomes the *outer*, but normally would be the *inferior* surfaces of its juxtapessular terminations, because of a characteristic downward flexure of their expanded obtuse extremities.

Fig. 34.

Front view.

Fig. 35.



Back view.

Aburria caruncaulata.

The lateral intrinsic tracheal muscles are thin, and run down to cease opposite the ring fifth from the bifurcation of the tube, as in nearly all Gallinaceous birds. I cannot trace any fibrous continuation to the lower rings from their muscular extremities.

Incidentally it may be mentioned, with reference to the development of the extrathoracic tracheal loop in the Cracidæ, that, as far as my facts go, this loop is found in the males only of the genera Page 380.
Crax, *Pauxis*, and *Mitua*; whilst in *Penelope purpurascens*, *P. cristata*, *Pipile*, and *Aburria* it is wanting in both sexes, it being present in both sexes of *Penelope jacucaca.* In the males of *Penelope pileata* and *Ortalis albiventris* * it is present; the females I have not seen.

The flattening of the trachea of the male Cracinæ, excellently depicted (inverted) in Temminck's figure of the windpipe of *Crax alector*,† is lateral or from side to side, so that the well-known anterior and

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* *Vide* Temminck, *loc. cit.*, pl. viii. fig. 1.

† *Loc. cit.*, pl. v. fig. 1.

posterior notching of the rings of the trachea is on the thin edges of the flattened tube.

In conclusion, it may be asked what light this detail concerning the bifurcation of the trachea throws on the mutual affinities of the genera of the Gallinæ. It is very infrequently that the study of a single organ justifies the formation of an ultimate classification of any group; and the windpipe of the Gallinæ is not peculiar in this respect. Several hints are to be derived from this investigation, however, not unimportant in my estimation.

Pavo seems to stand alone on account of the simplicity of its bronchial bifurcation.

There seems also to be a tendency for the majority of the Gallinæ to fall into two divisions, a Coturnicine and a Phasianine; in the former of which it is the bronchial semirings which are most specalized, at the same time that the anterior extremities are pointed and produced inwards. In the latter group it is the last tracheal ring that is most modified, its sides being always upturned. Upon this assumption it is not easy to place the genera *Gallus*, *Lophophorus*, *Meleagris*, and *Numida*. The others fall into the following order:—

COTURNICINÆ.	PHASIANINÆ.
Caccabis.	*Euplocamus.*
Argus.	*Pucrasia.*
Polyplectron.	*Ceriornis.*
Ithaginis.	*Phasianus.*
Lophortyx.	*Thaumalea.*
Oreortyx.	*Crossoptilon.*
Arboricola.	*Lagopus.*
Rollulus.	*Tetrao.*
Ptilopachys.	(*Meleagris ?*).
Coturnix.	*Perdix.*

It is surprising to see how much the lower end of the trachea of the adult *Gallus* differs from that of *Phasianus* and its allies. A study of the development of the windpipe of the Common Fowl—which I have not had the opportunity of undertaking—would probably throw considerable light upon the subject.

82. NOTES ON THE ANATOMY OF *GELADA RUEPPELLI*.*

(Plate XXXI.)

Page 451. HAVING had the opportunity of dissecting the adults of both the sexes of *Gelada rueppelli*, the female of which lived a short time in the Society's Gardens, where it died, I desire to record some points in the anatomy of the species which appear to be of interest.

The following are measurements from the skins, except when otherwise indicated :—

	♂ adult.	♀ adult.
	inches.	inches.
From margin of upper lip, over head and along back, to base of tail	28·75	29·2
Same measurements from body with skin removed	24·5	25
Tail, without hairy tuft	24·75	25
Tuft of tail	8	3·5
From wrist to end of nail of middle digit of hand	5	4·5
From heel to end of nail of middle digit of foot	7	6·25
From angle of axilla to end of nail of middle digit of hand	16·25	15·1
From mid-perineum to end of nail of middle digit of foot	9	11
Nail of middle digit of hand along convexity	1·1	1·15
Nail of middle digit of foot along convexity	1·01	1·01

Page 452. With reference to the male, its general colour is a dark sooty chocolate-brown. The shoulder, forearm, back of hand, and instep, as well as most of the tail, with the exception of its end, are black. The palest brown is found on the abdomen, though this is very dark. A few white hairs mixed with the brown-black of the tail-tuft, give that a lightish tint. The longest hair is that between the shoulders, where it reaches as much as eleven inches. This lengthy hair extends upwards over the occiput quite forward to the superciliary ridge, and downwards to the loins, below which it rapidly reduces before the base of the tail is reached. Laterally the long hair extends over the shoulders, and less considerably under the arms, towards the lateral margins and to the surface below the nude chest-space. The hair on the abdomen is about 2·75 inches long, that outside the thighs 4 inches, that on the tail an inch, except the end tuft, where it reaches 3·5 inches.

The characteristic nude chest-space is double in the male, being

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* "Proceedings of the Zoological Society," 1879, pp. 451–7. Pl. XXXVIII. Read, May 20, 1879.

formed of two median triangular isosceles areas reversely directed, with their apices approximate, but separated by an interval 1·5 inch in length, of hair-covered skin. The base of the very obtuse-angled upper triangle, which is margined by black hair, is five and a half inches from the middle of the lower lip, and is situated opposite the larynx, its length being 3·75 inches, and its depth not being more than an inch. The lower triangle is also very obtuse-angled, with its base, slightly concave downwards, six inches long.

Although the two nude triangles above described do not meet, they tend to form an hour-glass surface of florid skin, 7·75 inches along each lateral curve from horn to horn. The hair bordering it is an inch long or so and iron-grey in tint, from the almost equal admixture of black and white hairs. There is no caruneulation of the skin in the nude spaces or at their borders. The pair of nipples are closely approximate, not being more than a quarter of an inch apart in the dried skin. They are situated in the nude area of the lower triangle, an inch above its base.

In the female the general tint is much the same as that of the male; the hair is very much shorter and less faded at the tips. The interscapular hair is the longest, reaching nearly four inches, whilst that of the loins is not so black as in the male.

The pectoral nude space is in the female carunculated all along its lateral and inferior borders. The two triangles which go to form it join apically by an isthmus 1·3 inch broad. The marginal hair is not mixed with white. The caruncles are numerous, and about a quarter of an inch in breadth, being ovate and flattened. The nipples are situated as in the male, and are an inch apart.

In both sexes the face is nude below the line of the frontal eminences, and laterally from points a little less than half an inch outside the outer canthus of each eye, the nude spaces running straight downwards in the direction of the angles of the mouth, just before reaching which they turn and include the chin.

The ischial callosities, which are subcircular, and a little less than two inches in diameter, are situated in a naked area which is carun-
Page 453. culated in the female. This area extends forwards for three and a quarter inches, broad opposite the mons veneris, which is therefore nude, the anterior border being non-carunculated, and gradually lost in the sparse hair of the abdomen.

Osteological comparisons between *Gelada* and its allies are very attractive, but do not lead to very definite results. Those most important in my estimation will be here recorded.

The following are measurements of the larger bones in the male:—

	inches.
Length of humerus	7·1
„ radius	7·4
„ ulna	8·35
„ femur	7·45
„ tibia	7·6
„ fibula	7·0
„ scapula	5·25 (extreme)
From anterior margin of præmaxilla to occiput	6·5 (5·8 in ♀)
Extreme breadth at posterior parts of zygomata	4·1 (4·0 in ♀)
Extreme breadth of orbit	0·9 (same in ♀)
Interorbital interval	0·425 (0·35 in ♀)

There are 13 pairs of ribs, of which 5 are false. The sacrum consists of three vertebræ. The clavicles form a single curve; and the anterior margin of the manubrium sterni is *not* much thickened.

My opportunities for examining the skulls of adult specimens of Monkeys being but few, it is impossible to generalize to any extent with safety. *Cercopithecus* differs from *Macacus* and *Cynocephalus* in not possessing a fifth lobe to its mandibular third molar. In *Gelada* this extra lobe is large, as is the anterior talon on the maxillary molars, which are small in *Cynocephalus*, and much smaller still in the Macaques I have examined. In *Gelada* the upper incisors are at right angles to the alveolar margins of the premaxillary, which is the case in *Macacus;* in *Cynocephalus* and *Cercopitheeus* they converge as they descend.

The profile view of the Gelada's skull exhibits the great anterior development of the sharp median portion of the supraorbital ridge and the deep concavity of the nasal contour. In *Gelada*, *Cercopithecus*, and *Cynocephalus* the nasal bones are separate, elongate, and narrow, appearing superficially upon the skull as high as the supraorbital frontal ridge. In *Macacus* they fuse, and form a short broad triangle whose apex does not reach the frontal bone, the maxillaries meeting above it.

In *Gelada* there is no trace of any groove or foramen for the supraorbital vessels and nerve. This is also the case in *Cercopithecus*. In *Macacus* and *Cynocephalus*, however, the groove is very deep, almost forming a foramen. The malar foramen is also wanting in *Gelada*. Its presence in allied genera is uncertain. There is a foramen in the fronto-malar suture.

In *Macacus* and *Cynocephalus* the anterior palatine foramina opens into an osseous depression, which is continued for some distance for- Page 454.

wards, almost to the alveolar margin. In *Gelada* they open directly upon the surface of the palate.

In *Macacus* and in *Cercopithecus* a powerful transverse ridge of bone is seen to form the posterior boundary of the osseous palate. This is not seen in *Gelada* or in *Cynocephalus.*

In *Cynocephalus* the mastoid process of the temporal bone is fairly developed. In *Gelada*, *Cercopithecus*, and *Macacus* it is obsolete.

In *Cynocephalus* and *Macacus* the hamular process of the internal pterygoid plate of the sphenoid bone is much more superficial, and is placed more forward than in *Gelada.*

The left lung is two-lobed, the lower being slightly the larger. The upper is nearly divided transversely into two moieties, of which the lower is a little the smaller.

The right lung has four lobes, the (bifid) azygos being the smallest, the middle next in size, elongate and triangular. The obliquely cut upper lobe is smaller than the subquadrate largest lower lobe.

There are three circumvallate papillæ at the base of the tongue, arranged in the characteristic V.

The following are intestinal measurements :—

	Male. inches.	Female. inches.
Small intestine	90	129
Large intestine	58	51
Cæcum	3	3

The stomach much resembles that of man in shape, being a little more elongate. There is no appendix vermiformis to the sacculated cæcum, which does not differ from that of the lower Old-World Monkeys. The colon is sacculated throughout.

The spleen is three inches long, one and a half inch broad, being suboblong and slightly bifid at one extremity.

The kidneys are ovate, not reniform, and with but a single pyramid in each.

There is an os penis three quarters of an inch long. The vagina is very hirsute, with large broad transverse rugæ. The uterus is pyriform.

To understand the bearing of the details of the anatomy of the liver of the *Gelada*, it will be necessary to view the peculiarities of the organ in allied genera. This the inspection of a large number of species enables me to do.

In the genus *Macacus* the liver is comparatively uncomplicated. The right and left lateral fissures are well marked, the umbilical fissure being less considerable and less constant in depth. The abdominal surfaces of the right and left central lobes are frequently connected by a bridge of hepatic tissue. The inferior margin of the right central lobe is straight, and at right angles to the axis of the gall-bladder, which latter organ is deeply imbedded in a cystic fossa, never deep enough to appear on the diaphragmatic surface. The fundus of the gall-bladder never reaches the inferior margin of the organ, though it approaches very near to it. There is no trace of a cystic fissure. The interval between the inner border of the cystic fossa and the umbilical fissure is always broad, a quadrate lobule intervening. The left central is generally the smallest of the four main lobes, it being vertically elongate. The left lateral lobe is shaped much like the sector of a quarter of a circle, with the apex directed to the portal fissure. This apex is often simple; but when not so a slight fissure runs for a short distance from the superior border of the lobe, not far from the apex, *parallel* to the left lateral fissure. The right lateral lobe is subquadrate in form; its surface presents no irregularities, as a rule; but when present they take the form of deep semilunar incisions on its abdominal surface. The abdominal margins of the umbilical fissure frequently present small lobelets of a bluntly conical form, with their apices directed downwards. These are most frequently situated on the left central lobe, but sometimes on the right, sometimes on both. The caudate lobe is elongatedly subfusiform, without any real depression; its apex reaches *as far as* the extreme right margin of the right lateral lobe. The Spigelian lobe is well marked, being small and thin; its shape is that of the tip of the compressed finger of a glove; it is directed backwards. Page 455.

The genus *Cercopithecus* differs from *Macacus* in the following respects:—The inferior margin of the right central lobe is rarely anything approaching a straight line at right angles to the axis of the gall-bladder; a slight notch often also indicates the rudiment of a cystic fissure. The imbedded fundus of the gall-bladder is likewise generally visible on the diaphragmatic surface of the right central lobe. The interval between the left margin of the cystic fossa and the umbilical fissure is narrow, and often not more than a sharp vertical ridge of hepatic tissue. The apex of the left lateral lobe (directed, as in *Macacus*, towards the portal fissure), when complicated, is rendered so by a short fissure running from the superior border of the lobe, *not* parallel to the left lateral fissure, but downwards and inwards, so as to produce a subtriangular lobelet, in which the free margin is directed horizontally upwards. When complicated the right lateral lobe develops lobules on its abdominal surface, not semilunar incisions. The caudate lobe runs to the extreme margin of the right lateral lobe, as in *Macacus*. The Spigelian lobe is frequently absent, and when present is irregular and much smaller than in *Macacus*.

In the genus *Cynocephalus* the peculiarities of *Cercopithecus* are observed, except that the caudate lobe is very short, only extending half across the right lateral lobe horizontally. The Spigelian lobe is also well developed, quite as much or even more so than in *Macacus*, it being thicker than in that genus.

Page 456. In *Gelada* the right and left central lobes are proportioanlly larger than in the genera above described. Otherwise it most resembles *Cercopithecus*, differing from it in that the cystic fissure is shallow, at the same time that the fundus of the gall-bladder does not so nearly approach the inferior border of the right central lobe. It resembles *Cercopithecus* in that the Spigelian lobe is absent, at the same time that the caudate lobe is long, in both which respects it contrasts strongly with *Cynocephalus*. The only lobelet is one on the right border of the umbilical fissure, which is Macaque-like. It differs from *Macacus* in the obliquity of the inferior border of the right central lobe, and in the nearness of the gall-bladder to the umbilical fissure, as well as in the absence of a Spigelian lobe and the large size of the central lobes.

The brain of *Gelada rueppelli* is particularly instructive when compared with the beautiful series of figures in Gratiolet's "Mémoire sur les Plis Cérébraux de l'Homme et des Primatès." Its different aspects are represented, natural size, on Plate [31] XXXVIII. Its most marked feature is the relatively small size of the occipital lobe, which is about as large as in the *Semnopitheci*, smaller than in the *Cynocephali*, and much smaller than in *Macacus* as well as *Cercopithecus*. In the two last-named genera this lobe is unconvoluted, or very slightly so. In *Gelada* there is a simple horizontal sulcus (*h*, *h*) a short distance above its lower border, running from the posterior surface some way forward, but not so far as to meet the posterior transverse sulcus (*c*, *c*). In *Cynocephalus* the occipital lobe is more elaborately convoluted.

An inferior horizontal occipital sulcus, parallel to that just described, runs so far forward as to join the major oblique temporo-parietal sulcus (*b*, *b*). This is a condition recorded by Gratiolet in *Semnopithecus maurus* only, the sulcus generally turning upwards to end independently.

