ADDRESS

DELIVERED AT

THE ANNIVERSARY MEETING

OF THE

GEOLOGICAL SOCIETY OF LONDON,

On the 15th of FEBRUARY, 1878;

PREFACED BY

THE ANNOUNCEMENT OF THE AWARD

OF

THE WOLLASTON MEDAL,

THE PROCEEDS OF THE DONATION-FUND,

THE MURCHISON MEDAL

AND GEOLOGICAL FUND,

AND

THE LYELL MEDAL AND FUND

FOR THE SAME YEAR.

BY PROFESSOR P. MARTIN DUNCAN, M.B. (LOND.), F.R.S.,
PRESIDENT OF THE SOCIETY.

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PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

15TH FEBRUARY, 1878.

Award of the Wollaston Medal.

The Reports of the Council and of the Library and Museum Committee having been read, the President, Prof. P. Martin Duncan, M.B. (Lond.), F.R.S., presented the Wollaston Medal to Thomas Wright, M.D., F.R.S., F.G.S., addressing him as follows:—

Dr. Wright,—

It gives me very great pleasure to present this Medal to you, and to know that your name will be enrolled amongst those of the many distinguished men who, like yourself, have earned this distinction by long and successful labour in geological science. Your careful palæontological work amongst the Echinodermata of the Secondary rocks of England has been as interesting and important to those palæontologists who have followed you in the study, as your description of the Maltese Echinoidea. You have not only collected, but have described carefully some of the most important Mesozoic corals, and have clearly distinguished the succession of some local coral-reefs in the British area. Your stratigraphical labours amongst the Rhætic, Jurassic, and Oolitic formations have led to excellent results. Your classification of the great groups of Echinoidea has stood the test of time, and is still employed; and the descriptions and analyses of the species, illustrated so exquisitely, in the volumes of the Palæontographical Society are models of terse exactitude. Your determination of the correct relation of the Madreporic body to the antero-posterior axis of the Echinoid has been accepted by nearly every naturalist, and its bearing on the elucidation of the meaning of the apical system of the Saleniidæ is of much importance. The Council considers that your industry

and the excellent results of your study, establish your claim to this Medal, and I hope that its reception will not only stimulate you to further research, but will reward you for the sacrifices that every man who combines a scientific and a professional career has perforce to make.

Dr. Wright, in reply, said:—

Mr. President,—

I am deeply sensible of the very great honour the Council of the Geological Society has conferred in awarding me the Wollaston Medal, and I beg to return my most heartfelt thanks for their appreciation of my humble labours in palæontological studies. To be enrolled in the list of eminent men on whom this great distinction has been conferred is a position of which the most ambitious may well be proud, whilst the graceful and eulogistic phrases with which you, Mr. President, have conveyed the award, and the friendly greeting I have received from Fellows assembled here to-day, have all touched me exceedingly, and I can find no language adequate to express the sentiments of gratitude I experience on this occasion. It is at all times a pleasure to receive from our contemporaries working on the same line with ourselves a friendly estimate of our honest endeavours; but when the Council of this great Society, which counts among its Members some of the most learned masters of Geological Science, bestows its highest award as an acknowledgment of the worth of my scientific work, I confess how much indeed I appreciate the distinction, and how highly I value the prize.

You have kindly informed me that the Wollaston Medal has been awarded as a recognition of my detailed researches, continued through many years, on the structure, classification, and distribution of the fossil Echinodermata, published by the Palæontographical Society, and for other memoirs on the Jurassic and Tertiary strata of England. If my life is spared, the event of to-day will become a stimulus to renewed exertion in that path of scientific study in which I have plodded for the last thirty years. As much of that work has been carried out by the Palæontographical Society, perhaps you may allow me to say how much I consider the progress of Geology has been advanced by the splendidly illustrated volumes it has published. They form, indeed, a magnificent monument of unpaid voluntary effort in the cause of Science.

Let us never forget that much of the knowledge we have acquired in our researches concerning the mineral structure of the earth is due to Palæontology, and that the future of Geology will largely depend on its onward progress. The accurate description of organic forms, and the determination of their true position in time, and distribution in space, form the important province of Palæontology; and by correctly translating the archæology of organic

nature into the pages of geological literature, the palæontologist may hope to solve some of the great questions that distract the naturalists of our day, and to enable them to read aright the changing conditions under which life existed during vast periods of past time.

Award of the Wollaston Donation-fund.

The President then presented the Balance of the proceeds of the Wollaston Donation-fund to Mr. W. J. Sollas, M.A., F.G.S., and addressed him as follows :—

Mr. Sollas,—

I have great pleasure in handing you the Balance of the proceeds of the Wollaston Donation-fund in recognition of your careful morphological and mineralogical studies upon the fossil Spongida. The Council of this Society is impressed with the belief that you will continue to benefit palæontological science by your researches on those Amorphozoa, which, up to a recent date, were comparatively unknown, or whose anatomical characters were misunderstood. Having made an excellent beginning of a great course of investigation, you will, I trust, be stimulated to perseverance and exactitude by this testimony of the good wishes of this Society.

Mr. Sollas replied :—

Mr. President,—

I beg to express my thanks to the Council for their award, and to you, Sir, for the encouraging words with which it has been accompanied.

Next to the pleasure of discovering something new, and of adding something to the common store of knowledge, I can conceive of no greater gratification than the appreciation of one's fellow-workers, and the approbation of those whom I am proud to regard as my masters and teachers in Science. The study of the fossil sponges presents us with a true Eldorado of research, to which the way has been clearly opened by the labours of those distinguished spongologists, Bowerbank, Oscar Schmidt, and, lastly, Carter, of whom I hope I may be allowed to say that he is *facile princeps*. It will now be my duty, as it is my pleasure, to attempt to make use of this "way," to apply the facts which have been discovered concerning the structure of the living sponges to the interpretation of the sponges of the past; and I trust that in this endeavour I may meet with such a measure of success as shall prove that I have not been an unworthy recipient of the confidence reposed in me to-day.

Award of the Murchison Medal and Geological Fund.

The President next handed the Murchison Medal to Mr. Warington W. Smyth, F.R.S., for transmission to Dr. Hanns Bruno Geinitz, F.M.G.S., and spoke as follows :—

Mr. Warington Smyth,—

The Council of the Geological Society has awarded the Murchison Medal to Dr. Hanns Bruno Geinitz, Professor of Geology in the University of Dresden, for his researches in the geology and palæontology of the Palæozoic and Cretaceous formations of Saxony. For forty years at least Dr. Geinitz has been an assiduous cultivator and promoter of Geological science. He has especially devoted his attention to the study of the Permian formation, and has greatly increased our knowledge of its fauna and flora. The general differences of the Permian and Carboniferous floras have been pointed out by him in his work on the Permian plants of Saxony. His first essay, on the Zechstein, was in 1838; and subsequently he wrote on the "Grauwacke formation," which included the Silurian, Devonian, and Carboniferous strata of Saxony. The Cretaceous formation of the same country also received his attention.

A friend of, and co-worker with the donor of this Medal, he not only assisted him in his labours, but was occasionally his companion whilst investigating the more interesting localities around Dresden, services which are acknowledged in the work on 'Siluria.'

Dr. Geinitz has contributed many other important works to our science than those which the Council consider to be the most meritorious, and it therefore is a privilege that I should be able to ask you to convey to our old and much esteemed foreign Member this Medal which, I am sure, he will appreciate.

Mr. Warington W. Smyth replied :—

I have much satisfaction in receiving from the hands of the President for transmission to Prof. Geinitz the Medal awarded to one who has done so much to advance our knowledge of Central Germany. I have received a letter from the Dresden Professor, in which he states that he is deeply touched at being in this way again associated with the name of his old and venerated friend Sir Roderick Murchison, that he regrets being unable to attend this meeting, but begs to assure the Society of his high appreciation of the honour, and of his intention to consider it a spur to urge him on to fresh work in the same path.

In presenting the Balance of the proceeds of the Murchison Geological Fund to Mr. Henry Hicks, F.G.S., for transmission to C. Lapworth, Esq., F.G.S., the President said:—

Mr. Hicks,—

The Society has lately had the benefit of receiving a most important communication from Mr. Lapworth upon the Silurian rocks of the South of Scotland and the Graptolites contained in them. This work has been the result of many years' successful labour; and in recognition of its merits, and with the desire of stimulating its author to further investigation, the Council has made this award, which I will request you to transmit to him.

Mr. Hicks, in reply, expressed his high appreciation of the value of the work done by Mr. Lapworth among the Silurian rocks of Scotland, and the satisfaction that it gave him to be selected as the medium through which an award so well merited was to be conveyed to Mr. Lapworth, from whom he read the following letter:—

"Mr. President and Gentlemen,—

"Permit me to express my grateful acknowledgment of the honour you have conferred upon me by the award of the Murchison Fund. It is, indeed, a matter of the most profound gratification to myself that what little I have already accomplished has been regarded as meriting this valued distinction. Were any incentive needed beyond the pleasure which ever accompanies the diligent prosecution of original research to animate me to continued exertions in my endeavours to aid, in some degree, in determining the perfect order of nature among the rocks and fossils of the grandest of the geologic formations in the native country of its illustrious founder, it would suffice for me to recollect that the Trustees of his bounty deem these labours worthy of substantial encouragement, and to feel assured therein of the sympathy and approval of the Fellows of the Geological Society of London.

"Charles Lapworth.

"4 Kinburn Place, St. Andrews,
"February 12, 1878."

Award of the Lyell Medal and Fund.

The President next handed to Mr. Hulke, F.R.S., the Lyell Medal and part of the Lyell Fund for transmission to George Busk, Esq., F.R.S., and addressed him as follows:—

Mr. Hulke,—

The public duties of Mr. Busk prevent his receiving this token

of the Council's appreciation of his merits as a palæontologist; and in asking you to forward this Medal and Fund to him I am glad to express my personal gratification in being able to present an award, through you, to so distinguished a scientific man.