The major oblique temporo-parietal sulcus (*b*, *b*) commences below, near the inferior rounded margin of the temporal lobe, and runs upwards as well as backwards to near the middle line of the brain. It is joined by the prolongation upwards of the Sylvian fissure (*a*, *a*), two-thirds from its lower end, it being bent slightly forward at the point of junction.

Surrounding the upper end of this last sulcus, but not meeting it, is one whose posterior limb (*c*, *c*) forms the anterior boundary of the occipital lobe, the posterior transverse fissure, whilst its anterior limb (*g*, *g*) runs forwards, downwards, and outwards, to end independently as in allied Primates. Where these two limbs meet a small sulcus runs inwards to the middle line, becoming conspicuous on the median aspect of the hemisphere.

The prolongation upwards and backwards of the Sylvian fissure on the outer surface of the brain meets the major oblique temporo-parietal sulcus as above mentioned. Whether or not it should meet it is uncertain in allied species of the same genus according to Gratiolet. It is peculiar, however, in that from a little above and below its middle it sends forward small branches (*e*, *e* and *n*, *n*). In the *Cynocephali* alone is anything of this kind seen, and in them the Page 457. lower of these two sulci only (*n*, *n*).

The anterior transverse (parietal) fissure (*d*, *d*) commences externally between the two small sulci just described (*e*, *e* and *n*, *n*). After running forward and upward it bends, turning slightly backwards to the middle line, *where it is continued downwards upon the median surface of the hemisphere for a short distance*, as in no species described by Gratiolet.

The three-way convolution of the frontal lobe (*f f f*) resembles that in the *Cynocephali*—the *Semnopitheci*, *Macaci*, and *Cercopitheci* almost or entirely lacking its posterior limb, which is well represented in the Geladas and Baboons.

Small independent sulci are more numerous than in *Macacus* and *Cercopithecus*—about as many as in the *Cynocephali*, with which the Gelada most agrees in size.

Correlation of the facts above recorded makes me place *Gelada* along with *Cercopithecus* and *Cynocephalus* away from *Macacus*. Its affinities with *Cercopithecus* seem to me more intimate than with *Cynocephalus*, to which *genus* it most certainly does not belong.

EXPLANATION OF PLATE 31. (XXXVIII.)

Brain of *Gelada rueppelli*, natural size.

Fig. 1. Right hemisphere, outer aspect.
2. " " inner aspect.
3. " " superior aspect.
4. " " inferior aspect.

83. ON THE BRAIN AND OTHER PARTS OF THE HIPPOPOTAMUS (*H. AMPHIBIUS*).*

(Plates XXXII and XXXIII.)

Page 11. THE male Hippopotamus from the Upper Nile, presented to the Society by the late Viceroy of Egypt on the 25th of May, 1850, died on the 11th of March, 1878, without any serious disease of any organ, but after having suffered for some years from ulcers on the legs, which were much more inflamed during the winter- than the summer-seasons; because then the comparative coldness of its tank did not allow of its remaining in the water for any length of time, and the cutaneous surface became dry as well as cracked.

The animal was about thirty years old, and apparently aged. From the front of the nose to the base of the tail it measured 12 feet along the back, the tail being 22 inches long.

In his monograph on the anatomy of *Hippopotamus amphibius*,† Professor Gratiolet has fully described and figured the brain of the new-born animal. Nevertheless there is a want of definiteness about the delineation of the convolutions, and a difference in the proportionate size of the cerebellum, which makes me feel justified in asking the Society to grant me opportunities for giving illustrations of the brain of the adult animal. The necessity for a second figure is increased by the peculiarities in an outline sketch of the brain of *Hippopotamus liberiensis* given by Prof. Macalister in his account of that species.‡

In a valuable monograph on the brain of the Ungulata,§ recently published, Dr. Julius Krueg has introduced views and adopted a nomenclature which every student of the nervous system cannot help finding of particular service in any special investigation like the present. By an extensive comparison of the convolutions of individuals at different ages, and of different species, Dr. Krueg has arrived at a standard of which are fundamental and which secondary sulci, that has enabled him to represent what is the typical arrangement of the surface of the hemispheres in the Ungulata generally.

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* "Transactions of the Zoological Society," XI. pp. 11–17. Pls. III. and IV. Read, June 17, 1879.

† "Recherches sur l'anatomie de l'Hippopotame," Paris, 1867.

‡ "Proceedings of the Royal Irish Academy," vol. i. series 2, Session 1873–74, plate xxviii.

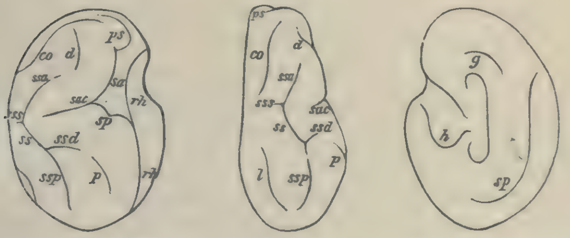
§ "Zeitschrift für wissenschaftliche Zoologie," Leipzig, 1878, xxxi. pp. 297–344.

The results arrived at by MM. Leuret and Gratiolet* tend strongly Page 12. in the same direction as those subsequently arrived at by Dr. Krueg; nevertheless there is a completeness about the investigation of the last-named author which greatly increases the importance of his work.

As it is my intention on the present occasion to employ the nomenclature adopted by Dr. Krueg, I cannot do better than introduce it by applying it to the description of the typical Artiodactylate brain as represented by that author.

Perhaps no nearer approach to this type can be given than that of the fœtal sheep (*Ovis aries*), 27·5 centimeters in length, figured by Dr. Krueg (figs. 1—3). Putting what is to be seen in words, the small upward-directed *processus acuminis* (*sac*) of the Sylvian fissure is just seen on the outer border of the superior surface of the cerebral hemisphere, along which latter surface the *supra-sylvian fissure* (*ss*) courses longitudinally nearly from end to end, slightly concave outwards opposite the Sylvian fissure. According to Dr. Krueg, this fissure (*ss*) has three limbs; but four seems to me to be the more correct number. Of these one is anterior (*ssa*), the second superior (*sss*), and the third posterior (*ssp*). The fourth, according to me, runs downwards (*ssd*) from the spot of origin of the posterior limb. Typically, all these processes terminate freely.

Fig. 1. Fig. 2. Fig. 3.



Sheep's brain: fig. 1. Outer aspect; fig. 2. Superior aspect; fig. 3. Inner aspect. (After Dr. Krueg.)

Next in importance, on the superior surface, is the coronal fissure (*co*), longitudinal in direction, at no great distance from the middle line of the brain, and situated so far forward that its posterior extremity is in front of the superior limb of the supra-sylvian fissure (*sss*). It runs forward almost to the anterior margin of the hemisphere.

A minor longitudinal (*lateral*) fissure (*l*) tends to divide the surface between the posterior branch of the supra-sylvian fissure and the

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* "Anatomie Comparée du Système Nerveux," Paris, 1839–1857.

middle line of the hemisphere into two equal parts. The præsylvian, diagonal, and posterior fissures, though they appear on the superior surface, are so much better seen in the lateral view of the brain that they will be there described.

The inner aspect of the hemisphere presents, besides the hippocampal fissure (h), a long *fissura splenialis* (sp), or *calloso-marginalis*, some distance from the superior margin, curved concavely towards Page 13. the corpus callosum, opposite the hinder end of which its posterior extremity ceases, whilst anteriorly it continues nearly as far forward as the perpendicular level of the genu of the corpus callosum, which is partly embraced anteriorly, as it were, by a small *fissura genualis* (g).

The outer aspect of the hemisphere has a basal fissure running nearly its whole length—the *fissura rhinalis* (rh), some little distance above which the anterior and posterior limbs of the Sylvian fissure (sa and sp) diverge, the hinder extremity of the latter sending downwards an extension to meet it. The anterior end of the anterior limb of the Sylvian fissure also joins the posterior extremity of the small præsylvian (ps) fissure, concave upwards, situated low down in the outer frontal region, with another small and very similar *diagonal fissure* (d) half way between it and the coronal fissure (co). The *fissura postica* (p) is a small one between the hinder part of the fissura rhinalis and the posterior limb of the supra-sylvian fissure.

So much for the typical cerebral convolutions in the Ungulate animal, which undergo special modifications in the different families of the order, some of which are particularly constant, and must be here referred to in order that comparisons may be made between the Hippopotamus and its allies.

The brain of the genus *Sus*, together with *Phacochœrus*, is distinguishable from that of any other Artiodactylate animal by one or two well-marked characters, the most striking of which is the blending of the coronal with the splenial fissure by means of a curved sulcus of so considerable a depth that the convolution between the middle line of the hemisphere and the coronal fissure appears to be quite cut off from the rest of the superior cerebral surface. The præsylvian fissure, however, as usual, runs up on the inner side of the outward-directed anterior extremity of the coronal fissure. Behind the sulcus of communication between the fissures just referred to there is always an equally characteristic second one, parallel to it, and a short distance behind it, joining the fissura splenialis and a prolongation of the superior limb of the suprasylvian fissure. Again, as Dr. Krueg puts it, the posterior extremity of the suprasylvian fissure turns downwards on the outer side of the hemisphere, and ceases near the lower border of the brain; whereas in the Cotylophora it runs backwards and *inwards* rather than outwards. In my opinion this arrangement is better indicated by saying that the descending limb of the suprasylvian fissure is developed in the Swine at the expense of the posterior, whilst in the Cotylophora the posterior limb is large and the descending limb rudimentary. In the Swine, also, the fissura rhinalis and the fore-and-aft prolongations of the Sylvian fissure become continuous. In the Cotylophora they do not unite, the former being at a lower level.

A careful comparison of the brain of *Dicotyles tajaçu* with Dr. Krueg's illustration of the same in *D. torquatus* does not lead me to see that *Dicotyles* resembles the true Swine so closely as might be expected from that author's sketch. The characteristic descending limb of the suprasylvian fissure is quite wanting in the two specimens at my disposal, and its posterior limb turns inwards slightly, as in the Cotylophora. There is one upward branch of the splenial fissure which *joins* the fissura coronalis, and is not a continuation of it, as in *Sus*. If it were not for this the fissura coronalis and fissura lateralis would be continuous in *Dicotyles*. Page 14.

In *Sus* there is a minor longitudinal fissure between the fissura splenialis and the fissura lateralis, or there may be two. In *Dicotyles* it is the same, the outer moiety being the broader.

The convolution between the fissura lateralis and the fissura suprasylvia is broader than that between the fissura lateralis and the middle line—considerably in *Sus*, not so much so in *Dicotyles*. Gyri of the included convolution, towards its outer border, make its outer contour less distinctly marked than is its inner boundary, and the complication may be increased by the presence of transverse bridging convolutions.

In *Dicotyles* the superior limb of the suprasylvian fissure terminates, as in the Swine and Cavicornia, without communicating with any other of importance, at the same time that a wedge-shaped convolution is always more or less developed in the region under consideration, with its backward-directed apex formed by the junction of the superior and anterior limbs of the suprasylvian fissure. In the Cervidæ it is the rule that the superior limb of the above-named fissure blends with the posterior extremity of the coronal fissure. The specimen of *Elaphodus michianus* figured by me* does not, however, quite conform with this law.

The adult *Hippopotamus* brain which forms the subject of this communication differs so much in the arrangement of the convolutions of the two sides, that from a study of one or the other singly very different results might be arrived at. This evidently depends

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* "Proceedings of the Zoological Society," 1876, p. 757. (*Suprà*, p. 387.)

upon the considerable development on the right side of bridging convolutions, the great number of which in the brain of the Hippopotamus is laid special strain on by Gratiolet,* who, whilst referring to the "middle series" of convolutions, remarks:—"Il acquiert une importance exceptionelle, et si son existence est au premier abord dissimulée, cela tient à la grande quantité de plis de passages verticaux qui lient cet étage supérieur à l'etage inférieur proprement dit." On the left side these bridging convolutions do not exist, and as a result an extra longitudinal fissure is seen, which must be one of the typical sulci of the cerebral hemisphere, it being conspicuous in the brain of *Hippopotamus liberiensis*, according to Prof. Macalister's outline sketch, though absent in the figures accompanying Gratiolet's memoir on *H. amphibius.*

The brain of the Hippopotamus is not richly convoluted. It is about as much so as that of the genus *Bos*, decidedly less so than *Camelopardalis giraffa* or the Camelidæ. The considerably smaller Rhinoceros, *Ceratorhinus sumatrensis*,† has more convolutions.

Its weight immediately after removal from the skull was one pound and seven ounces.

The most conspicuous fissure on the superior surface of the brain **Page 15.** is one running from front to back, not far from the middle line, which it more nearly approaches anteriorly than posteriorly. This continuous fissure must be compound, and made up of the coronal (*co*) in front, blended with the lateralis (*l*) behind, between which latter and the splenialis (*sp*) a secondary longitudinal fissure develops in the usual manner. Though, as far as I am aware, there is no other Ungulate animal with the two above-named fissures actually joined, they are nearly so in the Camelidæ, *Camelopardalis*, *Dicotyles*, and *Bos.*

Between the above-described fissure and the fissure of Sylvius there are, on the right side of my specimen, only transverse twisted convolutions of considerable length, five or more in number, according to the way in which they are counted. On the left side an irregular longitudinal and fairly lengthy suprasylvian fissure exists, nearer the Sylvian than the lateral fissure, and therefore quite lateral in position, with several smaller sulci joining it. Having the typical Artiodactylate brain before us, it is possible to recognize among these the descending (*ssd*), posterior (*ssp*), anterior (*ssa*), and superior (*sss*) branches of the main fissure, the first-mentioned (if correctly identified) running in the direction so characteristic of the true Swine.

The anterior branch of the suprasylvian fissure has no connexion

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* "Anatomie de l'Hippopotame," p. 325.

† "Transactions of the Zoological Society," vol. X. Pl. LXX. p. 411. (*Suprà*, p. 143, pl. 4.)

with the coronal fissure. It ends independently, much as in the Cavicornia and Swine, with a downward tendency; nevertheless I am not able to recognize anything corresponding to the wedge-shaped convolution formed between it and the insignificant superior limb of the same fissure, so well marked in the Swine, as above described.

The fissura splenialis does not curve upwards anteriorly to become superficial, as it does in *Sus*, but continues onwards to blend with the fissura genualis, at the same time that it sends up a short perpendicular fissure about one-third from the anterior extremity of the hemisphere, just long enough to be seen upon the surface. There is a short vertical sulcus, generally more or less developed in the Ungulata, to be noticed, separating the posterior limb of the splenial fissure from the corpus callosum, nearer the latter than the former in the present case.

The Sylvian fissure is insignificant, the fissura rhinalis being continuous with it before and behind.

The small size of the optic and the olfactory nerves, and the not great development of the corpora quadrigemina, are sufficiently emphasized by Gratiolet to require no further mention.

If the view here adopted is not the correct one, and what is above described as the lateral fissure is the suprasylvian, then the brain of the Hippopotamus differs from that of all allied forms in the *immense* breadth of the interval between the Sylvian and the suprasylvian fissures, a breadth not to be explained upon any known hypothesis, and opposed by what is found in *Hippopotamus liberiensis*. There are no analogies, also, in favour of what would then be the correspondingly peculiar narrow interval between the splenial and suprasylvian fissures.