The Council and this Society are under great obligations to Mr. Busk, not only for his long series of contributions to science on the fossil Polyzoa and extinct Mammalia, but also for his having very constantly given most careful and conscientious advice upon the value of communications. In giving this award to Mr. Busk I trust that you will remind him that, although he has been awarded the Lyell Medal for those researches which appear to the Council to be the most important in relation to the science of Geology, his great industry and careful method of study have enabled him to advance our science in many subjects which refer to the antiquity of man and the Quaternary cave- and gravel-faunas. The examinations of the spoils of Brixham cave and of the bones of the breccias of Gibraltar have been published by him, and the results are lasting proofs of the ability of an accomplished and cautious naturalist. Moreover, Mr. Busk, whilst studying the fossil Polyzoa, investigated the recent forms, and his descriptions and classifications are those which are the most followed. In his numerous researches, whether they relate to biology or to palæontology, the inductive method has always been followed; and as in connexion with the study of the fossil forms, he has constantly availed himself of the knowledge he was acquiring of their recent representatives, the award of the Lyell Medal to him is consistent with the wishes of its great founder.

Mr. Hulke, in reply, said that, although he regretted that circumstances had prevented Mr. Busk from being present to receive personally the award of the Council, it was with great pleasure that he undertook to be the means of conveying to that gentleman this testimony of the Society's appreciation of his palæontological labours. Mr. Hulke also read the following letter, which had been received from Mr. Busk:—

"32 Harley Street,
Feb. 11, 1878.

"Dear Mr. President,—

"I much regret that I shall be unable to attend the Anniversary Meeting, and have therefore to beg that you will be kind enough to express to the Council my very grateful sense of the honour they purpose to do me in the award of the Lyell Medal.

"There is none I could esteem more highly, coming as it does from a body with which I have been so long connected and containing so many old and valued friends, whose opinion, as thus expressed, of the little I have been able to do in the cause of Geological Science has afforded me the greatest gratification.

"The testimonial is doubly pleasing also from its being associated with the name of one whom, when alive, we all so much

esteemed and loved, and whose memory will be venerated in all future time.

"With my best thanks to yourself and the Council, believe me, dear Mr. President,

"Yours sincerely,

"Geo. Busk.

"*To the President of the Geological Society.*"

In handing the Balance of the proceeds of the Lyell Fund to Dr. Oldham, F.R.S., for transmission to Dr. W. Waagen, the President said:—

Dr. Oldham,—

In asking you to forward Dr. W. Waagen, of Vienna, and who was lately on the Geological Survey of the East Indies, the Balance of the proceeds of the Lyell Fund, I perform a very pleasing duty. Dr. Waagen's labours in India have commended themselves to the Council on account of their great merit and interest, and we sincerely regret that he has suffered from the climate and from overwork. His palæontological work has been admirable, and his great knowledge of the Ammonitidæ has enabled him to arrange and identify the geological series of Cutch. His classification and his careful analysis of species has placed him in a high rank amongst his fellow labourers in science; and I trust that you will be able to satisfy him that his English brethren sympathize most thoroughly with him.

Dr. Oldham, in reply, said:—

It is, Sir, to me a source of true gratification to have been able to comply with Dr. Waagen's request, and to receive on his behalf the award which you have just announced; and this because, in all probability, it has fallen to me to be more intimately acquainted with Dr. Waagen than any one here present, inasmuch as for some years I had the happy good fortune of his cooperation on the Geological Survey of India, as an assistant, a colleague, and a friend. And it will always, as it is now, be to me a pleasure to be able to bear testimony to the untiring devotion, zeal, and ability which he brought to his work, and to the regret which we all felt when continued ill-health compelled him to resign his connexion with India. I greatly regret to say that ill-health has continued, and has, in his native country, prevented his obtaining such employment as would bring with it even the poor remuneration which science commands. The award of the Geological Society of London will therefore prove to him a great solace in his depression, and a great stimulus to his further exertions. With your permission I will read to you a few words from Dr. Waagen's letter to myself. He says he had received with mingled feelings of pride and gratitude the announcement of the award, and he adds:—"I do not know how I have deserved the high honour the Geological Society

of London has in mind to confer upon me. I know only that I have always endeavoured to do my duty as long as my strength lasted, and I hope to do my duty to science again as my strength returns. It will be a great inducement to me to use now so much the more my utmost zeal and endeavours to show myself worthy of the high distinction I am to receive at the hands of the Geological Society. I wish I were able to attend personally to express before the assembly of the Council and Members of the Geological Society the feelings of gratitude which have been awakened through the great kindness shown to me. A journey to London, however, at this time of the year, would be death to me. I cannot do anything, therefore, but ask you to express, if possible, my warmest thanks to the Society for the great honour they have deemed me worthy to receive."

THE ANNIVERSARY ADDRESS OF THE PRESIDENT,

Professor P. Martin Duncan, M.B. (Lond)., F.R.S.

In accordance with the usual custom I commence this Anniversary Address with some short biographies of the more important Fellows whose deaths, fortunately few in number, have been chronicled during the past year.

Sir Henry James, F.R.S., died at the age of 74. Sir Henry was by birth a Cornishman, his family having been for a long period prominent in the county for its connexion with all liberal movements. He was born at Rosemundi, in St. Agnes, in 1803. In 1825 young James entered the Royal Engineers, and from the first distinguished himself by his scientific acquirements, and especially by his geological knowledge. This led to his being appointed the Director of the Geological Survey of Ireland, which he conducted for several years, under Sir Henry De la Beche, who was then Director-General. On the death of Colonel Colby, in 1854, he was appointed to conduct the Ordnance Trigonometrical Survey of Great Britain, and in 1860 he received the honour of Knighthood. Considerable activity was shown in this department of the public service during the whole period of Sir Henry James's direction. Not only have the surveys, on the several scales sanc-

tioned by Parliament, been carried out, but the maps, especially those on the one-inch and the six-inch scales, with every improvement, have been regularly published at very short intervals. Sir Henry James availed himself to the utmost of photography, the electrotype process, and other applications of science. He also paid much attention to the process styled "Photo-zincography," by means of which he was enabled to print and publish copies of the Doomsday Book, of many ancient charters, and other documents of historic interest. Sir Henry James was the author of works on the Tertiary deposits of Co. Wexford, on the section exposed at Portsmouth Dockyard, and on the figure, dimension and mean specific gravity of the Earth, and of 'Notes on the Pyramids, 'On the Tin Trade of the Phœnicians,' and other matters of scientific interest.

James Bryce, M.A., LL.D., a much esteemed geologist, investigated many points in the geology and palæontology of Scotland, Ireland, and the Northern counties of England. He was the son of the Rev. James Bryce, and was born at Kalleagre, near Coleraine, in October 1806. Educated at home, and subsequently entered at the University of Glasgow, he distinguished himself in Greek classics and carried off the Blackstone prize. Devoting himself to the educational profession, he was soon appointed to superintend the mathematical and geographical department of the High School, Glasgow. There he spent the greater part of a useful life, characterized by much diligence and careful teaching. In 1831 he contributed a paper on "Plesiosaurus in Ireland" to the Philosophical Magazine, and in the following decade wrote upon the geology of the North of Ireland, on some bones from caverns in the Giant's Causeway, and on the geology of Antrim. Subsequently he paid much attention to the altered Dolomites of Bute, and wrote on the Geology of the peninsula of Roseneath. The parallel roads of Lochaber, rock-striation in the Lake-districts, and the Boulder-clays of Scotland, were the subjects of his contributions to this and other Societies down to about 1867. Since that time the Trap rocks near Glasgow, the syenitic rocks of Westfield, near Linlithgow, the Jurassic rocks of Skye, and reports on Earthquakes, afforded scope for his intelligent industry. A keen observer of nature, and loving the work in the field as much as in the study, he fell a victim to an accident in the pass of Inverfarigoig, near Foyers, whilst on a geological excursion. Dr. Bryce became a Fellow of this Society in 1834.

Mr. John Leckenby was born at Ripon, in Yorkshire, on the 20th of September, 1814, and died on the 7th of April, 1877. He was elected a Fellow of this Society in 1859. When he was twenty-three years of age he came to Scarborough, and soon afterwards made the acquaintance there of the late Mr. William Bean, an enthusiastic naturalist and palæontologist, who gave young Leckenby a taste for his own favourite pursuits, and induced him

to collect the recent fauna as well as the Oolitic fossils of that district. His first publication on a scientific subject appeared in the 'Annals and Magazine of Natural History' for 1858, "On a species of Pipe-fish (*Syngnathus equoreus?*) lately found at Scarborough"; and in the following year papers by him were published in the 'Geologist,' viz. "Note on the Speeton Clay of Yorkshire," and in the 'Quarterly Journal' of our Society, "On the Kelloway Rock of the Yorkshire Coast." Another excellent paper of Mr. Leckenby's was likewise published in our Journal for 1863 and 1864, entitled "On the Sandstones and Shales of the Oolites of Scarborough, with descriptions of new Species of Fossil Plants." His last scientific publication was in the 'Annals' for December 1875, in conjunction with Mr. Marshall, on "North-Sea dredging." During all this period Mr. Leckenby was the manager of one or another of the branches of the Yorkshire Banking Company, and for many years the Treasurer of the Borough of Scarborough, and he lately acted as a Justice of the Peace for that borough; so that his leisure for scientific work was considerably restricted. His valuable collection of Yorkshire Oolitic fossils is now in the Woodwardian Museum of the University of Cambridge. He was highly esteemed by the lamented Professor John Phillips, both as a geologist and as a personal friend; and the numerous surviving men of science who had enjoyed the privilege of his acquaintance sincerely regretted the loss of the amiable and hospitable subject of this memoir.