Looked at generally, the brain of the Hippopotamus is evidently very different from that of the genus *Sus* and its nearest allies. In the great breadth and complicatedness of what, in my paper on the brain of the Sumatran Rhinoceros,* I term "the middle oblique convolution" (that between the lateral and suprasylvian fissures), it most resembles the Camels and the Giraffe, from the form of which it strikingly differs in the much less "pronation," as Dr. Krueg terms it,† of the hemisphere. On the whole, it stands very much by itself. Page 16.

The enormous stomach, with an axial length of 11 feet, is identical

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* "Transactions of the Zoological Society," vol. X. p. 411. (*Suprà*, p. 143.)

† By this "pronation" or "supination" of the brain is meant the degree of, as it were, inward or outward rotation of the surface which allows less or more of the surface between the corpus callosum and the suprasylvian fissures to appear superficially.

in all respects with the beautifully mounted specimen of a new-born individual in the Museum of the College of Surgeons, the latter, in its long cylindrical bottle, agreeing with that removed from the abdomen of the adult by me in position also, its axis being longitudinal, the pylorus being situated almost in the pelvis. I could find no confirmation of the peculiar positions of the different parts described by Mr. J. W. Clark in his specimen.* Along the greater curvature the stomach measures 15 feet. The upper (or vertebrad) compartment is 31 inches in axial length; the second or lower, 44 inches, with a circumference of 45 inches in its broadest part. The cylindrical third stomach is 9 feet 2 inches in axial length, with an average circumference of 40 inches; there are six transverse folds of its mucous membrane. The œsophagus is 9½ inches in circumference.

The small intestine is 147·5 feet in length, and 5 inches in circumference. The large intestine is 21·5 feet in length, and 9 inches round. No colic cæcum is developed.

The liver of the adult is quite different from that of the new-born animal. It is extremely simple, elongate transversely, and narrow from above downwards. Its extreme transverse length is 39·25 inches, whilst its average measurement from vertebral to ventral margin is 16 inches, never exceeding 16·5 inches. There are no fissures, but from the position of the very small umbilical notch it is evident that the left lobe is much the more developed of the two. With this is associated the peculiarity of the position of the gall-bladder, which, from the normally situated portal fissure runs directly *outwards* to the right. The gall-bladder is 2 feet long, its globose fundus projecting free 5 inches beyond the right margin of the liver. There is no trace of a Spigelian lobe, whilst the caudate is represented by a prismatic thickening, with a minute free apex in the position of the lobe when Page 17. more largely developed. The suspensory ligament had disappeared. The margins of the liver are unbroken; and its oblong shape [rounded at the angles] is only slightly disturbed by a slight extra development upwards [vertebrad] of its left extremity.

This liver does not at all agree with that of *Sus* or its allies, so fully described by Prof. Flower in his Hunterian Lectures of 1872.*

DESCRIPTION OF THE PLATES.

PLATE 32. (III.)

Fig. 1. Brain of Hippopotamus, seen from above.
Fig. 2. The same, from below.

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* "Proceedings of the Zoological Society," 1872, p. 185.

† "Medical Times and Gazette," Sept. 21, 1872, p. 319.

PLATE 33. (IV.)

Fig. 1. View of right half of brain, from outside.
Fig. 2. View of the left half, from the inside.
Fig. 3. View of left half, from the outside.

ss. Suprasylvian fissure.
ssa. Its anterior limb.
sss. Superior limb.
ssp. Posterior limb.
ssd. Descending limb.

84. NOTE ON THE MECHANISM OF RESPIRATION AS WELL AS OF THE RETRACTION OF THE HEAD AND LIMBS IN CERTAIN CHELONIA.*

FOR some time past I have been acquainted with the fact that in Page 649. Tortoises the movement of the limbs influences the degree of inflation of the lungs; and on one occasion I have been able, in a dead specimen of a large species, to blow out a candle by means of the current of air issuing from the nostrils consequent upon my forcibly pushing inwards one of the previously extended anterior limbs. From this I inferred that the rigidity of the thoracic and abdominal walls (which entirely precludes their being employed in respiration) is made up for by the great difference in the capacity of the thoracic and abdominal Page 650. cavities which results from differences in the degree of retraction of the limbs. And I also inferred that the activity of the respiratory movements—as in the Lobster, which has some of its larger gills connected with the bases of the ambulacral legs—must depend, in great measure, on the amount of the mechanical force employed in locomotion, in the same way that in the locomotive steam-engine the draught through the boiler-tubes of the furnace depends upon the rapidity of the movement of the engine, because the waste-steam pipe is made to open at the bottom of the funnel.

A specimen of *Trionyx perocellatus* (three and a half inches in length of carapace), which had died a day or two previously, lying on my dissecting-room table with its neck and limbs fully extended, I happened to take it up by the lateral margins of its shell, when, upon grasping it between my fingers and thumb, I noticed, to my surprise, that its head and limbs immediately retracted to their full extent. At

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* "Proceedings of the Zoological Society," 1879, pp. 649–50. Read, June 17, 1879.

first I was inclined to attribute the movement to the persistence of muscular irritability in the recently dead individual, but, on making a cut into one of the limbs, found that this was not the case.

As frequently as I chose to extend the head and limbs to their full extent they so remained until the body was laterally compressed, whether it happened to be lying on its abdomen or on its back, or in any other position. Immediately it was pinched the limbs were completely withdrawn from view and the head fully retracted—the cervical region of the spine, from being straight, assuming the curve essential to the cephalic retraction.

To determine the mechanism of this unexpected movement was my next proceeding; and I made a small hole in the centre of the plastron which opened into the body-cavity. I then again, with the limbs and head extended, repeated the lateral compression, and found that they were no longer retracted as they had been previously, air rushing in at the newly-formed opening. Upon extending the head and limbs and closing the orifice, full retraction followed lateral compression, as at first. This experiment was repeated several times with the same result.

It then became evident that in laterally compressing the plastron (which in the extended condition projects beyond the margins of the carapace) its slight convexity is increased, and that this is associated with an augmentation of the capacity of the body-cavity, which, to fill the deficiency thus produced, causes an insucking of the head and limbs upon simple pneumatic principles. The retraction of the head and limbs is therefore nothing more than a movement of suction, and does not depend upon any important direct osteological or myological peculiarities of the animal.

Whether the creature is in the habit during life of employing this suction method of withdrawing itself with its shell is a question that I am not able to determine just now, as the number of Soft Tortoises living at the present time in the Society's Gardens is reduced to a single large Egyptian *Trionyx*, which is unmanageable and of a more rigid build than the one above described.

85. NOTES ON THE ANATOMY OF *PELECANOIDES* (*PUFFINURIA*) *URINATRIX*.*

It being my good fortune to have had the Procellariidæ which were preserved in spirit during the "Challenger" Expedition placed in my hands, I take the present opportunity to describe some points in the anatomy of *Pelecanoïdes urinatrix*, one of the most interesting of the species.

I may mention that since writing my paper "On Certain Muscles of Birds, and their value in Classification," I have changed my views as to the affinities of the Procellariidæ. In that communication† I place the family amongst the Anseriformes: now it is evident to me that it is with the Ciconiiformes that they are most intimately related. Reasons for my change of opinion will be found in what here follows.

The Procellariidæ may be divided into the Storm-Petrels or Thalassidrominæ, and the true Petrels or Œstrelatinæ, the former differing from the latter in possessing the accessory semitendinosus muscle. *Pelecanoïdes urinatrix* lacking this muscle must be placed with the Œstrelatinæ. The semitendinosus is present in all the Procellariidæ, *Pelecanoïdes* included. The same may be said of the femoro-caudal: but with reference to the accessory femoro-caudal *Pelecanoïdes* differs from all its allies, as far as my experience goes, except *Bulweria columbina*, in not possessing it.

In all the genera of Œstrelatinæ with which I am acquainted, including *Diomedea*, *Œstrelata*, *Daption*, *Pagodroma*, *Bulweria*, *Ossifraga*, *Thalassœca*, *Puffinus*, and *Prion*, the ambiens muscle is present, but it is wanting in *Pelecanoïdes*, as it is in *Thalassidroma fregata*‡ amongst the Thalassidrominæ.

A peculiarity in the arrangement of the vessels of the groin is constant in *Pelecanoïdes*. In birds generally the femoral vein on entering the thigh traverses obliquely downwards and forwards to

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* [This paper was never published, but having found it in its present state amongst the MS. papers of the author, I have thought it worth while to print it here, as, though manifestly incomplete, it contains one or two important facts. It was written during the spring or early summer of 1879.—Ed.]

† "Proceedings of the Zoological Society," 1874, p. 117. (*Suprà*, p. 214.)

‡ [The birds so called here and elsewhere (*suprà*, pp. 175 and 204) are, as I have lately shown ("Proceedings of the Zoological Society," 1881, June 21st), specimens of the *Thalassidroma nereis* of Gould, which I have made the type of a new genus, *Garrodia*, in memory of the author of these papers.—Ed.]

reach the sciatic artery, with which it then runs parallel to the knee. It crosses the femur on the inner side of that bone, and passes *internal* to the tendon of the femoro-caudal muscle, in such a way that on dissecting the subfemoral region (the femur being assumed to be at right angles with the tibia, and parallel with the ground) from the outer side of the thigh, after the biceps cruris is turned back, the femoral vein is seen to emerge from the *anterior* margin of the femoro-caudal tendon, quite close to its insertion into the femur. In *Pelecanoïdes* the femoral vein always runs *external* to the femoro-caudal tendon, so that in the dissection just described it is seen to cross it, instead of being crossed by it. In no other Procellarian with which I am acquainted does this condition obtain; the only other bird in which I have found a similar condition being *Dacelo gigantea* amongst the Alcedinidæ.*

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* *Vide* "Proceedings of the Zoological Society," 1873, p. 629. (*Suprà*, p. 191.)

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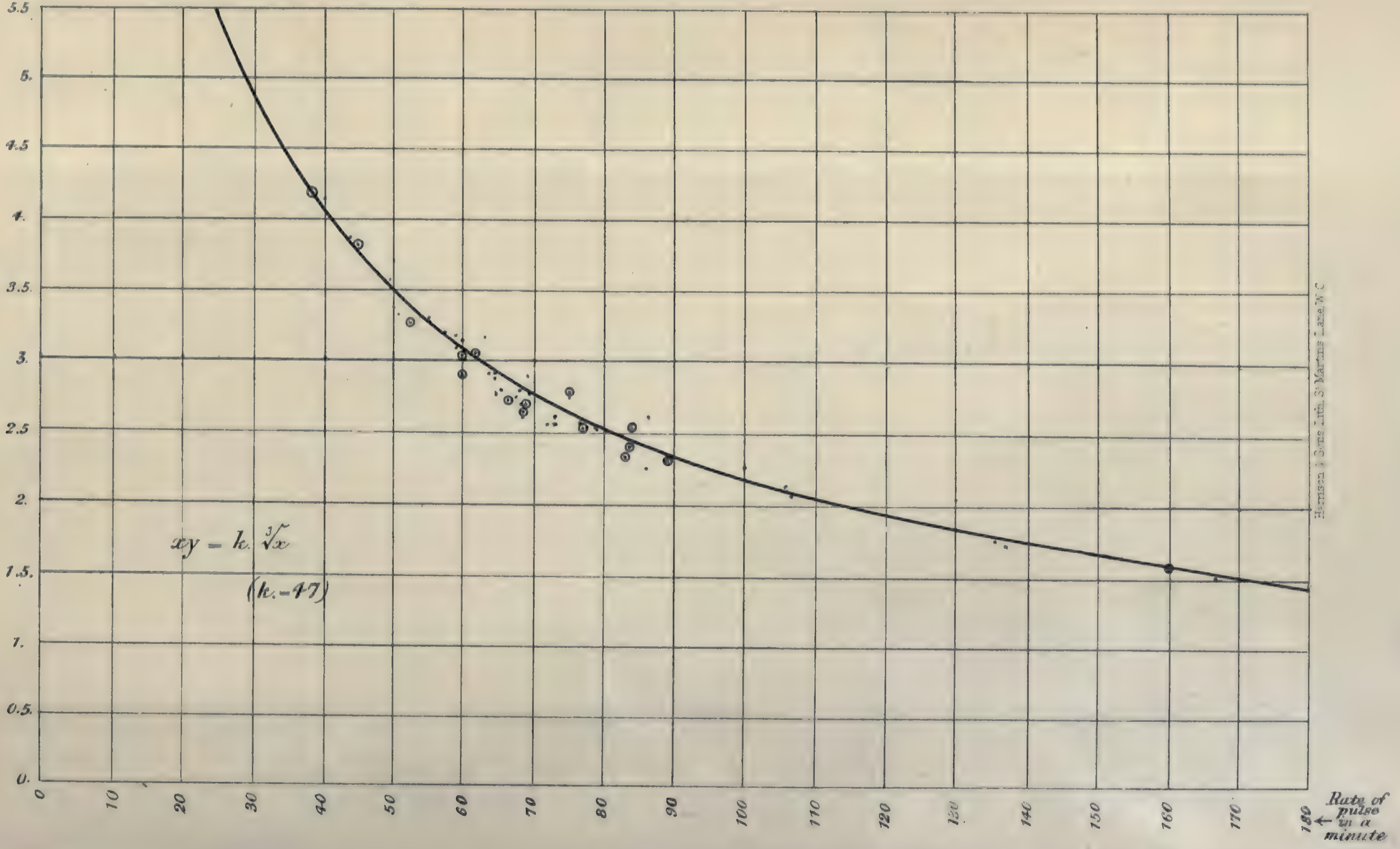
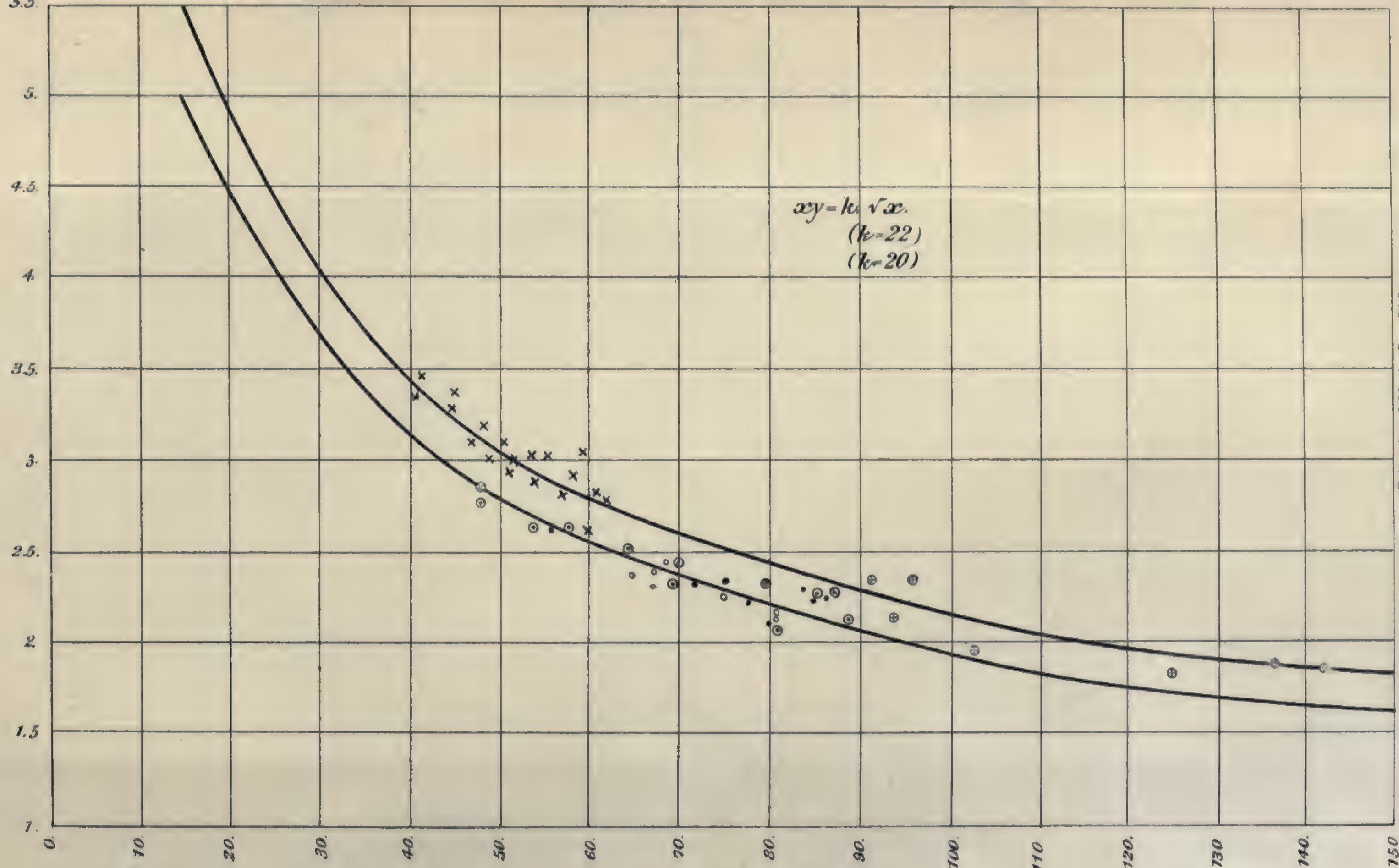
HARRISON AND SONS, PRINTERS IN ORDINARY TO HER MAJESTY, ST. MARTIN'S LANE.