James Scott Bowerbank, LL.D., F.R.S., was for more than fifty years an earnest student of some of the lower forms of life, and his name will always be associated with the history of the Spongida. Born in Bishopsgate, London, in 1797, Bowerbank succeeded to a business which not only placed him in a position of pecuniary comfort, but which enabled him to open his house and museum with a hearty welcome to all scientific men who were interested in the microscope, and in the study of palæontology and of the groups of Protozoa. A man of great energy and industry, he in his early years not only earned the character of a careful and attentive man of business, but obtained sufficient knowledge to publish papers on the Insecta and their anatomy, and to lecture on botany, and even on human osteology. This last branch of knowledge may have prepared his mind by a stern discipline for, at that time, an equally dry subject, the study of the sponges. This he pursued with great vigour, and paid much attention also to the fossils of the London Clay. Moss-agates, and the minute structure of shell and coral, occupied his leisure. He published in 1840 an admirable volume on the Fossil Fruits of the London Clay, which is still a standard work. Two years after he entered the Royal Society, and in 1847 he initiated the Palæontographical Society; and being well supported by Buckland, De la Beche, Fitton, Prestwich, and others, this important national work was commenced. The Journal of the Microscopical Society, the

Annals and Magazine of Natural History, the publications of the Zoological and Linnean Societies, the Journal of our Society, and the publications of the British Association contain numerous essays by this indefatigable and accomplished naturalist. His classification of the Spongida, his observations on their spiculate elements, and his paper on the Vital Powers of the Sponges, were only second in importance to his papers published in the Philosophical Transactions on the anatomy and physiology of that group. It is pleasing to read Zittel's appreciative remarks on the value of the good solid work done by the veteran spongologist, who cleared the road for future observers, and collected, thanks to his wealth, a host of specimens now safely housed in the National Collection.

Mr. Bowerbank paid some attention to the question of silicification, and contributed papers on the Pterodactyles of the Chalk to the 'Proceedings' of the Zoological Society. Not a frequent attendant at the Meetings of this Society during the last twenty years, he retained to the last all the desire to enhance its progress, whilst working on as long as life would let him at his favourite Amorphozoa. Mr. Bowerbank died March 8, 1877.

Mr. William Harris, a very old Fellow of the Society, died on the 13th of May last, at the advanced age of 80 years. He resided for most of his life at Charing, in Kent, and devoted all the time that he could spare from his business avocations to the investigation of the geology and antiquities of the surrounding district. He assiduously collected the fossils of the Chalk and Chalk Marl, and paid particular attention to the minuter forms occurring in these formations, and especially in the disintegrated Chalk Marl of the locality, to which he gave the name of the "Charing detritus," and which is known to be so rich in minute organic remains. The specimens which he obtained were always most liberally placed at the service of those who were working upon different departments of palæontology, and many writers have acknowledged their indebtedness to Mr. Harris in this respect. Thus, he furnished specimens of Chalk Ventriculites to Mr. Toulmin Smith to assist him in the preparation of his monograph of that family; many of the Foraminifera and other fossils discovered by him in the Chalk districts were described and figured by Prof. Williamson in the Memoirs of the Literary and Philosophical Society of Manchester, and by Dr. Mantell in his 'Wonders of Geology' and 'Medals of Creation'; the Entomostraca obtained by him from the same source and from the Kentish Gault supplied the chief materials for Prof. Rupert Jones's Monograph of the British Cretaceous Entomostraca published by the Palæontographical Society; and several small Brachiopoda were furnished by Mr. Harris to Mr. Davidson. Prof. Morris, also, in the Preface to the second edition of his 'Catalogue' refers to important aid received from Mr. Harris's investigations.

While thus promoting the advancement of his favourite science

by assistance rendered to others, Mr. Harris never attempted himself to put on record any of the results of his investigations; but their value and the energy which he displayed caused him to be highly esteemed by many geologists.

Mr. Edward Wood of Richmond, in Yorkshire, who died on the 16th August last, is another geologist of note who has left but little mark behind him, although his name will survive in connexion with various fossils described from specimens in his collection, and more especially with the genus *Woodocrinus*, named in his honour by Prof. de Koninck. For many years of his life Mr. Wood, who was engaged in business at Richmond, devoted most of his leisure to the study of the geology of the interesting country in the neighbourhood of that town, and accumulated a particularly fine series of the Yorkshire Carboniferous fossils and of the Permian fishes of Durham. His collection of Mountain-Limestone fossils was probably the finest private collection in England.

Feeling strongly from his own experience the advantages of a knowledge of natural history, and extending his sympathies to other branches of science with which he was less familiar, Mr. Wood exerted himself for many years to foster a taste for scientific pursuits in his native town; and in furtherance of this object, he spent much labour and considerable sums of money. He was the Founder and President of the Richmond Naturalists' Field Club, the members of which were frequently taken by him, at his own expense, on excursions to visit the more interesting geological localities of the district, often at distances of forty or fifty miles. He was President of the Richmond Mechanics' Institute, and in this capacity used all his influence to encourage the delivery of good lectures upon scientific subjects to his fellow townsmen. To his liberality Richmond is also indebted for the foundation of a Natural History Museum in the town. Mr. Wood was in his seventieth year at the time of his death.

The broad principles of the Huttonian philosophy form the basis upon which Palæontology has become a science. Continuity and the persistent operation of the same natural laws are as much the fundamental doctrines of the branch of knowledge which relates to changes in the organic kingdom, as they are the essential ideas of that which treats of the mutations of inorganic nature. Moreover, the philosophical method of investigating the past by the study of the present, applies to both of these sister sciences, in which evolution by law is recognized to be of intrinsic and primary importance.

The greater the accomplishments of the palæontologist, in the classificatory natural-history sciences, which relate to existing nature, the more correct will be his appreciation of the relics of the past; just as the more perfect the acquaintance with physical geography and its correlated sciences, the surer will be the

deductions of the geologist from the facts he observes and records. As the most complicated stratigraphical and petrological problems can be solved by principles of dynamics and chemistry, which have been founded by observation and experiment upon the present, so the organic remains of the distant past are to be comprehended by reference to the recent faunas and floras. And as no energy, now unknown, is admitted to have been associated with matter in the former physical history of the globe, so no aberrant development of vital energy has happened. Linked in a bond of law and ever progressive, the physical and biological changes of one age were foreshadowed in the previous, and are therefore comparable with those of the present. But as in the former periods of the globe the degree of physical change exceeded that of the later epochs, so during the times of collateral mutation, the evolutionary vicissitudes of animated nature were more frequent than later on, and are hardly comparable with the present apparent stability of specific forms. With certain modifications, the modern example suffices for the investigation of both sciences; and every ancient organic form will nearly find its natural position directly, or as a link, in any classification which is the result of the study of recent faunas and floras.

The offspring of modern comparative anatomy and zoology, the important relational science is ever sustained by them. It has risen with them in exactitude and accomplishment, has reacted upon them, has given them a broader philosophy, and has been subjected with them to occasional retrogressions incident upon the result of hypothesis preceding the analysis of facts. By the reaction of palæontology, even descriptive anatomy has received a transcendental environment; some incomprehensible and apparently useless structures have assumed a positive value from the process of comparison, and embryology has passed out of the domain of the causeless. In fact, progressing in exactitude, contemporaneously with its modern fundamental sciences, palæontology has passed the stage of a recording art, and seeks to solve the biology of the former ages.

A palæontologist of the first rank, to whom science owes the description of a part of the fossil fauna of the New World, wrote that Palæontology was an exact science. Perhaps it is more correct to state that, in principle, it ought to be, but in practice it cannot. Depending, directly or indirectly, upon the comparison of the preservable hard parts of formerly living things with those of existing faunas and floras, can the science be exact when the osseous framework and the calcareous shell, alone, are not positively safe guides to the external shape and peculiarities of the soft parts? Offering frequently fragmentary portions of the osteology of an animal, can palæontology be more exact than comparative anatomy, when it assumes zoological powers, after the examination of the cranium or limb-bones or vertebræ alone? The answers cannot be in the affirmative. It is an inductive and comparative science, and when the elements of comparison are

definite and relate to existing types, immediately, the exactitude should be great. But they are often indefinite, as in the case of many extinct families, whose genera and species are comparable with forms that existed later on, but which have not lived to the present day. Then the line of exact and immediate comparison is broken, to a certain extent, and inferences have to be drawn, the exactitude of which may be open to exception. In fact, the inference involving restoration and classification of forms has a scientific value, depending, not only on the knowledge of the recent natural-history sciences, which are never fixed quantities, but on all sorts of logical peculiarities produced by the varying element of the personal equation. The classificatory value of certain structures, and the application of the notion of the species, the genus, and the greater groupings, all more or less artificial and arbitrary abstract ideas, cannot be the same throughout the animal scale; and the experience and logical and analytical power of every naturalist and palæontologist differ, more or less considerably. Darwin remarks that the experienced investigator gradually synthesizes, and that whilst, in our early days, there is a desire to separate and establish species, so later on, the notion of the genus is predominant in the mind. This truth, and the facts that the species of small are not equivalent in separability with those of large genera, whose species often resemble varieties, and that, owing to the incompleteness of the record, the genus preponderates in the palæontological classification, tend to show how many are the opportunities for erroneous conclusions as soon as the immediate comparison ceases to be available.

The persistence of certain types, which are accompanied or not by what are called allied forms, throughout a few or many strata or formations to the present day, the presence of identical species in distant strata, the so-called alliances of fossil species, and the idea of representative forms (matters with which advanced palæontology has to deal constantly) depend, if they are of the least value, on most exact zoological and morphological analysis, tempered by the consideration of the possible variability of forms. Their positive value, in geological argument, in estimating the equivalency of horizons, and their inferential worth by involving belief in the persistence or mutation of physical conditions, depend entirely upon the capacity and accomplishments of the palæontologist, his knowledge of the recent faunas and floras, and his powers of limiting specific and generic distinctions. And certainly the progress of morphology and zoology, whilst it has enabled the palæontologist to reduce the vagueness of the idea of specific identity, has shown that in the majority of the instances of the so-called persistent species, some modifications of structure can be traced in them.

The tendency to give species a generic value, and to multiply species and genera unnecessarily, so detrimental to science, is still of some use; for the process of manufacture is attended by very elaborate morphological analysis, the results of which may be employed more satisfactorily in testing absolute identity and

the value of certain statements regarding persistence and affinity. The distinctions thus occasionally brought to light are often of the greatest value. They especially assist in the criticism of the bold generalizations regarding the line of descent of fossil forms, the majority of which are regardless of the presence or absence of structures which indicate a physiological species at the present time. The influence of advanced morphological research and of zoology upon palæontology and geology may, after these remarks, form the subject of careful consideration.