Harrison & Sons Lith. St Martins Lane, W.C.



Harrison & Sons, Lith. St Martins Lane. W.C.

Fi

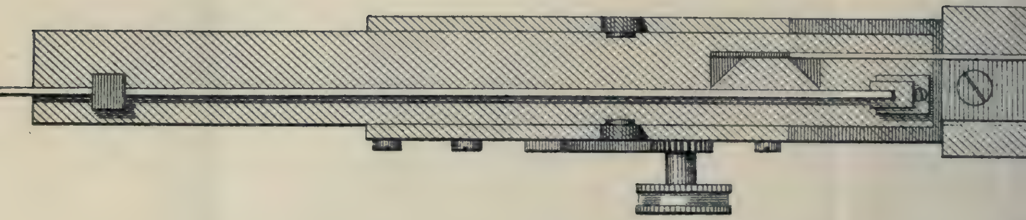


Fig. 2.

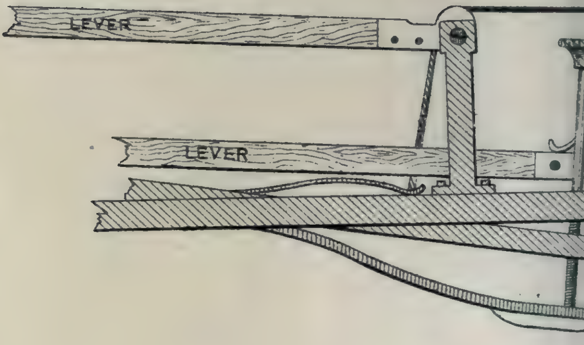
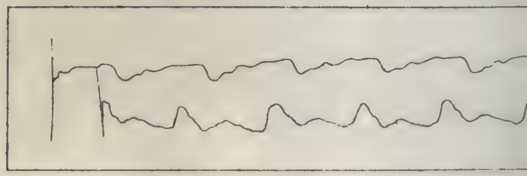


Fig. 4.



Harrison & Sons, Lith. St Mar

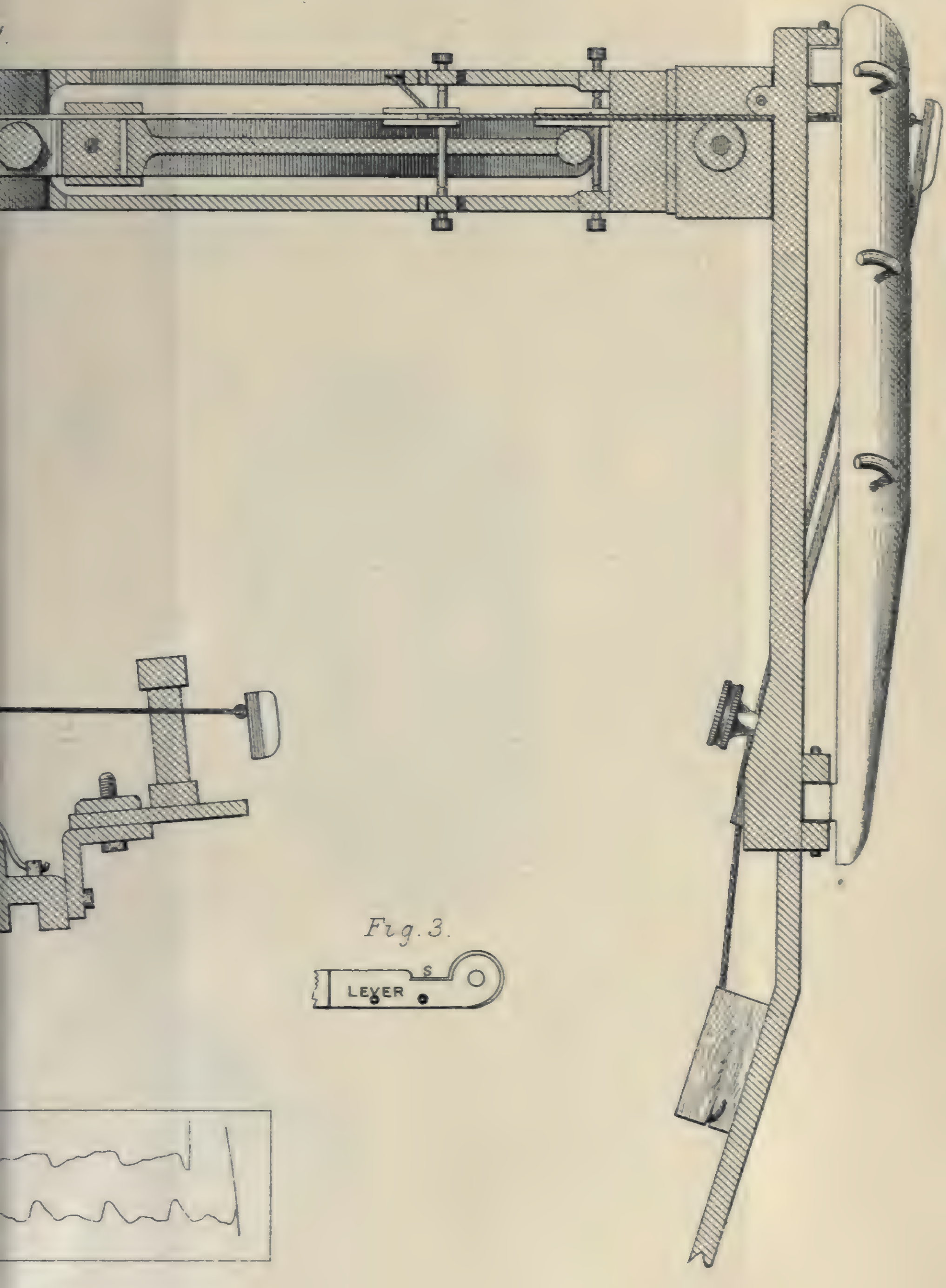
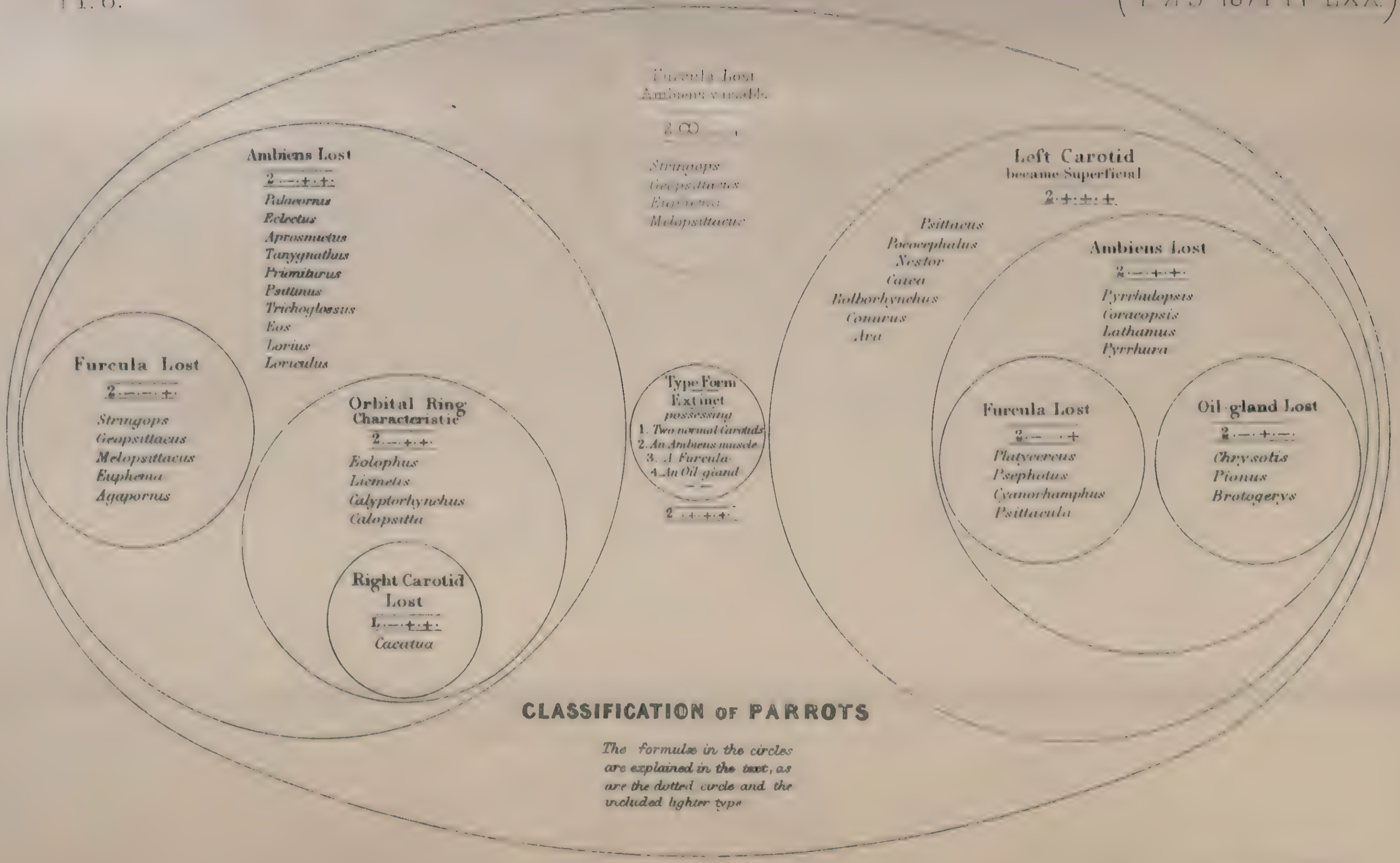


Fig. 3.

ne.W.C



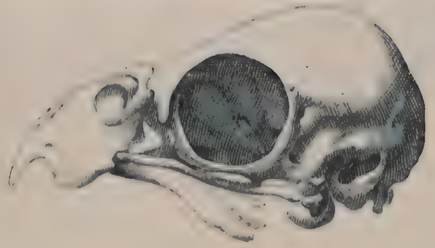
CLASSIFICATION OF PARROTS

The formulæ in the circles are explained in the text, as are the dotted circle and the included lighter type

Engraved by Edw^d Weller

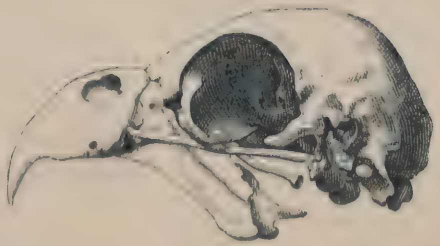
Pl. 7

(P. Z. S. 1874. Pl. LXXI.)



EOLOPHUS ROSEICAPILLUS

Shewing the complete orbital ring with the extra temporal process characteristic of the Cacatuinæ

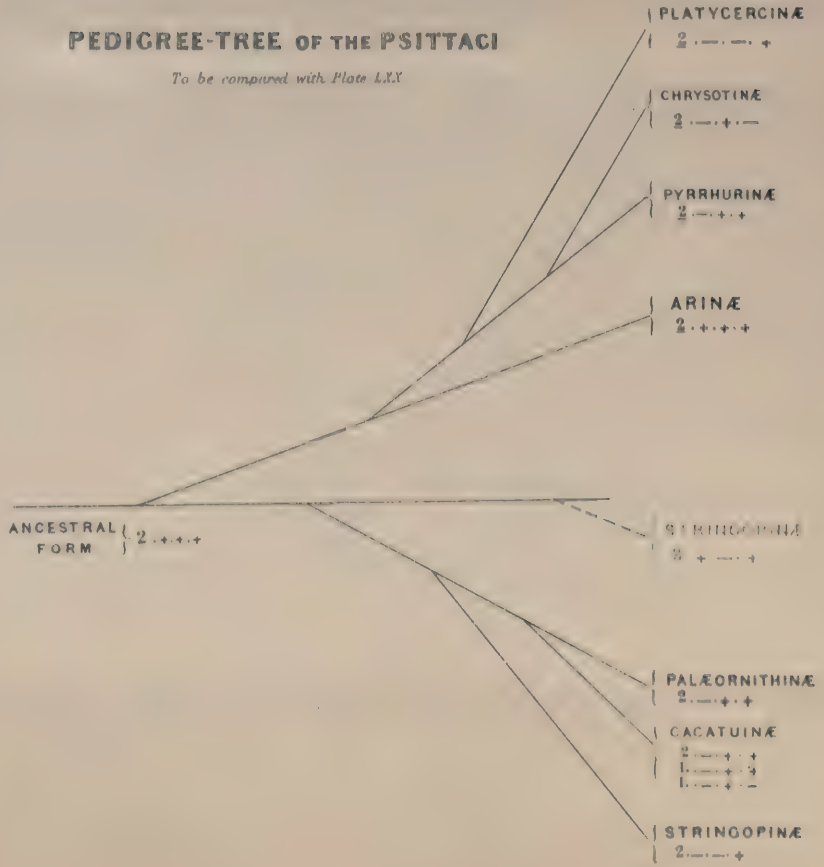


PYRRHULOPSIS SPLENDENS

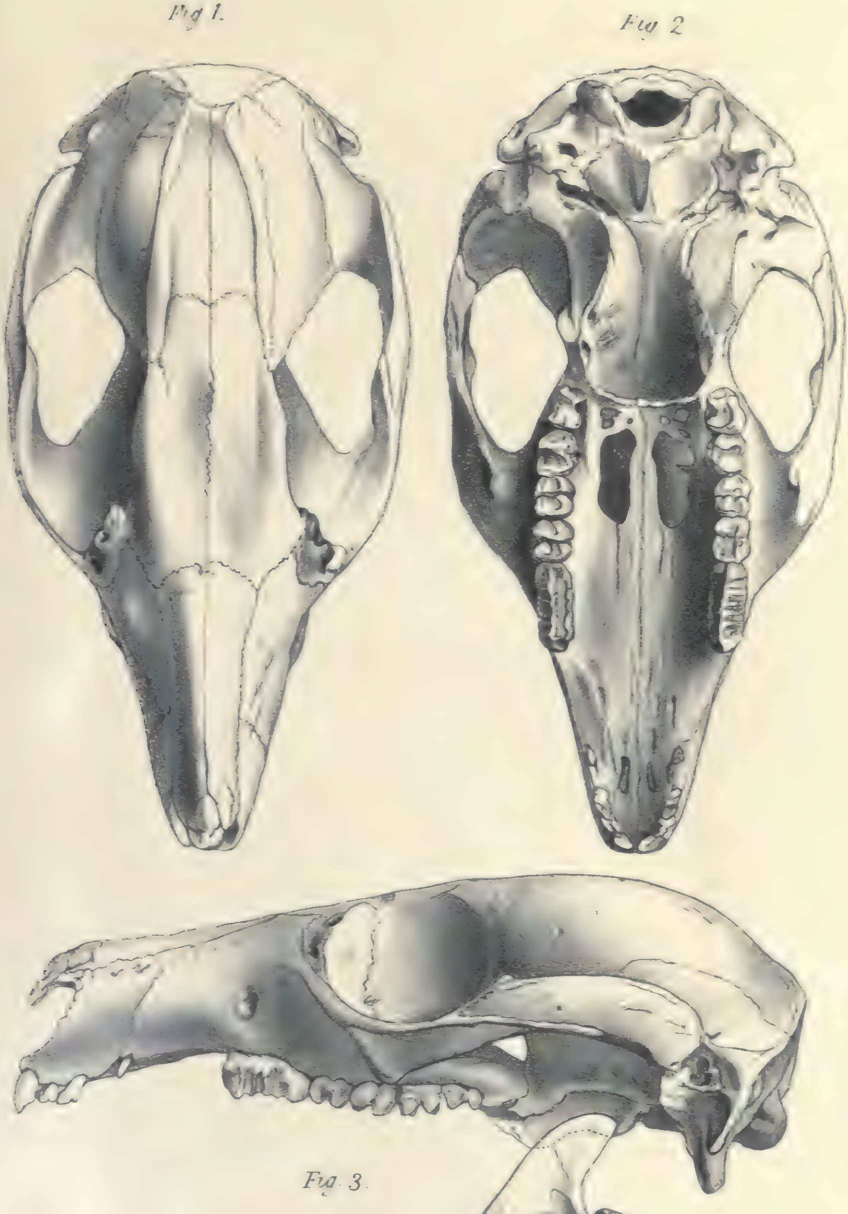
Shewing the incomplete orbital ring & the absence of the temporal process

PEDIGREE-TREE OF THE PSITTACI

To be compared with Plate LXX



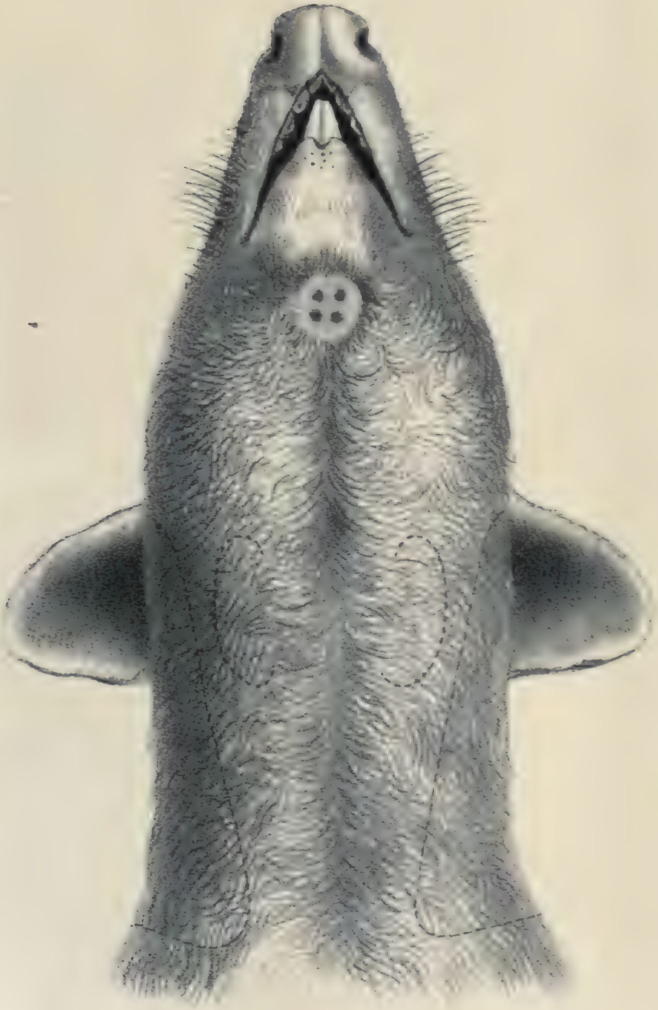
(P. Z. S. 1875. Pl. VII)



J. Smit lith.

Hanhart imp.

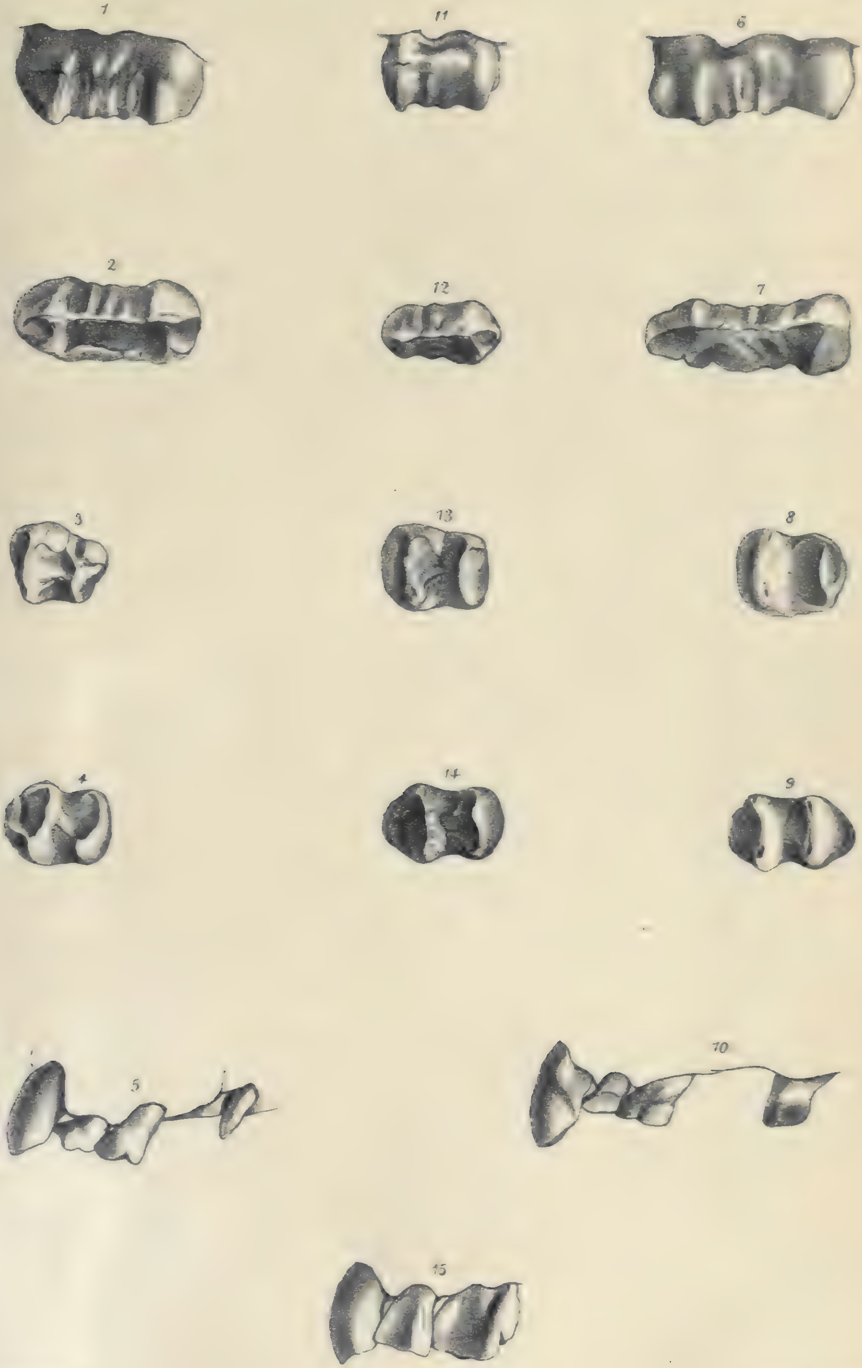
SKULL OF DORCOPSIS LUCTUOSA



J Smit lith

Hanhart imp

SUBMAXILLARY REGION OF DORCOPSIS LUCTUOSA



J Smit lith.
Hanhart imp

1_5 TEETH OF DORCOPSIS LUCTUOSA
6_10 „ „ „ MULLERI.
11_15 „ MACROPUS BRUNII.

Pl.11.

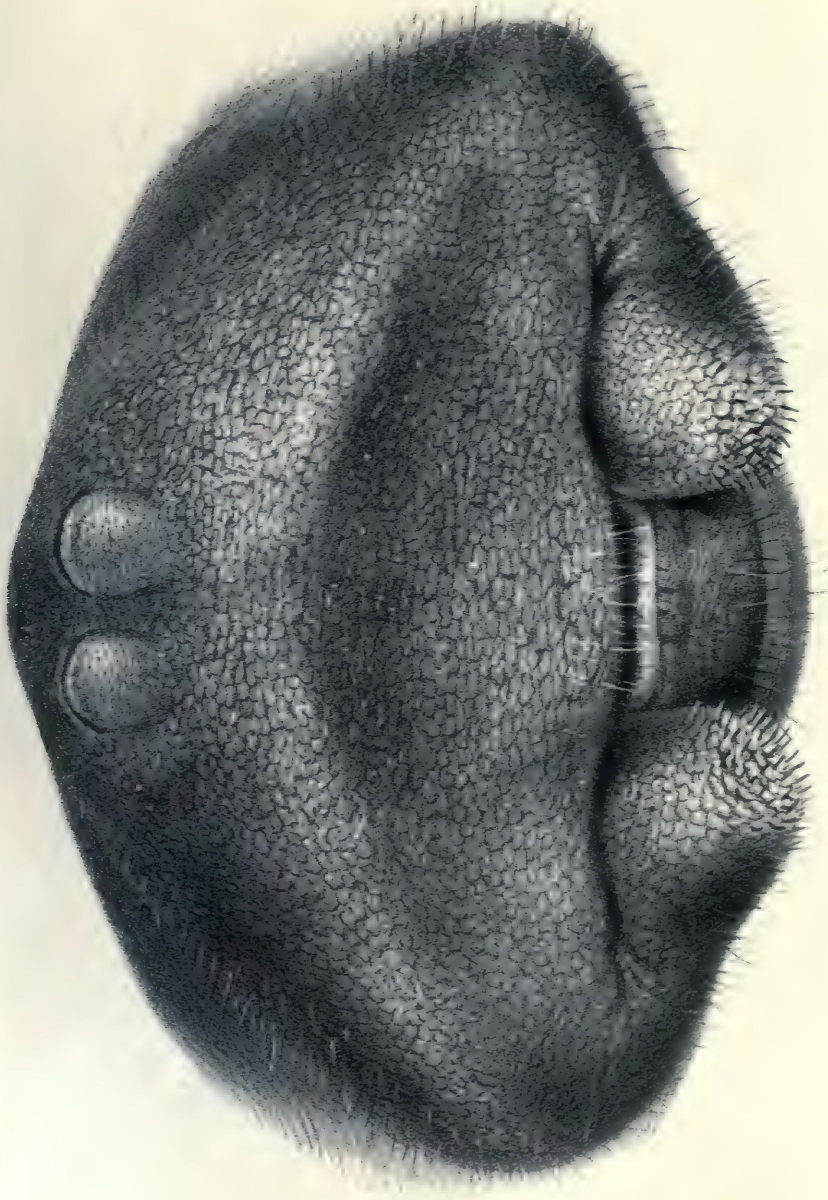
1.

J Smit lith.

1. MANATUS AMERICAN
2 „ „

(Trans Zool Soc Vol 10 Pl XXVIII)

2

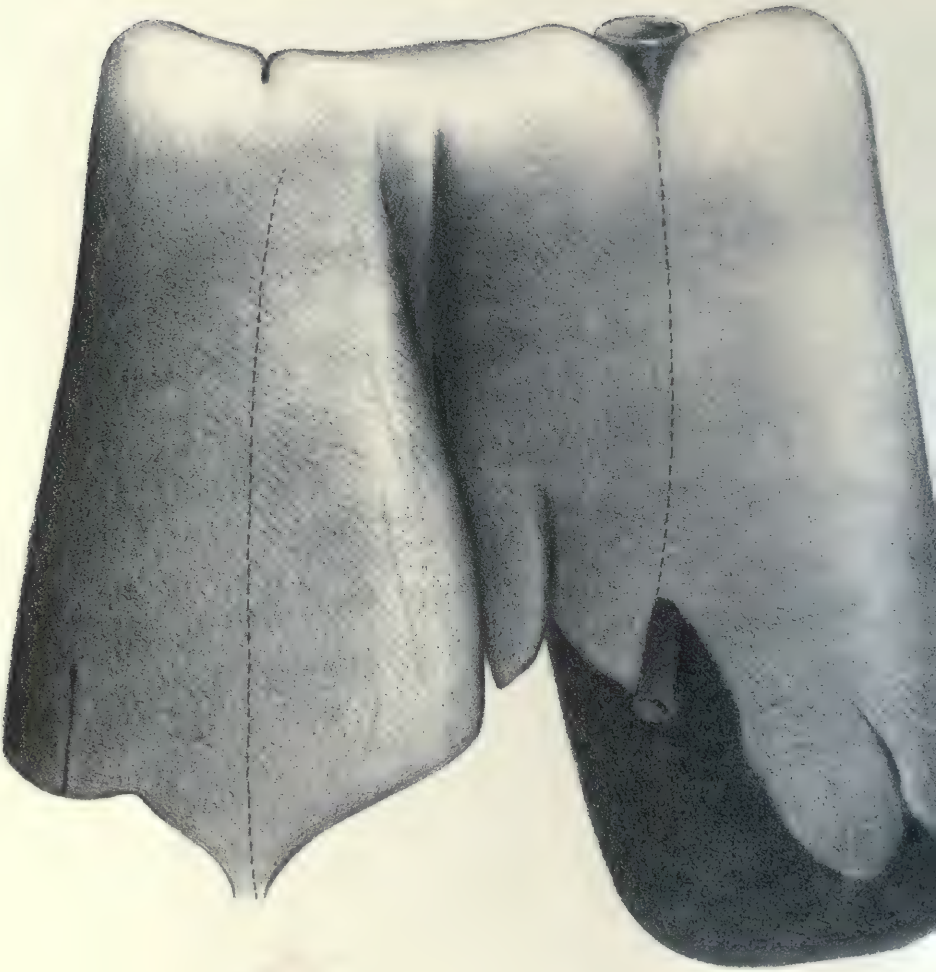


Hanhart imp

S, LIPS CONTRACTED
LIPS EXPANDED

Pl.12.