Careful zoological investigations, aided by an elaborate osteological analysis, the result of great experience and prolonged study, have placed the fossil mammalian fauna of Gibraltar in its correct geological position, and have shown the former wide distribution of many members of the African fauna *. The bone-breccias of the fissures of the contorted strata of the Jurassic hill have long been celebrated; and their contents, lately thoroughly reexamined and compared with living types, are now presented to science perfectly classified and with their affinities determined. Hence important knowledge has been obtained concerning the former distribution of animal life in the Mediterranean region; and the palæontologist has acquired information regarding the relations of the South-European to the South-African faunas in the earlier part of the Quaternary epoch, and as to the date of the final formation of the Straits. The great limestone rock has been fissured of old, and has suffered subsidence and elevation to the extent of its entire height more than once since the testaceous fauna was the same as at present †. The surface of the sterile rock has been much eroded, and the products of denudation frequently have swept into the fissures and have filled them up. Animals have fallen down the deep cracks, bones long exposed to the sun have been washed in by floods, and the osseous remains, often infiltrated with manganese or carbonate of lime, are found cemented by stalagmite or an ochreous indurated matrix into a dense breccia. Hyænas, although they were abundant, did not carry the bones down the fissures; and the specimens showing marks of gnawing by *Arvicola* or perhaps the fox, were found in the upper compartments of a cave, and are either human or of species coexistent with man. Bones of Carnivora, Perissodactyla, Artiodactyla of both divisions, Rodentia, and Proboscidea were found.

The genus *Ursus* was represented by a species whose bones are thoroughly fossilized, and the analysis of the shape and size of the teeth, showed that it was intermediate between *Ursus ferox* = *fossilis*, or Grizzly bear, and *Ursus arctos*; the vertebræ and the metacarpals resemble those of *U. ferox* most. Compared with a fossil quaternary bear from the province of Constantine, no satisfactory result was given; but the interesting fact remains, that whilst *Ursus arctos* still roams over the Atlas,

* "Quaternary Fauna of Gibraltar," by George Busk, F.R.S., Zool. Trans. vol. x. pt. ii. 1877.

† Smith (of Jordan Hill) "Researches in Newer Pliocene and Pleistocene Geology," Quart. Journ. Geol. Soc. vol. ii. 1846, p. 41.

a large bear, now extinct, once covered the same ground, and a congener, probably a variety of the Grizzly bear (now restricted to the north-west of America), lived in considerable numbers, under very different conditions of surface-area and vegetation, on the land of which the rock is the relic. The remains of *Hyæna*, studied by the accurate Falconer, have now a different signification, not from any error of that distinguished man, but by the reception of fresh materials for comparison, by which the existing species can be better distinguished by their osteological characters, and therefore can be more accurately compared with Quaternary forms.

The Gibraltar hyæna is identical with *H. crocuta*, or the spotted species of Southern and Western Africa, and is quite distinct from the Striped hyæna of Western Asia and Northern Africa. The result of the necessary minute investigations of A. Wagner years since, and of the author of the interesting work now under consideration upon the recent and fossil hyænas, has been to prove the identity of *H. spelæa* and the Gibraltar forms. *H. spelæa* is the same species, then, as the existing *H. crocuta*, and it found its way to the north through Spain. It is of suggestive interest, to note, that this spotted species has been found in the Sicilian caves and at Mentone, where it was coeval with man. There are no remains of the striped species in Spain or Italy, but they occur at Lunel-Viel. Hence it may be credited, that when Europe and Africa were continuous land-tracts, the fauna of the latter continent did not, as now, include *Hyæna striata*, whose centre of distribution was probably Asia.

The Felidæ are well represented in the breccias; and an elaborate and exhaustive examination of their remains and of those of many other localities, and of the osteology of the recent forms, determines that the panther (*Felis pardus*) of the opposite African coast lived on the Spanish area, and that even the form from the Mendip Hills was closely allied to it. The northern lynx, unearthed by Dawkins and Sanford in Derbyshire, never wandered south of the Pyrenees; but the smaller *Felis pardina*, Oken, of Portugal and Spain, roamed to the south, and left its remains to be washed into the Gibraltar fissures. A smaller fossil cat, forming part of the same fauna, is *Felis caligata*, Temminck, a species that appears to have a very extensive range from one end of Africa to the other, and to have formed one of the three feline species that were regarded as sacred by the Egyptians, and were frequently converted into mummies.

The other remains of Carnivora are not of any great antiquity; they are those of the fox, mongoose, badger, and dog. Rhinoceros has three individuals in the fissures, and they belong to the group of small forms which, under the name of *R. hemitæchus*, Falc., or *R. leptorhinus*, Owen, formed part of the Pleistocene fauna of the Thames valley. The African and Etruscan species are not found. Amongst the remains of Ruminants those of the red deer (*C. elaphus*), also the companion of the small

rhinoceros in England, can be distinguished; the fallow deer, the Pyrenean ibex with lyrate horns, and an ox as large as *Bos primigenius* were present, with a *Sus* and a molar of *Elephas antiquus*.

Remains of the Barbary ape, which now exists on the rock, are absent; the general facies of the fauna is Quaternary, and the forms have, for the most part, southern or African affinities. None of the leading forms which characterize the northern division of the mammalian fauna of the period, and which ranged over Northern and Central Europe and the British Isles to the French shores of the Mediterranean, are found at Gibraltar. The tichorhine rhinoceros, *Ursus spelæus*, and the reindeer are wanting. They appear to have been arrested by the Pyrenees; but *Elephas primigenius* got to the further side of those mountains. The African incursion is also shown by the discovery of *Elephas africanus* in the neighbourhood of Madrid. Of the most widely wandering forms, the panther, the spotted hyæna, and *Cervus elaphus* are also widely distributed to the north of the Pyrenees. As no such forms could now exist in the neighbourhood of the rock, and as the African relationship is beyond doubt, it is inferred that the district formerly was wooded extensively, and that the straits were not in existence during the time of the fauna.

The former restriction of the Mediterranean Sea is also inferred from the results of the zoological and palæontological analysis of the Maltese Mammalian and Chelonian faunæ.

Many years since, the remains of tortoises were noticed in the fissures and caves of Malta, in association with a vast quantity of bones of a Quaternary fauna*. They were presumed to be fluviatile or marsh species; and whilst some specimens indicated small animals, others were those of creatures of at least 2 feet in height. During the last year or two, the national collection has been enriched by a collection of these remains, and zoology has received the results of many years of elaborate toil upon the great extinct land-tortoises of the Aldabra, Mascarene, and Galapagos Islands; and the Quaternary fauna of Malta has again been sedulously examined and compared. The date of the entombment, by water action, of the Maltese Chelonian remains was contemporaneous with that of the remarkable associated fauna of large and pigmy extinct elephants, of two species of hippopotamus, a great *Myoxus*, an extinct swan, and some small reptilia. The fallow deer left its remains with them, and it is probably the only link between this remarkably local assemblage and the Pleistocene faunas of North and Western Europe. Not without affinities with the Sicilian cave-fauna, the Maltese mammalia were represented up the Nile by *Hippopotamus Pentlandi*; and the Proboscidea had affinities with the existing African and Asiatic species. No Carnivore or cameleopard was found; and the gigantic dormice and tortoises are old-fashioned looking types.

How impossible it would be for the present restricted area, stunted vegetation, and dry soil of Malta to maintain such a Mammalian

* Leith Adams, Quart. Journ. Geol. Soc. vol. xxxiii. p. 177.

fauna, as is represented in its fissures and caves, can be readily understood. But the vastness of the area of which this locality was possibly a distant corner, is brought forcibly before the imagination by the contemplation of the Chelonian remains and of their zoological affinities, and by the inevitable inferences they involve.

Gigantic land-tortoises have long been known to live or to have lately become extinct on very distant islands, and the results of the consideration of their distribution, anatomy, and classification are most significant*. The great living tortoises are found on the island of Aldabra, to the north-west of Madagascar, and on several of the Galapagos Islands off the west coast of South America. Remains of tortoises of extinct species, associated with the bones of the Dodo and Solitaire, have been found at Rodriguez and in the Mauritius. All these insular forms are gigantic in size and were exceedingly numerous; and the distinguished zoologist who has investigated them has come to the following conclusions :—

The Aldabra living tortoise is round-headed, has a convex cranium, its beak is truncated, the third cervical vertebra is biconvex, and a narrow bridge exists between the obturator foramina.

The gigantic tortoises brought from the Mascarenes (that is to say, from the Mauritius and Rodriguez), and found with the remains of the Dodo and Solitaire, have a very thin carapace, a flat cranium, and a broad bridge between the obturator foramina; and different species inhabited the islands, those of one differing from those of the other. Distinct specifically from those of Aldabra, these lately extinct Chelonia have the greatest structural affinities with those now living, or which were so within a few years, on the Galapagos Islands. In fact the Mascarene and Galapagos tortoises cannot be separated, as groups, osteologically, but they differ in external configuration. Differing thus from the four species from Aldabra, the Galapagos species may be separated from those of the Mascarenes by having a double instead of a single gular plate, and a sternum of moderate extent instead of a short one.

By the light of the zoology of these widely separated groups, the extinct gigantic chelonian of Malta is now shown to be a land-tortoise, and its long neck is paralleled by that of *Testudo elephantopus*, Harlan, and others of the Galapagos recent fauna; whilst its general structural details identify it with this widely spread section of the genus. The second Maltese example is a *Lutremys*, and is comparable with the existing European species. In order to comprehend the bearings of this relationship between the extinct and living gigantic tortoises, it is necessary to consider the geological inferences which are dependent upon the facts of their isolation on distant islands, and of some being longer extinct than others†. I quote, first of all, the words of the accomplished natu-

* "Description of the Living and Extinct Races of Gigantic Land-tortoises," by Dr. A. Günther, F.R.S., Phil. Trans. 1875; and in a work about to be published.

† Dr. Günther has kindly forwarded me his, as yet unpublished, introduction to his work on the Gigantic Land-tortoises.

ralist to whom we owe the elaboration of the details of the recent Chelonia.

"The instances of occurrence of the same form of terrestrial animal at widely distant points of the globe are more numerous than we find recorded in treatises on geographical distribution of animals; they form the most interesting element in the investigation of this subject, inasmuch as they have a direct bearing upon, and will greatly assist in the solution of, the problems of the origin of species and the history of the distribution of animals. Of all those instances no one appears to me more remarkable than the reappearance of the 'Indian' gigantic land-tortoises in the Galapagos —not in typical singularity, but with nearly all the principal secondary modifications reproduced. How can this be explained with the aid of the doctrine of either a common or manifold origin of animal forms?

"On the hypothesis that there is no immediate genetic relationship between the tortoises of the Galapagos and Mascarenes, we may assume, without overstepping too far the limits of probability, that some terrestrial tortoises were carried by stream and current, or some other agency, from the American continent to the Galapagos, and that others from Madagascar or Africa found in a similar manner a new home in the Mascarenes. These tortoises may originally have differed from each other, like the *T. tabulata*, *radiata*, and *sulcata* of our days, possibly not exceeding those species in size; but, being placed under similar external physical conditions evidently most favourable for their further development, they assumed in course of time the same gigantic proportions and other peculiarities, the modifications in their structure which we observe now being partly genetic, partly adaptive. To test (if test it can be called) this hypothesis, I compared our tortoises with those of the neighbouring continents, but did not succeed in finding any evidence in their osseous frame which might be used as argument in favour of such direct genetic relationship. In none have I found the singular modification of the articulations of the nuchal vertebræ of the Aldabra tortoise.

"The naturalists who maintain a common origin for allied species, however distant in their habitats, will have to assume a former continuity of land (extending over 150° of longitude, but probably varying in extent, and interrupted at various periods) between the Mascarenes and Africa, between Africa and South America, and, finally, between South America and the Galapagos.

"A continuity of land in this direction is more probable than one in the opposite hemisphere, which would extend over 210°. Indeed the terrestrial and freshwater faunæ of Tropical America and Africa offer so many points of intimate relationship as very strongly to support such a theory. The tortoises, then, would be assumed to have been spread across the whole of this large area, without being able long to survive the arrival of man or large carnivorous mammals. The former, especially before he had provided himself with missile weapons, would eagerly seek for

them, as they were the easiest of his captures, yielding a most plentiful supply of food; consequently they were exterminated on the continents, only some remnants being saved by having retired into places which, by submergence, became separated from the mainland before their enemies followed them."

Many other thoughts crowd on the mind in reading these suggestive sentences. The absence of corresponding living huge Chelonians on the continental areas, the extinction of the great Struthious birds of the group of *Dinornis*, of the *Æpyornis*, of the Dodo, and of the great Marsupial beasts, the anomalies of the distribution of Lemuroids, the extraordinary African facies of the flora of South-western Australia, the piscine and floral affinities of New Zealand and South America, all demand attention, when the solution of this interesting problem is attempted. The anthropologist, dealing with primæval building and monument-erecting, shows that the great erections on remote and isolated Easter Island involve the belief of a former greater land area; and the same argument is necessary in order to explain the origin of some of the races of man in Oceania and America. And it has been put with great force that tradition and the character of the skulls connected with the earliest buildings in America, and the peculiar excellence of the oldest Egyptian edifices, infer former geographical and ethnological conditions which are paralleled by those demanded by the natural historian.

The islands on which the great Chelonia lived and flourished, like the others which are scattered over the Indo-Pacific and the great Pacific, are of volcanic origin. They rise from deep water, and their base is usually some 12,000 feet or more below the surface.

Of many different heights above the sea, crowded here and there, or separated by many hundreds of miles elsewhere, these submarine mountains, supporting land, are not placed without some order. They show in many instances deep gulleys and valleys leading to the sea, and so fashioned that the sea could not have excavated or formed them; and the soundings of these valleys indicate that they are prolonged down the mountain flank. Or, with abrupt cliff-like sides, they stand solitary, emerging from very abyssal depths. From the evidences of the denudation, from the fact that these natural upbuildings, some of which are over 16,000 feet in height above their bases, could not have been formed under water; and from the evident directional trend of their long lines, it must be inferred that they afford the proofs of a subsidence, still in progress in some parts, and second to none in the world's history.

Dana has happily called the atoll a "monument over a departed land," and, by observing their relative position to those islands with barrier-reefs and with fringing reefs around them, has shown, that, with great probability, the parallel N.W. and S.E. trending series of islands are on a region where the greatest activity of subsidence is central, and is less to the north and south.

Darwin and Dana have shown that the vast area under consideration has its zones of upheaval as well as of subsidence, and their researches tend to prove that the present condition has prevailed for a very long period. The trend of the disconnected islands is more north and south in the Indo-Pacific; but in that ocean, as well as in the greater, the lines of direction, parallel and distant, resemble those of the distribution of volcanoes and other hills on the flanks of continents. There is room for two former continental areas, thus indicated, in each of the oceans; and as there is no modern instance of long lines of volcanoes, except tolerably near a coast-line, it may be inferred that the great sea-tract was once occupied by several land systems which were as volcanic as western South America.

A third mass of continental land was not dominated by lines of lofty volcanic cones, and this, the Australoid, had its mountain systems, presenting a different trend to those of the volcanic lines. The old volcanic area of Australia to the south is limited by the sea, and there has been subsidence after the extinction of the energy; but in New Zealand the evidence of elevation in some parts and of subsidence in others explains, as in the case of Australia, the cause of the present confined limits of the areas. Probably the subsidence of the vast volcanic areas was slow, had a definite relation to the undermining, and was partly due to the superincumbent weight of the cones, which was, of course, increased in its effects as the weight of the sea began to be felt. In addition, it is credible that deeper-seated changes had much influence, and that the destruction of such a vast part of the land surface of the globe was accompanied by the elevation of distant sea-floors into land, or of land into mountain-regions and tablelands.

In following out this subject it is requisite to examine the evidence relating to the age of this subsidence. There are no known Miocene marine deposits on any of the partly submerged volcanic mountains; but part of the present marine fauna of the reefs around them has, in some instances, a generic and specific relation with the existing fauna of the Caribbean sea. This is true for some of the deep-sea forms, as well as for the surface corals; it is true with respect to some fish and echinoderms. Hence this subsidence commenced when there was still open water between the two great divisions of the Americas.

Furthermore, the upheaved beds of the isthmus of Panama have been shown to contain Miocene invertebrate fossils, which agree in species with those of the upheaved reefs and shallow seas of the Caribbean Miocene. If there was land where the Pacific now rolls, its eastern limit was the marine tract of Central America. The subsidence in some parts of the Caribbean must have been considerable after the so-called Miocene, for a deep and pure limestone of Pliocene age covers the remains of the marine Miocene in Jamaica. Did the lost land sink irregularly along definite lines relating to those of its volcanic cones, and become invaded by the Pliocene marine fauna from the east? Clearly the

faunal relations occurred before the occlusion of the strait and the upheaval of the isthmus, and at a time when the Testacea of the Caribbean were mixed with a Tertiary element, and had species which are now diffused over the sunken land. In the Indo-Pacific the subsidence was during the lifetime of the South-African flora, but there never was continuous land to the south. Following the prevailing belief, it may be stated that the sunken land was once continuous between the African coast north of Madagascar, and India; and that an insular tract has reached from the Mascarenes to the east, in the late Tertiary age. The connexion of these land-tracts, over which Chelonia wandered, with the Maltese area, was probably through a tract in the direction of Persia, Arabia, and Eastern Egypt, and south of the line of migration by which the Sivalik and Pikermi faunas had communicated. In endeavouring to comprehend this, the results of the marine zoology of late years must be considered, and the facts remembered that there are species of Crustacea, Corals, and Mollusca common to the Mediterranean and the Japanese seas, and that Japanese fish and corals are recognized in the Caribbean. This distribution must have culminated after the great land subsidence was complete, although it may have been in progress before.

There was then, a land fauna that became comparatively extinct during the submergence, which was probably Pliocene in its age of commencement, and that fauna was of course the outcome of those of previous Tertiary ages. The plants and Chelonia, now recognized by their wide geographical distribution, were a part of that fauna; and it is indeed difficult to disprove that man did not leave the plains for the hill-sides and these for the mountain-tops in that age of extraordinary crust movement.

Wherever we turn for evidences of elevation around that great area of subsidence, they abound, and usually they can be associated with remarkable biological phenomena. Thus, to take a lately investigated instance, there are remarkable proofs of two upheavals of the coast of South America, one of which must have occurred subsequently to the establishment of the Pacific coral-fauna, and the other probably much earlier and more or less contemporaneously with the commencing subsidence. Some corals, such as could not live at a greater depth than 50 fathoms, were found in a raised beach at a height of from 2900 to 3000 feet above the level of the sea, in a straight line from the Pacific, at a distance of 20 miles. Moreover in a pool, which of course must have been saline, a living coral and a large *Æga*-like crustacean were found. The ravine where they were discovered is about 450 feet below the general level of the great nitrate basin of Peru; and it requires but little imagination to reconstruct the former inland sea, formed by the coast range, which must, within comparatively recent geological times, have covered the whole of the nitrate basin, and which has been gradually elevated to its present position. The inland sea, elevated gradually, discharged its waters, cutting down cañons, and suffered division into minor shallows or lagoons, evaporation

taking place on the grandest scale*. In one of these cañons or ravines coral grew in the position in which it ought, from comparison with the present method of growth; and since then the upheaval has progressed, and a great land-surface has been formed in Peru.

The second instance gives a proof of a far greater elevation at an earlier date. Lake Titicaca, above 100 miles north of Arica, and in lat. 16° S. and long. 70° W., is large, irregular in shape, and in the midst of a fossiliferous Carboniferous sandstone district, being at the vast height of 12,500 feet above the sea. Its depth is 154 fathoms. The fauna is most remarkable; and its most striking members are eight species of *Allorchestes*, belonging to a truly marine family of Crustacea, the Orchestidæ. These Amphipodous Crustacea, whose males are so well known to most naturalists from their large peculiar claw (or propodite) attached to the second thoracic leg, are inhabitants of the shore above low-water mark, and never appear to go into deep water. One or two species live in fresh water, ranging very widely from Maine to Oregon and the Straits of Magellan, but none are known in the eastern continents, although a few terrestrial Orchestidæ are described as inhabiting moist soil away from the sea. In Lake Titicaca they are found at a depth of 66 fathoms in some instances; the majority, however, crowd in the shallows; the species are not all unknown elsewhere, and some only differ from the marine forms in having a spiny condition of the back segments. The most important species is unspined, and is *Allorchestes dentatus*, var. *inermis*, synonymous with *Hyalella inermis*, Smith. It was taken from the shallow water on the side of the lake, and was found also further south, in the nitrate basin of Peru, at the lower elevation of 3300 feet. Again, it has been found in its truly marine habitat at Puerto Bueno, in the Straits of Magellan. The presence of this truly marine type, associated with two or three spineless species and several spiny forms, in Lake Titicaca necessitates the belief in the former marine condition of that highly perched piece of water; and the slight modification of the Crustacea during so many years, and after such extraordinary mutations of altitude and other external conditions, is extremely interesting.