2



J.Smit lith.

LIVER OF M

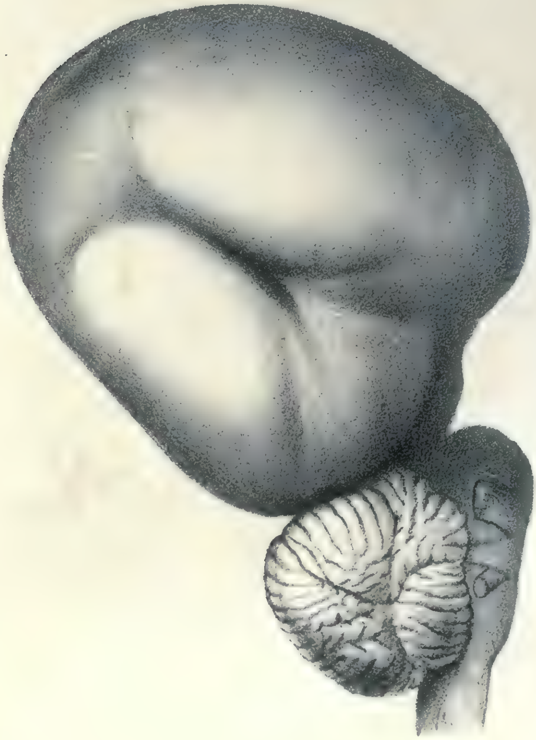
(Trans Zool Soc Vol 10, Pl XXIX)

1

Hanhart imp

TUS AMERICANUS

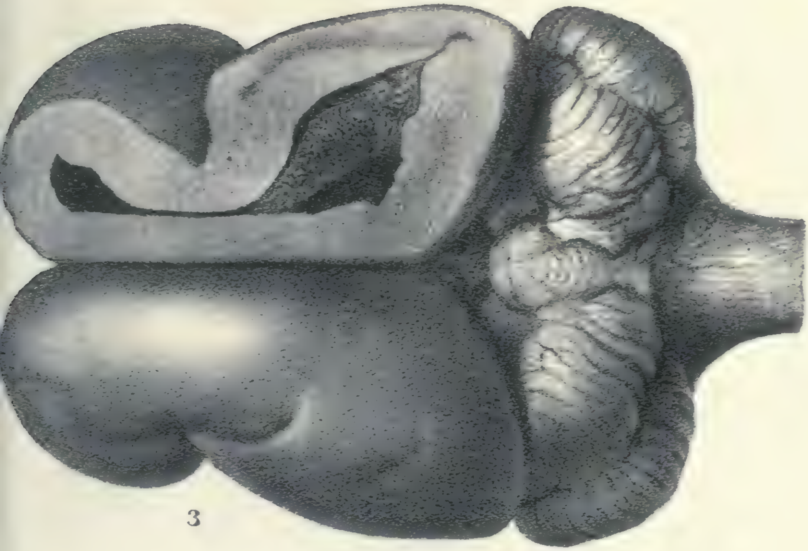
Pl.13.



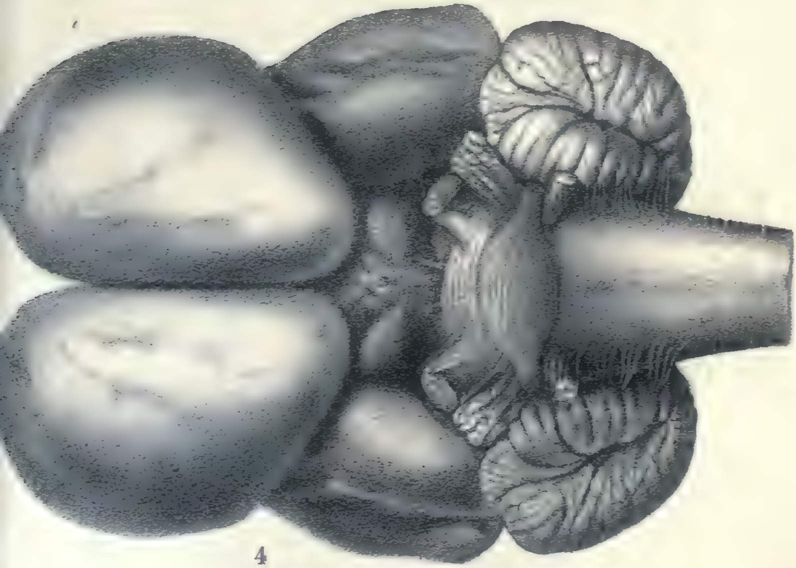
J.Smit lith

BRAIN OF

(Trans Zool Soc Vol 10 Pl XXX)



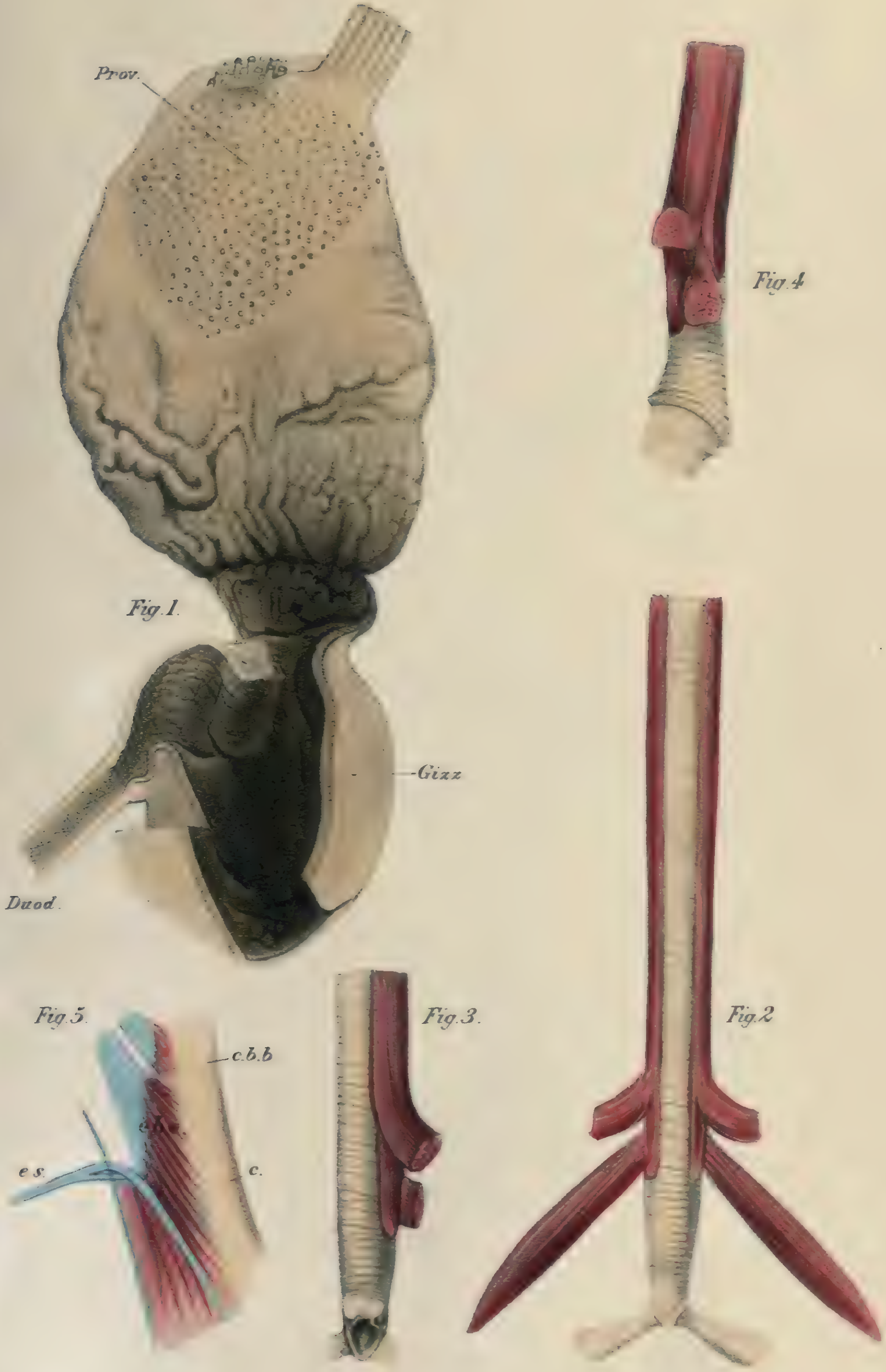
3



4

Hanhart imp.

ATUS AMERICANUS



J Smit lith

Hanhart imp

ANATOMY OF CHAUNA DERBIANA

Fig. 1.

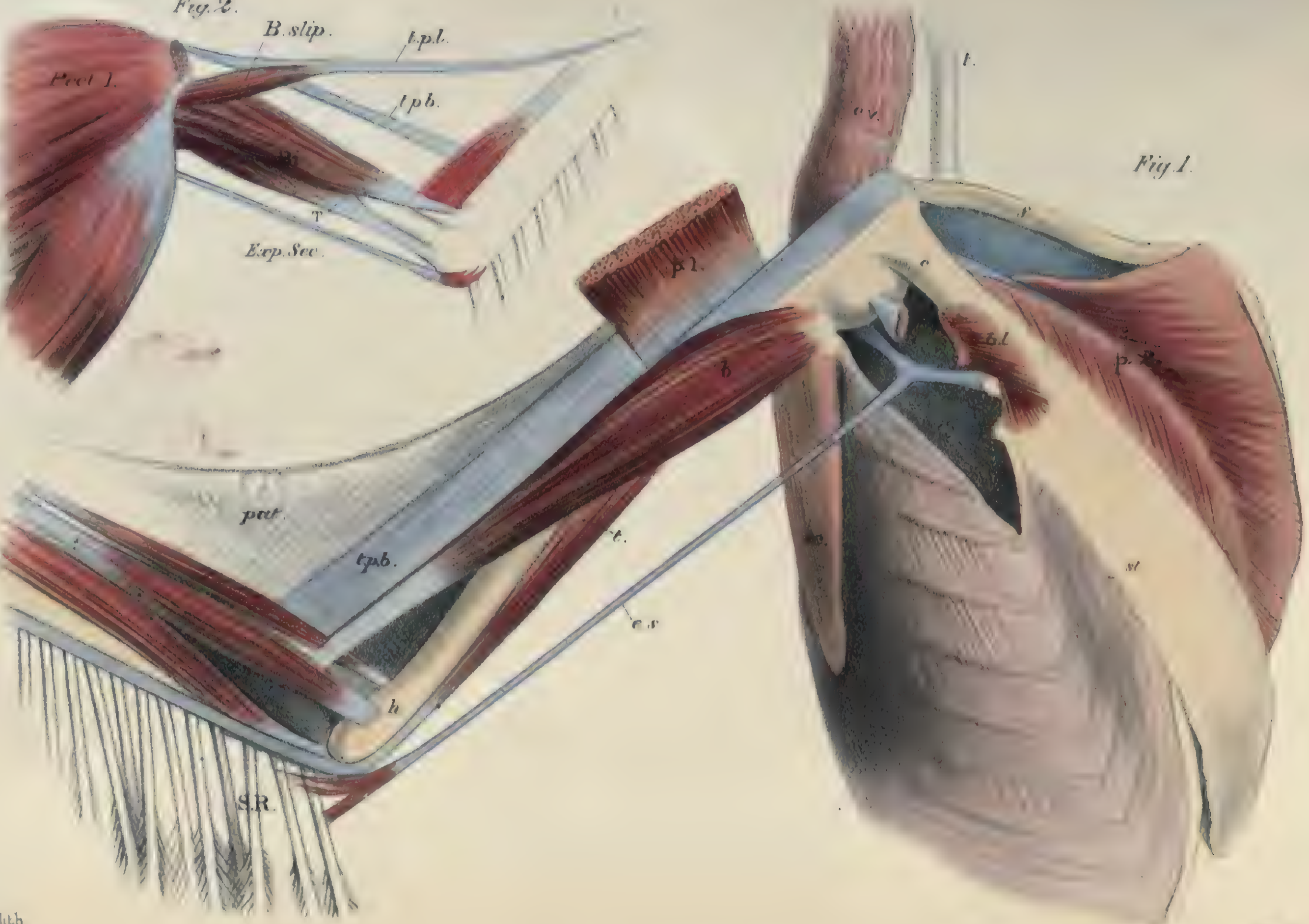
Fig. 2.

J. Smit lith.

Hanhart imp.

ANATOMY OF CHAUNA DERBIANA.

(P.Z.S.1876.Pl.XIV)



J.Smit lith.

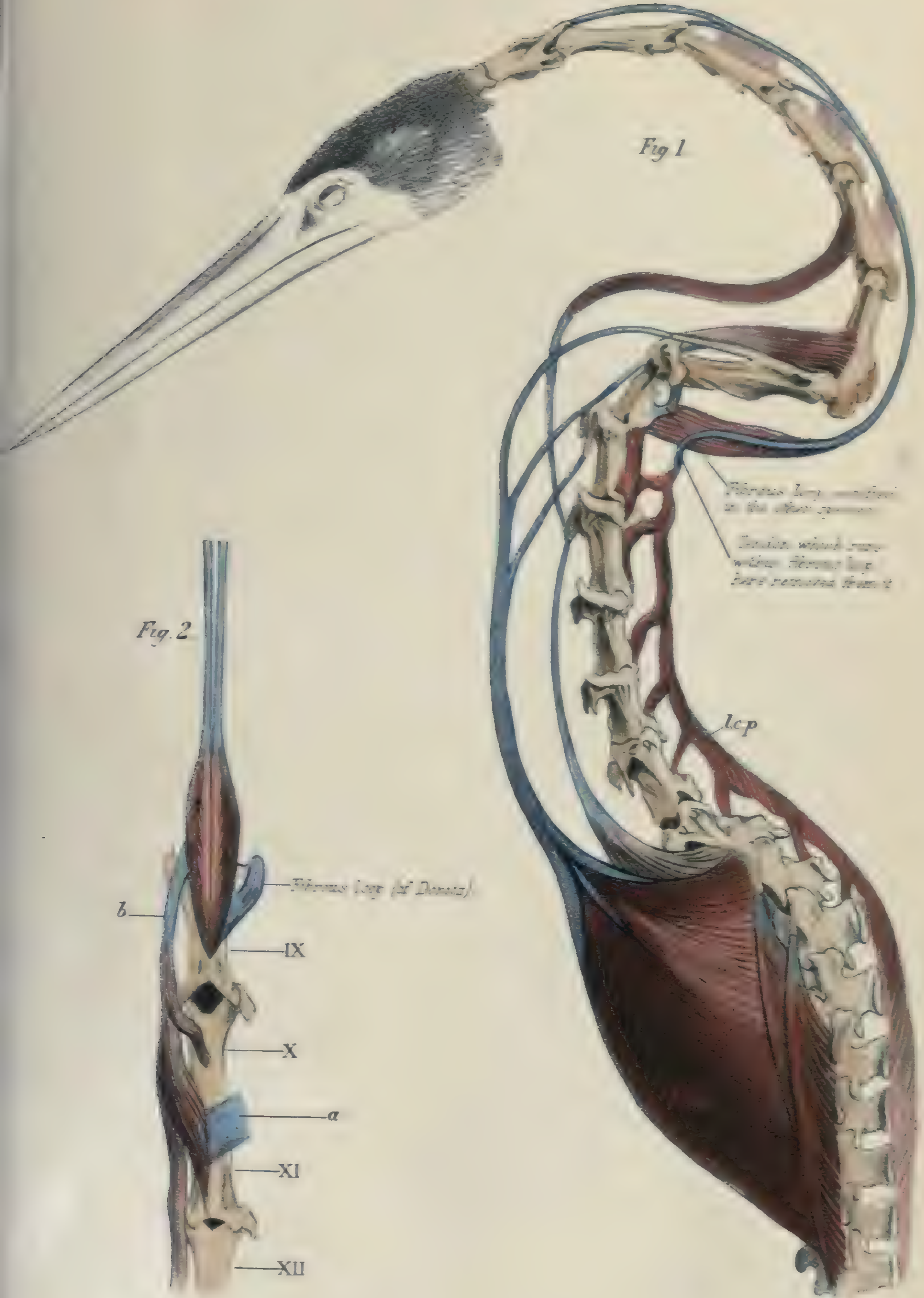
Hanhart imp.