There are about 81 species of this family of Crustacea, and only one tenth part are truly inhabitants of fresh water; and it is very remarkable that in none of the other lakes in which marine forms have been found, such as Lake Superior, Michigan, or Lake Baikal, has this type been discovered. Apart from the considerations relating to the great upheaval near the area of subsidence during the lifetime of the existing *Allorchestes*, these freshwater forms of Crustacea, some of which are marine elsewhere and all of which had marine ancestors, open out the question of the origin of lacustrine faunas, and to a certain extent that of freshwater faunas generally. That many alpine lakes contain Salmonidæ, that many lakes within the Arctic Circle do the same, and that one of this

* A. Agassiz and L. F. Pourtalès, "Recent Corals from Tilibiche, Peru," Bull. Mus. Comp. Zool. iii. No. 13.

group was lately found in very high latitudes close to the remotest Polar land, are facts well known but not quite understood. The possibility of a fish having a freshwater habitat in one part of the year, and a saltwater one in another, was removed from the domain of doubt long since, and its influence over the importance of the *entourage* of the Devonian fish of Western and Eastern Europe was great and satisfactory. But the necessity for acknowledging that the presence of a Salmonoid in a lake, wherever it may be placed geographically, or in relation to mountain-systems and coast-lines, infers the former salinity of the piece of water, or its original direct continuation as a fresh-water lake with a viable river to the sea, has not impressed geologists. Researches undertaken many years since offered many examples of migration of marine forms to fresh water, and many proofs have been obtained that permanent lacustrine or fluviatile habitations have been assumed by marine species of many genera of Invertebrata and Vertebrata*. It is not safe to argue from the presence of some forms of *Sphæroma*, *Palæmon*, *Gobius*, and *Blennius*, which occur plentifully in the North Sea, that they will be found everywhere marine. Several species of *Blennius* occur in the fresh waters of Southern Europe; *Gobius* is a freshwater East-Indian fish; *Palæmon jamaicensis* is a freshwater form; and a *Monolistra* of the Adelsberg Caves is a freshwater representative of *Sphæroma*, a species of which is found in the Pontine marshes. Again, several families which are marine to the south, as in the Mediterranean for instance (of which the Scomberoidea and the skates and rays are remarkable), are represented in tropical regions by freshwater forms. *Monocirrus polyacanthus*, Heckel, inhabits the Rio Negro. *Carcharias gangeticus*, Müll. & Henle, is found sixty leagues from the sea; *Pristis Perroteti* of the same authors lives in the Senegal. *Raia fluviatilis* has been taken near Rampur, nearly 1000 miles above tide-reach; and Schomburgk found a *Trygon* in the river Magdalena. The land-crab of the West Indies is represented in fresh water by a *Telphusa*; but all the rest of the Brachyurous section, reaching in its distribution to the extreme north, is marine. Several Mollusca which are marine as a rule, are known as fluviatile or lacustrine in some parts of the world; and it is impossible to resist the inference that, as in the case of the lacustrine polyzoon *Hislopia* and the other well-known forms, the gradual change of physical conditions prevented that extinction which is common when the marine habitat is changed for the fresh water. That the lowest types of life readily become accustomed to the gradual introduction of the salt-water element is well known. The generalization has been made, in considering data of this kind, that the similarity of the total freshwater fauna to the total marine fauna increases from the pole to the equator, and that numerous family-forms which are exclusively marine in the north, are principally marine in subtropical and tropical regions, but are also there represented by species in fresh water. And it would

* E. von Martens, Wiegm. Archiv, 1875, p. 188, and Ann. & Mag. Nat. Hist. 1858, p. 80 (tr. Dallas).

appear, in applying these rules, that the relative ages of great tracts of land and the relative frequency of their alterations of level since late geological epochs, have as much influence, as factors, as temperature. The theoretical importance of the existence of such slightly modified or identical marine forms in the great lakes is great, in arguing against their comparatively late origin by glacial erosion. It would be impossible for a fauna and flora like that of the great American, the Scandinavian, and of the larger Swiss lakes to have existed during the formation of a lake by glacial erosion. If the lakes had that origin, the fish, Crustacea, and Mollusca were subsequently introduced. But in the many instances where there is now no possibility of migration, of the Salmonoids from the lake, or of Crustacea into it, there has not been any since the country around received its relative level, and that was in most instances before the period of land glacialization. There is no doubt that the lacustrine faunas are not much influenced by cold. The depths of the Swiss lakes have a persistent temperature of from 40° to 46° F.; yet the piscine faunas are not surface-fish alone, and the temperature of the ice-covered tarns of the extreme north is insufficient to destroy their Chars. Dredgings and soundings of the Lake of Geneva indicate that the greatest depths have a fauna of fish and Insecta. There are found also an *Atax* amongst the Arachnida; Isopods, Amphipods (some blind), Entomostraca, and Copepods amongst the Crustacea; Chætopod, Nematoid, and Turbellarian worms; and the leech *Piscicola*, *Fredericella* (a Polyzoon); and *Valvata*, *Pisidium*, and *Lymnæus*. This last, *L. peregeri*, has had its respiratory sac modified into a branchia, and the form is water-breathing, but otherwise retains its usual morphology. A bottom of the finest "limon," without sand or stones, attests the absence of erosive currents. Deep lakes cannot have been formed by running water alone; and certainly the study of their faunas carries back their date to a time when totally different physical and geographical conditions prevailed, and there was either a connexion with rivers peopled with migrating forms, or the sea was close at hand.

The other more or less contemporaneous elevations surrounding the great area of Pacific subsidence, which appears to have dwindled in a north-westerly direction, were of vast extent in Europe; and it is probable that the limitation of Malta to the north was produced by upheaval along a line of fault to the south of Sicily, and that it occurred during the earlier days of Etna.

Dana considered that the general upheaval of the northern circumpolar districts, towards the close of the Glacial period, was the geanticlinal equivalent of the Pacific geosynclinal; and the theory is highly probable.

Although zoological research has extended the known distribution of some of the implacental Mammalia, and has shown that the great island of New Guinea is, to a great extent, Australoid in its fauna, no Miocene or Pliocene or later deposits of the Old World have been proved to contain the fossil

* Favel, "Faune profonde," Act. Soc. Helv. 1872–3, p. 136.

remains of Marsupials. The Sivalik, Pikermi, and German and French mid-Tertiary and Pliocene rocks do not contain a trace of these oldest forms of the Mammalia; and the triumph of Cuvier, the *Didelphis gypsorum* of the Old-World Eocene, still illustrates the assumption that the essentially American family to which it belongs was then the sole representative of the Implacentalia in the European area. Most interesting, then, was the discovery of the remains of Marsupialia in the Lower and Higher Eocene of the Western territories of the United States. The specimens from the Lower Eocene are said to be too imperfect for accurate description; but those of the higher series are tolerably abundant, and belong to small animals with an insectivorous or carnivorous habit. They are stated to be Didelphine; and thus this type, which Owen has not discovered, during his long years of illustrious labour, amongst the Australian fossil forms, and which may be said to be less essentially marsupial than the other families, had an American and European habitat soon after the Cretaceous age. Entirely extinct in Europe at the present time, the Didelphia remain in the warmer districts of the Americas; and the small amount of structural and zoological change in them during the lapse of time may be estimated by examining the Opossums and *Chironectes*. It is interesting to note, especially in these days, when the new and amusing art of phylogeny is eagerly followed as a kind of relief from the labour of exact science, that in all the ages of the past, and in spite of successive changes in external conditions, the Didelphines of America depart from the characters of their special Marsupial group only in the diminution and loss of the marsupium, and the presence of webbed feet. No remains of Marsupials have as yet been found in the plant-beds or land-surface remains which immediately underlie the marine deposits of the Cretaceous age, either in the New or Old World. That vast land stretching widely east and west in a great continent was the outcome of the final upheaval which, after a long age of alternating rise and fall and of unstable equilibrium of the crust on which coral-reef deposits collected, does not appear to have been tenanted by Mammalia.

In the Trias of America there is a Marsupial form, and it belongs to the same group of families as the Rhætic and Jurassic species of Europe. The type appears to have been lost afterwards in America, but it reappears through a considerable vertical series of Jurassic rocks in this country. And our veteran teacher has shown, in one of his most enduring works, that the Australoid Marsupials, fossil and recent, were foreshadowed in this remote past. The Rhætic *Microlestes* and the *Plagiaulax* of the Purbeck have been shown to have their dentition in more or less accordance with that of *Hypsiprymnus* and *Thylacoleo*; and although the ferocity and carnivorous character, or the amiability and innocency of disposition and gifts of that last portentous-looking form have been the subject of lively discussion, there can be no doubt about connecting the many-toothed Marsupials of the Lower Oolite with the family

that includes the existing *Myrmecobius*. *Phascolotherium* of the same age, according to the same author, has its dental characters nearly repeated in the existing carnivorous forms of *Thylacinus* and *Sarcophilus*.

Considering the number of specimens of the Purbeck Marsupials, the correctness of Lyell's conclusion regarding their abundance at the time must be admitted; and it is still interesting, although it has been long known that the forms can be critically associated with existing Australoids in families. Just as no trace of the Didelphine type existed in those Secondary rocks, so no evidence of its occurrence has been found in the examination of the extinct fauna of Australia. In endeavouring to estimate the nature of this apparent biological separation, it must be remembered that the comparative anatomy of the modern forms that most resemble the ancient and extinct, indicates the necessity of associating the shrew-like smaller species of *Didelphis*, the larger and omnivorous species, and the otter-like *Chironectes* in a family, forming a part of a primary group or tribe, the Entomophaga. Now this tribe must also include some Australoids, such as the families of the insectivorous *Myrmecobius* and the Bandicoots.

The Entomophaga, which form a very natural modern zoological tribe, contain families which may be separated on account of the locomotive peculiarities of their included forms. The ambulatory group appeared first in the geological succession, and it is a fair inference that the saltatory and scansorial families were its descendants, and that the limitation of the last family to early Tertiary Europe and to the Tertiary and present fauna of America, depended upon those great terrestrial changes which concluded the Jurassic and the Cretaceous ages. Certainly the history of the succession of the Secondary ambulatory and Tertiary ambulatory and scansorial Marsupials indicates the existence of much continental land during the period of the deposition of the marine Cretaceous strata. Although scientific research has been most active in Australia, and mining and other economic operations have laid open the older and Tertiary rocks, not a trace of the foreshadowing of the great Marsupial fauna of the last geological epoch has come to light. Denudation has worn the Tertiaries from off whole provinces; those of others are mainly marine; but still there is a lignitiferous Eocene, and Miocene gravel-beds are closed in by basaltic flows. Not one of these strata, or the representatives of our Jurassic and Cretaceous formations, has yielded a mammalian bone. The great work of the description and comparison of the fauna of the caves, bogs, and lake-beds, those relics of a once greatly extended continent, has approached completion; and the distinguished palæontologist who has made these extinct and persistent Marsupials his peculiar study has grouped them in two divisions by the relative numbers of the lower incisor teeth. The Polyprotodont group is remarkable for its representatives in the deposits of the mainland, indicating the former connexion of Tasmania with Australia, and points somewhat towards the position of the great area on which the larger and smaller animals would

lead their very diverse methods of life. It is interesting to note the presence in this group of an extinct Bandicoot of the tribe Entomophaga. It is not so important, however, as the group Diprotodontia, divided, as it is, into *Sarcophaga* and *Poëphaga*. *Thylacoleo* is placed in the first section; and the Poëphaga, subdivided according to the characters of the limbs and the supposed methods of progression, into Gravigrada, Fossoria, and Saltigrada, contain the huge *Diprotodon* and *Nototherium*, *Phascolomys gigas*, and many Macropodidæ. The marsupial type is evident throughout, although associated with the shape and habits of Pachydermata, Rodentia, Insectivora, and to a certain extent, of Ungulata. Some of the existing species are represented by fossils. But the statement is true, that although the foreshadowing of the present comparatively small Marsupial fauna is extraordinary, and the persistence of type is indubitable, there are reasons for not always associating the extinct genera with those recent forms which most resemble their species. There have been more or less patent generic and specific modifications of the type, in spite of the persistence of the marsupial characters. Why should not a *Didelphys* have existed amongst this varied assemblage? and why should not the present Australian fauna, which includes such a variety of forms, and even some with prehensile tails and habits not unlike those of the Opossum, contain one? The only solution to the question would appear to relate to the law of non-recurrence in the production of species, and to the fact of the long isolation of the Australian province.

Year after year a vast amount of knowledge has been acquired regarding the so-called Miocene mammalian faunas of Europe and Asia, and the geological surveying of the containing deposits, especially in India, has been occasionally at variance with the palæontological opinion regarding their age. The sub-Himalayas have been surveyed far to the north-west; and it has been shown that the typical section, formerly relied on in the Simla line of survey, does not represent all the beds. Besides the unconformable Subathu or Eocene deposits, there is a great depth of sandstones, clays, and lignites of the Nahun series, and, unconformably to them, a vast depth of conglomerates and sandy clays, the first kind of deposits prevailing at the top. On these detrital beds, whose depth is estimated in the Punjâb at 25,000 feet, there are some hundreds of feet of high-level gravels near the great rivers. Mammalian remains have been found above the Nahun strata, through thousands of feet of strata, and even amongst the topmost conglomerates. All these strata, except the gravels, have been folded, contorted, faulted, and their edges are often vertical. They contain the Sivalik fauna, which will be ever identified with the great names of Falconer and Cautley. These palæontologists gave a Miocene age to this vast deposit; and in consequence of there being osseous gravels in the valley of the Nerbudda containing some Sivalik forms, and others having a more modern facies, these last were called Pliocene. Certain newer gravels in the Deccan

which contained an extinct *Rhinoceros* have been placed as Post-Pliocene. As no effects of the Glacial period were felt beyond the Himalayas, this succession was naturally artificial; but still it seemed natural.

But Mr. Hacket found a stone implement beneath gravels containing the Nerbudda or Pliocene fauna; and a revolution commenced in the position of the mammaliferous series. The Mammalia which Falconer had proved to have affinities with Eocene types, the alliances of certain forms with the Miocene fauna of Attica, and the presence of *Dinotherium* and even of the hexaprotodont *Hippopotamus* in the Sivaliks, did not suffice to overcome the presumedly terrible results of the existence of Man in the Pliocene. The fortunate discovery of a *Bubalus* and *Camelus* (long since noticed lower down by Falconer) at the top of the Sivaliks in the midst of a conglomerate, offered the opportunity for the statement that they must be Pliocene, and therefore all the strata below them were of that age. The Nerbudda beds were raised to the Post-pliocene, in spite of the presence of the hexaprotodont *Hippopotamus* and *Stegodon ganesa*. The extinct Rhinocerides of the newer gravels, which are much later in age than the old Nerbudda valley-bottom, cannot be placed at all, under the new arrangement. A careful criticism of the very industrious work of the survey leads to the belief that the distinguished palæontologists, whose work will ever remain amongst us, were correct in their views that the great foldings of the Himalayan area occurred long before that of the Appenines, and that the Sivalik fauna was contemporaneous with that of the Miocene of Europe.

A recent discovery of the fossil remains of a mammal belonging to the *Manis* group, in deposits contemporary with the Calcaire de St. Ouen, beneath the Sables de Beauchamp which were exposed at the Parc de Monceau at Paris, affords evidence of the existence of the Edentata in Europe during the Eocene period. *Manis* and *Orycteropus*, now characteristic of part of Africa and of limited Asiatic districts, have not been found fossil, nor has any Edentate, in deposits on those areas. Known in the Upper Miocene of Greece, Eppelsheim, and in the Faluns, *Macrotherium*, with evident affinities with the recent Manidæ, is not without some with *Orycteropus*. The succession of Eocene, Miocene, and recent forms of Pangolins on the Europæo-African area is difficult to explain, unless, relying on the imperfection of the record, the diffusion is asserted to have taken place in the early Tertiary period or earlier. Under any circumstances there is a proof of the persistence of a type on part of an area which has suffered great physico-geological change.

The solution of this question, regarding the diffusion of the Edentata in the Tertiary period is still in progress. But at present, the rapid increase of palæontological knowledge respecting the Tertiary and Quaternary faunas of the Americas is rather complicating the matter. None of the groups of Edentata which are so magnificently represented in South America in the Post-tertiaries have been found there in earlier deposits. On the contrary,

the Miocene or Lower Pliocene strata of the Pacific coast of North America, California, and Nebraska have yielded evidences of a distinct family of Edentata, the Moropodidæ; whilst the Post-pliocene of North America yields the great Edentates *Megatherium*, *Mylodon*, and *Megalonyx*, which became extinct during that period. Did the Edentata migrate from South to North America? or did the reverse take place? There are no remains of them found in mid-Tertiary deposits in the south, and they occupy that position in the north. Emigration southwards is therefore probable, and it is rendered all the more certain from the fact that the Isthmus of Panama was not in existence whilst the great Bruta were living on the North-American area during the Miocene and Lower Pliocene ages. Their subsequent migration to the south may be conceded, and also that there was a greater extension of continental land in the area now occupied by the Northern Caribbean Sea, for two closely allied fossil Edentates are found in Cuba.

But the difficulty still remains, to account for the origin of the true Armadillos and Ant-eaters of South America. Their fossil remains have not been found in the north, but they are represented by closely allied, if not identical, species in the very late deposits in the southern part of the continent. They did not, and indeed could not, migrate, and it is not probable that they are the descendants of the Tardigrades. Their affinities with the Pangolins and Orycteropes are certainly more than equal to those with the Megatheroid group; and the balance of evidence indicates a prolonged and isolated South-American habitat, and a common ancestry in the early Eocene time, if not earlier, with the types which are now recent and fossil in the Old World.

A field for speculation regarding the direction of the dispersion of the Bruta appeared to be opened by the announcement that a suborder of the Primates, the Lemuroida, had been found represented by more than one species in the American Eocene. Their present distribution is not very unlike that of the African and Asiatic Bruta but Madagascar is also a stronghold. Zoologically next to the *Arctopithecini*, the Lemur ought to have preceded the Marmoset on the American continent; and the time of migration of the early Bruta would have suited them. But a study of the Lemurs indicates that not only are they very variable and peculiar in their dental characters, but that the only parts of the skeleton that can afford safe guides for distinction are the extremities. It does not appear, if these remarks are valid, that the American form is comparable with any Lemuroid, but it has resemblances to the Marmosets and Insectivora, the body-bones being said to be like those of Lemurs. A fossil Lemuroid was discovered some years since in Europe.

It may have been possible that the African and Madagascar Lemurs descended from the European type; and if the American form is Lemuroid, it may be suggested that the aberrant Nycticebidæ and Tarsidæ were offshoots with it from a common stock, which did not become modified into the genus *Lao-*

pithecus of the Miocene of Nebraska in the line of the *Arctopithecini*.

But in every argument relating to the distribution of ancient forms in South America and Africa, the evident present alliances between some parts of the faunas of the continents must be considered.

The existence in the distant Eocene deposits of the west of North America and the South of France of animals which were probably strictly limited to definite geographical conditions, and which required continuous forest in order that they should roam to any distance, leads to the inquiry, Where was the connecting land by which they and the few other types common to European and American Eocenes were diffused?

The group *Coryphodon* is common to the European and North-American Eocene; and a Selenodont of the Upper Eocene of the Western Territories is closely allied to *Dichobune* and *Cainotherium* of the European series.