ANATOMY OF CHAUNA DERBIANA.

Fig. 2.

Fig 1

ANATOMY OF CHAUNA DERBIANA



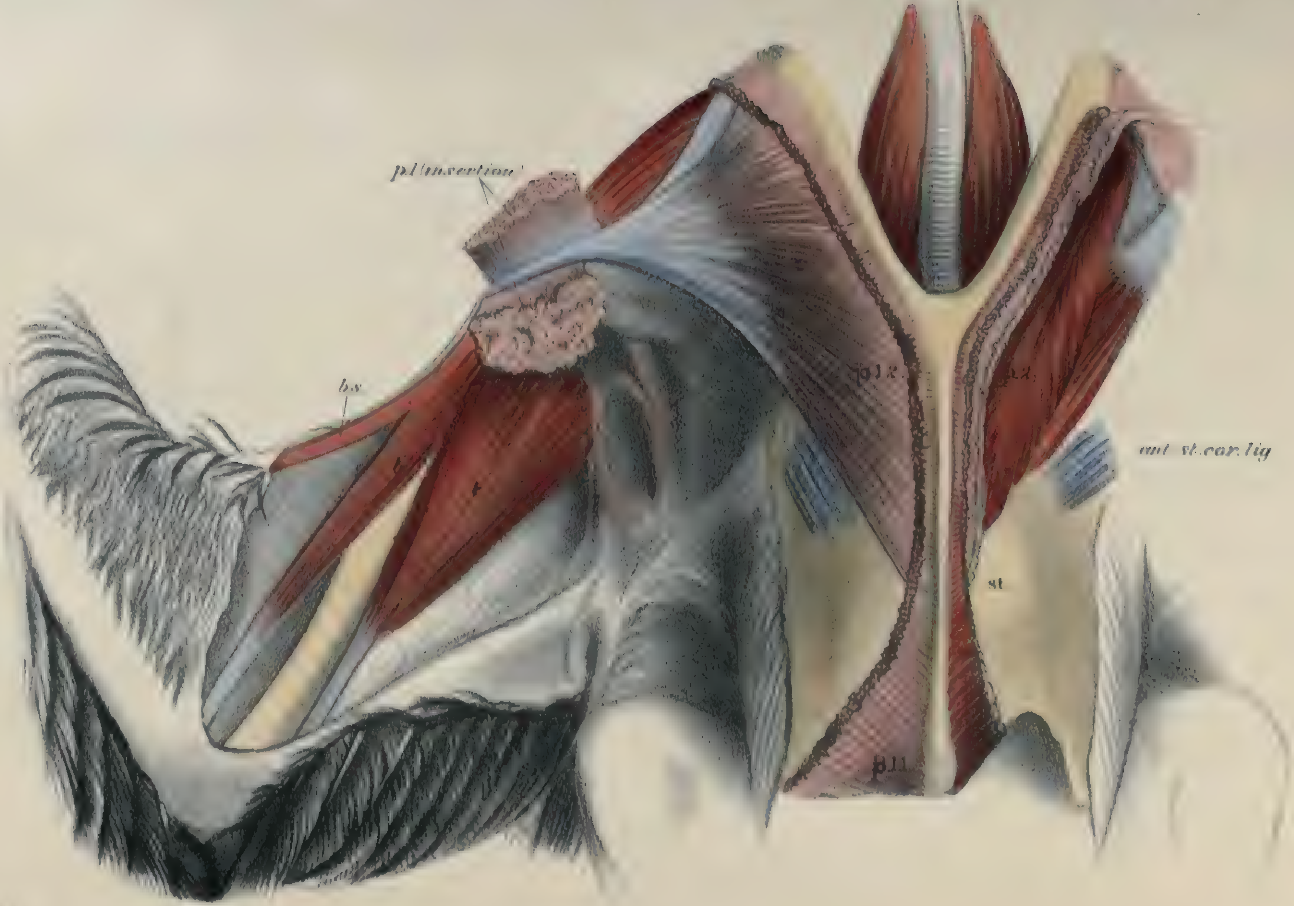
J Smit lith

Hanhart imp

ANATOMY OF PLOTUS ANHINGA

Pl 19

(P. Z. S. 1876, Pl. XXVII)



[illegible] lith

Hanhart imp.

ANATOMY OF PLOTUS ANHINGA

(P.Z S.1876 Pl XXXVIII.)

Fig 4.

Fig 1

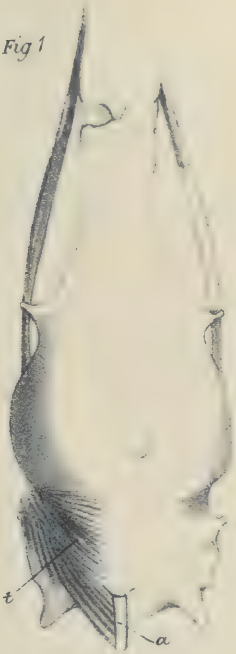


Fig 3.

Fig. 5

Fig 6.

Fig 2

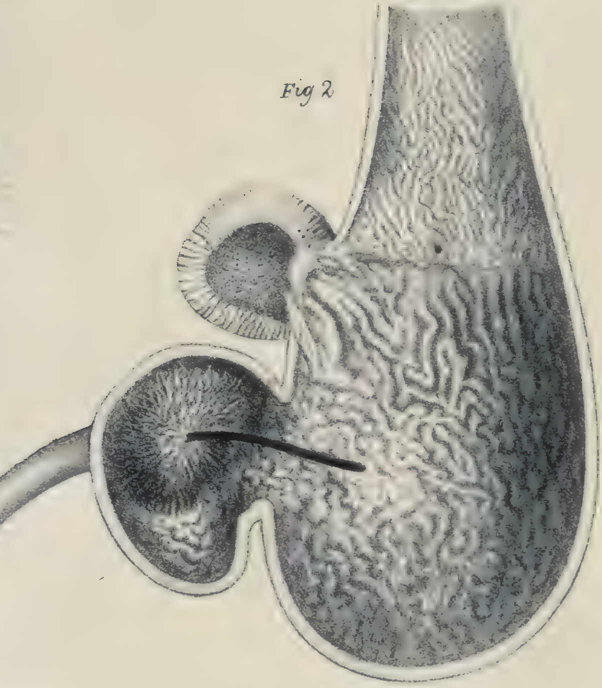


Fig 7

J. Smit lith.

Hanhart imp

ANATOMY OF PLOTUS ANHINGA

Fig. 1.

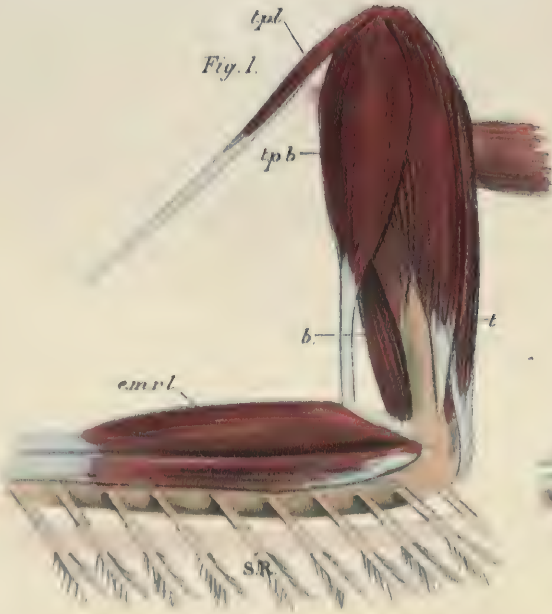


Fig. 2.

Fig. 3.

J Smit lith

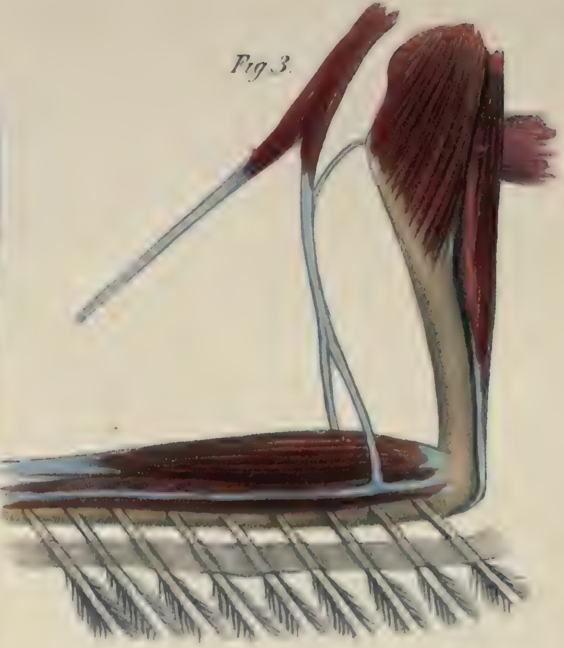
Hanhart imp

ANATOMY OF PASSERINE BIRDS

Fig 1

Fig. 2

Fig. 3.



J.Smit lith. Hanhart imp

ANATOMY OF PASSERINE BIRDS

Fig 1.

Fig 2.

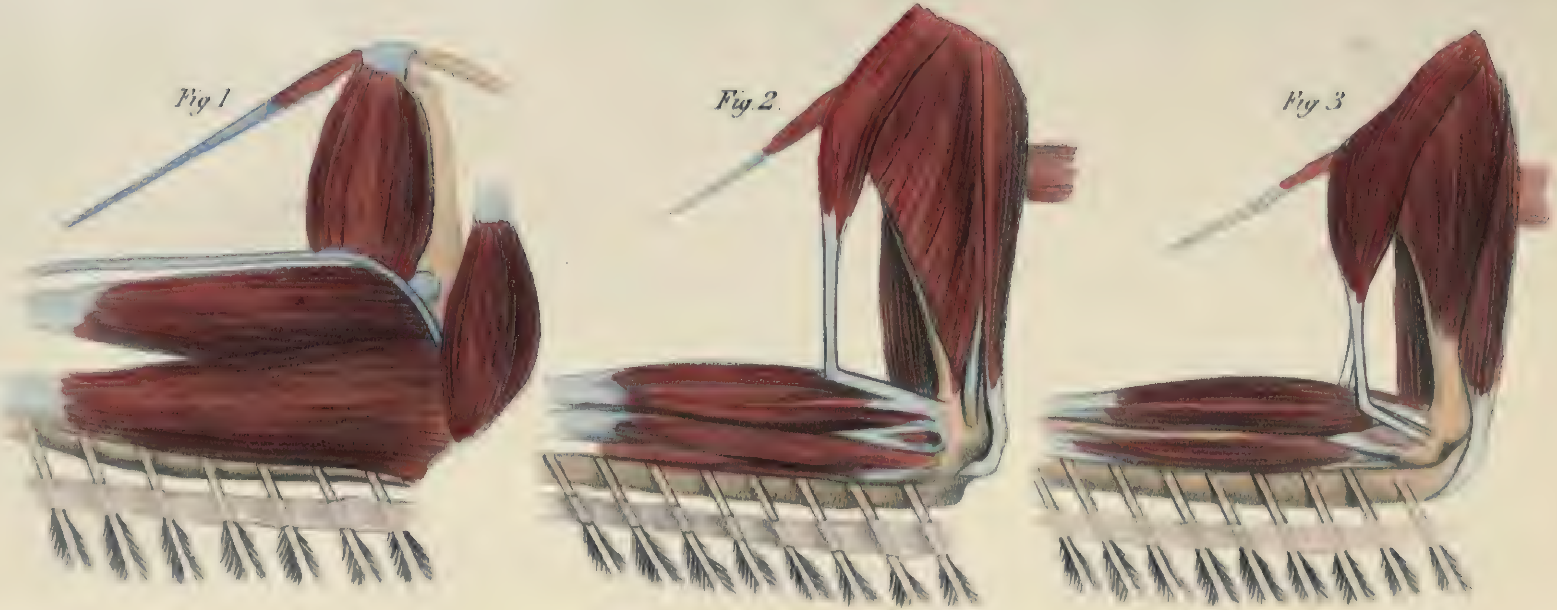
Fig. 3

J.Smit lith

Hanhart imp

ANATOMY OF PASSERINE BIRDS

(P.Z.S.1876.Pl.LI.)



J.Smit lith
Hanhart imp

ANATOMY OF PASSERINE BIRDS

Fig 1

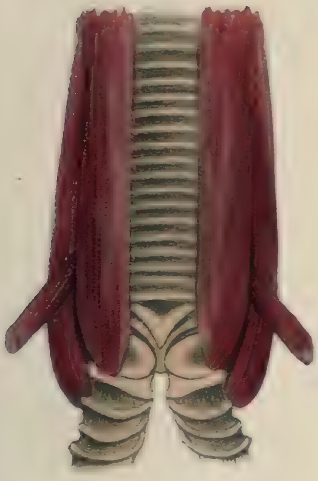


Fig. 2

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig 7.

J Smit lith. Hanhart imp

ANATOMY OF PASSERINE BIRDS

Fig. 1

Fig. 2

Fig. 3

Fig. 7

Fig. 8

Fig. 4

Fig. 5

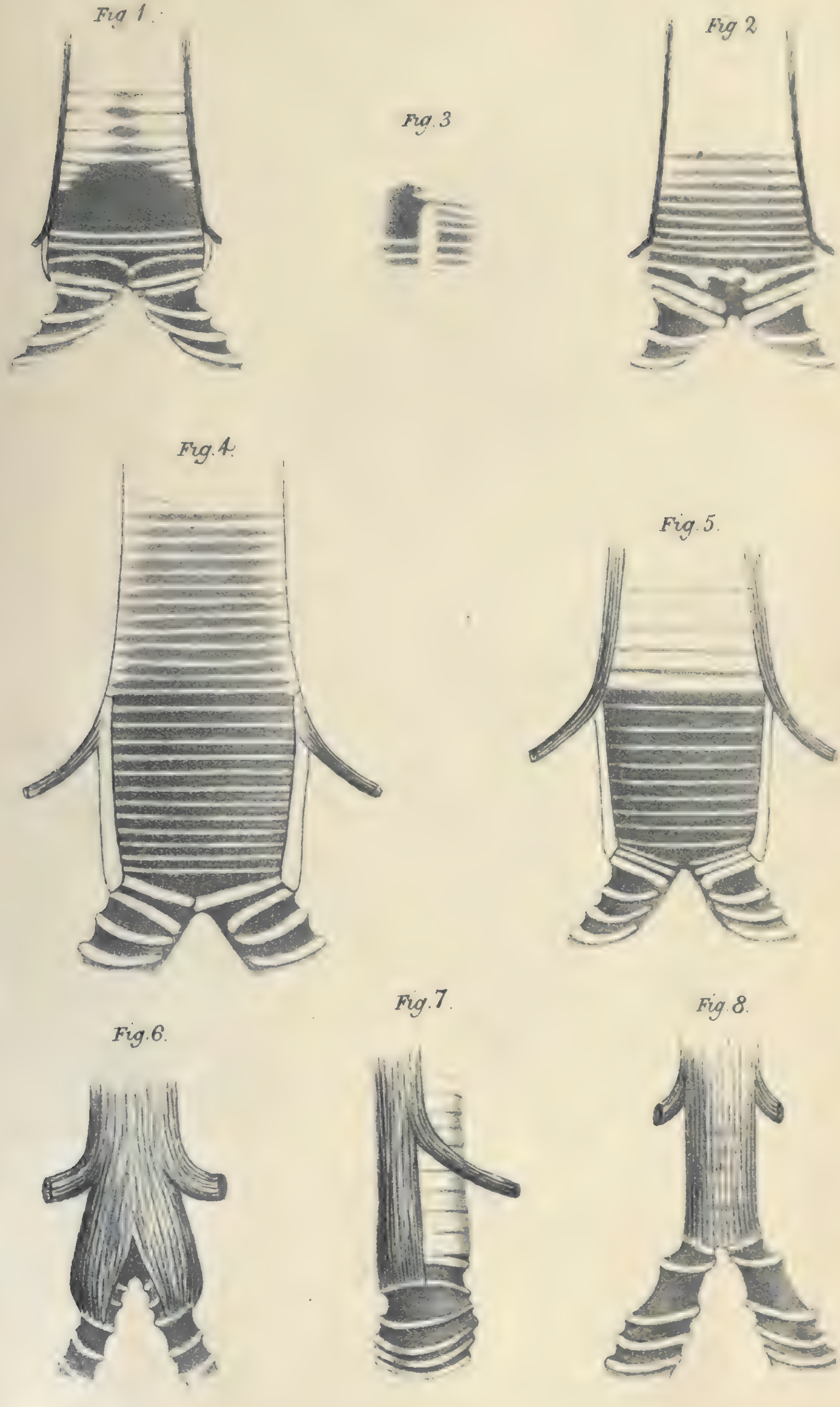
Fig. 6

J. Smit lith.

Hanhart imp.

ANATOMY OF PASSERINE BIRDS.

(P.Z.S. 1877 Pl LIII.)



J. Smit lith.
Hanhart imp.

ANATOMY OF PASSERINE BIRDS.

Pl 28

(P. Z. S. 1876. LXXVI.)

J. Smit lith.

Hanhart imp.

HEAD OF LOPHOTRAGUS MICHIANUS, ♂ juv.

Fig. 1.

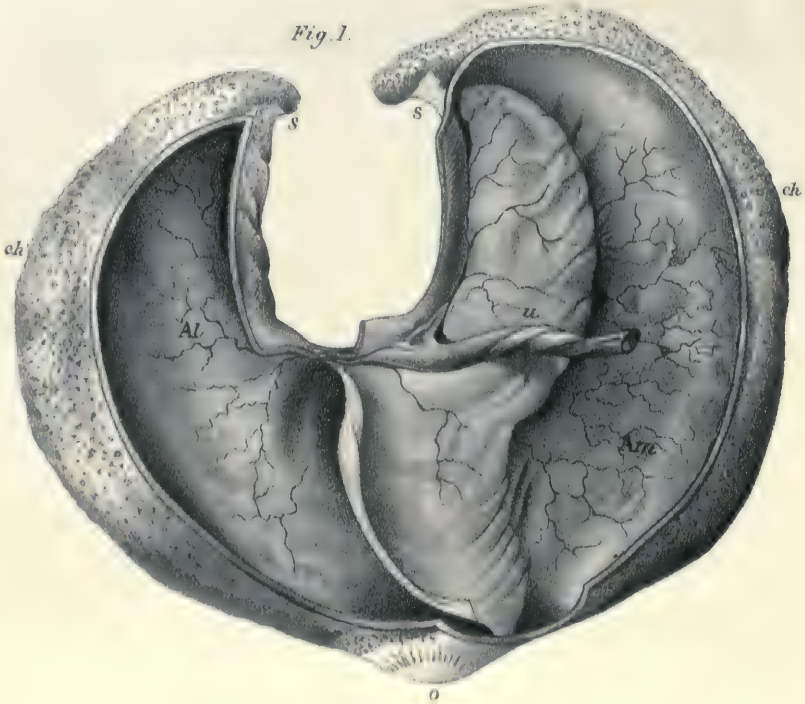
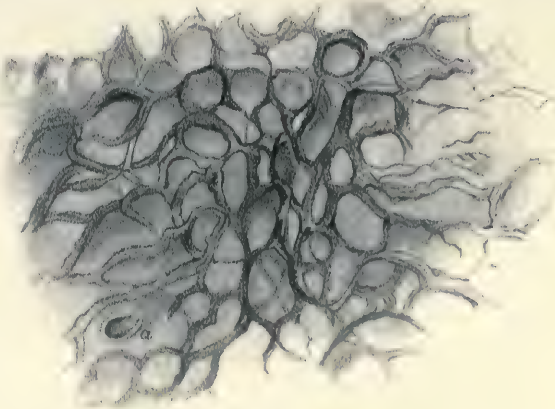


Fig. 2.



J. Smit lith.

Hanhart imp.

ANATOMY OF HYOMOSCHUS

Pl 30

(P Z S 1879 Pl XXIX)

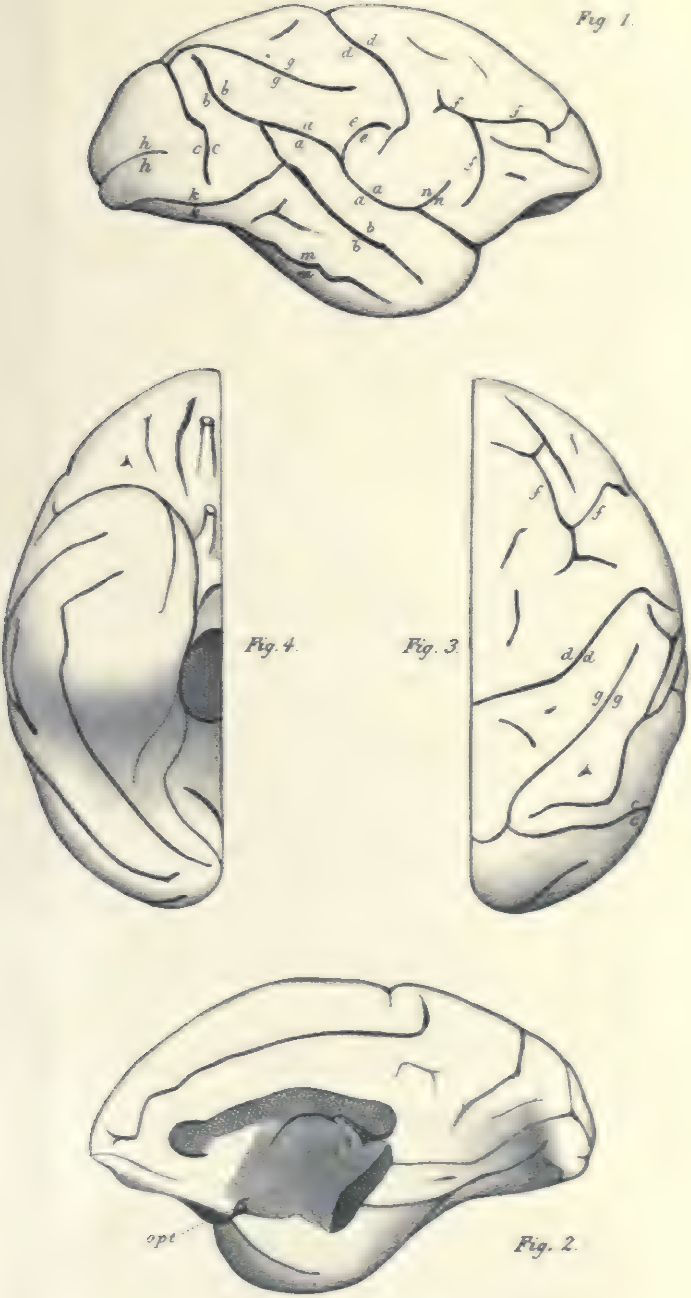
J Smit lith.

Hanhart imp.

HELICTIS SUBAURANTIACA

Pl. 31.

(P. Z. S. 1879. Pl. XXXVIII.)



J. Smit lith.

Hanhart imp.

BRAIN OF GELADA RUPPELLI.

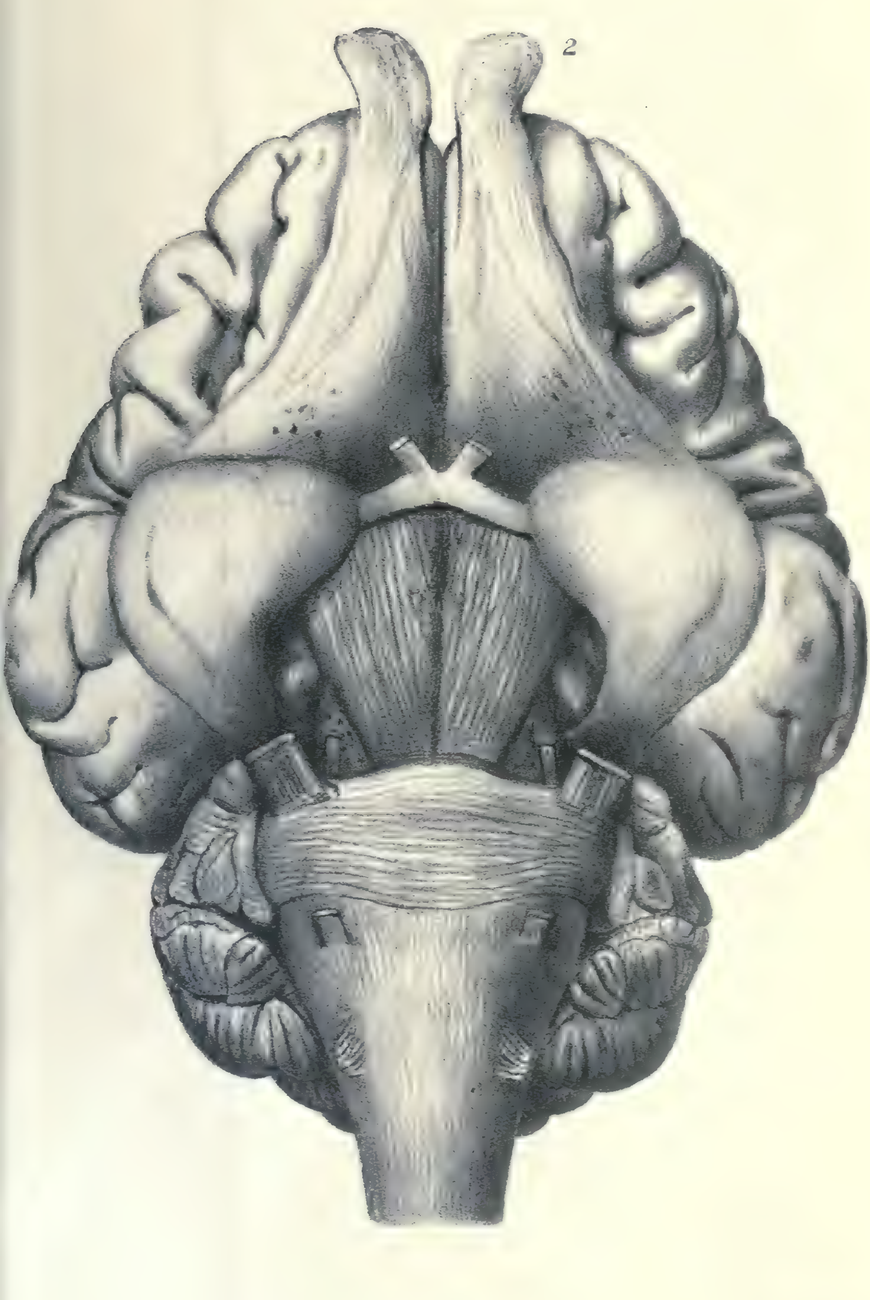
Pl.32.

J.Smit lith

BRAIN OF

(Trans Zool Soc Vol XI Pl 3)

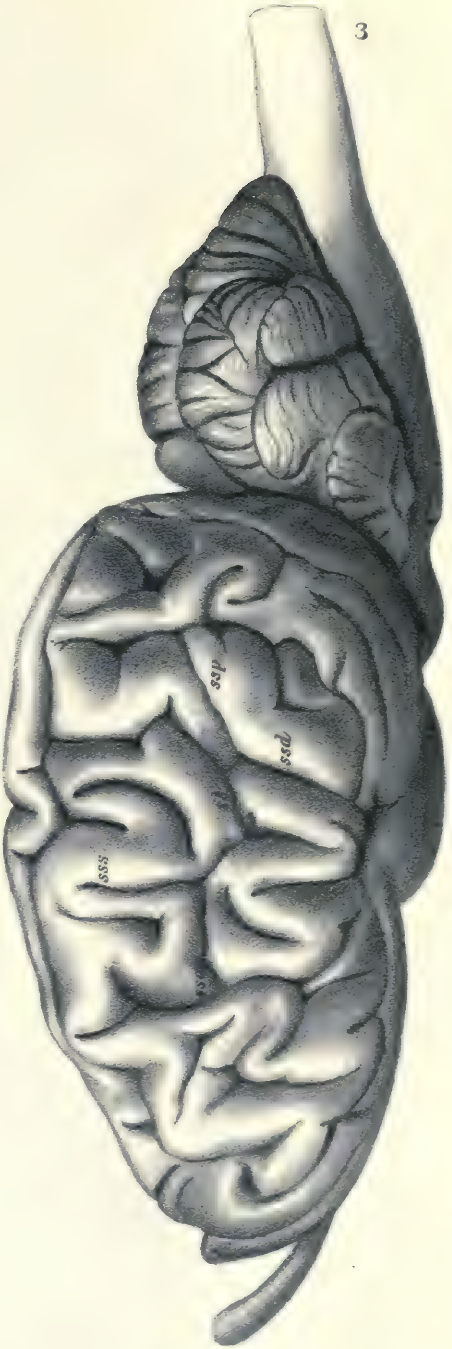
2



Hanhart imp

POPOTAMUS

(Trans Zool Soc Vol. XI Pl. 4)



Hanhart imp

Garrod, Alfred Henry
Collected scientific papers; ed. by
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