These, and the associated Eocene Carnivora, Rodentia, and Insectivora, are found in the first or second terrestrial series that overlies a vast upheaved oceanic deposit, without a trace of any antecedents except the Jurassic Marsupials. Where was the land on which they were reared, before they and their associated flora appeared on the localities they now peculiarize? The succession of terrestrial Cretaceous conditions and of those of the Eocene of the Western Territories of the United States is evident, and the stratum forming the very top of the highest Cretaceous series has a Dinosaurian fauna. Suddenly a mammalian fauna appears, and with it a vegetation, indicative of a difference of climate equivalent to a change of about 15° of latitude further south, mixed with old Cretaceous types. All this points to slow emigration, and surely not from the north, but from west and east, and from extensive land now forming ocean-floor, on which the Mammalia were reared during the marine conditions which prevailed during ages so persistently and consecutively over the greater part of what is now continent.

Marine strata form more than nine tenths of the existing land; and from the considerations involved in the distribution of living things in the Eocene and in the later Tertiary ages, together with the possibility of there having always been the same relative amount of land and sea, it may be credited that, instead of the present oceans having always been marine tracts, they have frequently been the area of the greatest land-surfaces.

The Niobrara group of the Cretaceous of America has yielded a grand collection of Reptilian remains, and those of the Mosasauroids have received most critical examination. The genus *Platecarpus* has been founded, the family Mosasauridæ being advanced to the rank of an order, the Pythonomorpha.

An elaborate criticism, founded on great osteological experience, has since disapproved of the propriety of connecting any thing

Ophidian with the Mosasaurs*, and of the value of the sentence:—"These sea-serpents, for such they were, embrace more than half the species found in the limestone rocks of Kansas, and abound in those of New Jersey and Alabama."

The greater correspondency of the basioccipital of Mosasaurs with that of the great existing sea-lizard *Amblyrhynchus* than with any other Lacertian,—the distinctive characters of that bone in the Lacertilia and Ophidia,—the extreme modification of the occipital in the Pythons,—the want of correspondency in the upper surface of the cranium,—the presence of a squamosal in Pythonomorpha, its absence in Ophidia,—the peculiar relations of the tympanic in these last,—and the differences of the front part of the face in the snakes and other Reptilia, are all advanced in opposition to the propriety of establishing a Lacertilio-Ophidian group. The complexity of the vertebral articulations of Ophidia, contrasted with their simplicity in Mosasaurs and Lacertilia, are noticed; and the deficiency of the sacrum in Mosasaurs and Ophidia is shown not to be of positive value. The question of the value of limbs in this Lacertian and Ophidian argument is then dealt with, and the common-sense remark is made that, as the fore and hind limbs are the rule in Lacertilia, and the questionable outwardly visible rudiments of the hind pair are exceptions in Ophidia, the presence of fore and hind limbs in Mosasauroids is relevant to the problem of the nature and affinities of those marine Reptilia.

Noticing the huge *Megalania* of the Australian later Tertiaries as a representative of the Megalosaurs, the calling of the Maestricht reptile a Pythonomorph is decided to be a raising of a delusive beacon, misguiding the voyager in the discovery of the true course of organic change. The American and our great British osteologist are fairly at issue; but it does not appear that the author of the term Pythonomorpha has shown that they possess more affinity to the serpents than does any other order†.

That Mosasaurs lived before the time of sea-snakes had arrived is in one of the sentences of the critical work, which time will not permit me to enter upon further; but it must be urged that whilst the Ophidia are first positively presented in the form of *Palæophis* from the London Clay, the so-called Pythonomorpha lived whilst strata very high up in the Cretaceous series were collecting, and that it is necessary to place the whole American series, lower plant-beds and all, higher than the Upper Greensand.

Probably the correct interpretation of the fossil Spongida has advanced, more than that of any other class, under the influence of recent zoological and microscopical investigations. Ten years since, their defective morphology, the confusion of their classification, and the influence of the dogma of the perfect structural differences between the fossil and recent forms, rendered their study difficult and unsatisfactory. The microscopic characters of the spiculate element and its distribution were studied, in more or less of a dilet-

* Owen, On Mosasauridæ, Quart. Journ. Geol. Soc., Nov. 1877, p. 682.

† Cope, "Cretaceous Vertebrata" (Rep. United-States Geol. Surv. Territ.).

tante manner; and at first this procedure rather added to the involved synonymy. But the beauties of the structure of *Euplectella*, demonstrated by Owen, and the great wrangle about the morphology of *Hyalonema*, stimulated research, and a wholesome spirit of criticism developed competition and produced admirable results. The classification became less artificial, from the study of the morphology of the internal parts, and of their relation to the external shape; and then the materials for the establishment of a new classificatory element were gradually dredged up by national and private expeditions. The superfluous subclass Vitrea, founded on the result of too hasty a generalization, gave way, after the discovery of the correct morphological interpretation of the genera *Holtenia*, *Lanuginella*, *Farrea*, and *Corallistes*; and the Hexactinellids, of which the first three are examples, were separated from the Lithistids illustrated by the last named, and both have remained as most important orders. The external form of the sponge, the constitution and thickness of the wall, the size, form, and position of the central cavity, the mode of union of polyzoic forms, and the method of attachment, together with the absence or the peculiarities of the canal-system, the nature of the crossing nodes, and the microscopic character of the fixed and loose spiculate elements, are now the bases of classification. By their use, in a differential sense, a number of important genera of great range in time have been described and understood.

But before the relative value of these classificatory elements was determined, the study of the Spongida received an impetus from the statement that "the general resemblance between some of the Ventriculites and *Euplectella* is very striking, whilst others approach the less regular form of *Aphrocallistes*; and this resemblance extends even to the details of the structure of the network of the wall"*. This statement, characteristically loose as it was, contained enough of the truth to urge careful comparisons between these forms which are so widely separated in time. The necessity of testing the truth of another assertion, from the same source, that the group *Ventriculites*, hitherto regarded as extinct, were siliceous sponges, and that these supposed Cretaceous forms "have attained probably a much higher development in our times," also stimulated microscopic and chemical research, for the purposes of comparison and classification. At the present time it may be said that, as a group of Hexactinellida (the order or subclass Vitrea being abolished by universal consent), the Ventriculitidæ form a definite *family*, and the *genus Ventriculites* is one of the many contained in it. The family characteristics are the meandrically folded wall, the latticed framework, with octahedrally perforated crossing-nodes or lanterns, canal-system generally well-developed, radial canals cæcal, both surfaces with ostia or longitudinal furrows, covering layer rarely deficient and generally produced by thickening of the outer skeletal layer, and root consisting of elongated siliceous

* C. W. Thomson, Phil. Trans. vol. clix. 1870, p. 714.

fibres, without axial canals, united by transverse bridges*. Divided into four subgroups it ranged from the Jurassic to the Miocene formations inclusive, the genus *Pachyteichisma*, Zitt., being the oldest, and *Tretostamnia*, Pomel, the newest of the Ventriculitidæ. *Ventriculites* as a genus, comprehending some other fossil forms (such as were erroneously described under *Scyphia* and *Cœloptychium*), is specially characteristic of the Chalk, and is not in a high state of recent development, being extinct. The Hexactinellid genus *Aphrocallistes*. Gray, is a persistent type, but it cannot be introduced within the family Ventriculitidæ without retrogression in the philosophy of classification. Forming part of a family in association with *Stauronema*, Sollas, it has been found in the Chalk, *Scyphia alveolites*, Röm., being synonymous with *A. alveolites*; and its beautiful recent forms are well known. Moreover *Euplectella*, Owen, and *Holtenia*, W. T., differing in their minute and essential morphology from the species of the genus *Ventriculites*, belong to a different suborder of the Hexactinellids, the *Lyssakina*; and it is remarkable that *Hyalonema* and *Rossella*, Carter, should be necessarily associated in a family of this same suborder. *Hyalonema* is persistent; and *H. Smithii*, Young, of the Lower Carboniferous of Scotland, is its earliest known species.

The researches among the order Hexactinellida have not only separated them into numerous families of two suborders, but have shown the remarkable duration of the group. The *Astylospongidæ* of the Silurian must come within it, but they are extinct. The *Euretidæ*, Zitt., contain Silurian, Devonian, Upper Jurassic, Cretaceous, and recent genera, proving, from the distribution of the modern analogue, the great persistent continuity of deep seas somewhere or other on the globe. It is interesting to note that the genera of this family which have outlived the Tertiary, or which are only known as Recent, have a retrograde development, the canal-system being scarcely developed or wanting. The correctly defined family *Ventriculitidæ* was Jurassic and Cretaceous; and its neighbour the *Staurodermidæ*, containing Jurassic, Cretaceous, and Miocene genera, has its latest forms also with a less developed canal-system than the earlier. The *Mœandrospongidæ*, which contain the recent *Mytiusia*, Gray, with a lantern spiculate arrangement (the true modern representative of *Ventriculites*), had genera in the Cretaceous seas; and here, again, the modern forms are without the special covering layer which characterizes the older. The second suborder of the Hexactinellids had Silurian, Carboniferous, and Jurassic genera; but the vast majority are in the large family which contains such forms as *Holtenia* and *Euplectella*. Many families of the Hexactinellida are extinct. Six out of nine of one suborder (the *Dictyonina*), and one out of three of the *Lyssakina* have no modern representative. In the three families of the first suborder which have recent genera, these only predominate in one; and the mass of recent forms is classified remotely from the others.

* K. A. Zittel, "Studies on Fossil Sponges," Ann. & Mag. Hist. Nov. 1877.

for they form the entirety (with two doubtful exceptions) of the two families of the Lyssakine suborder.

It is evident, then, that the fundamental grouping of the skeletal element, alone, connects the great majority of the recent Spongida with those of the past.

In the second order of the Spongida to which attention has been drawn of late, the Lithistida, separated from the Hexactinellids on account of the difference of the angle formed by the axis of the siliceous rods in crossing or coming together, and their forming usually quadriradiate bodies, there are the forms erroneously classified under the genus *Siphonia*, many of which are popularly called Choanites. These have so constantly a calcareous mineralization that they have been considered calcareous Spongida; and it is a point of great importance, that two most careful investigators, working separately and perfectly independently, should have arrived at the conclusion that the *Siphoniæ* were siliceous Lithistids, and that the silica has been replaced often by carbonate of lime or other mineral matter.

The evidence brought forward by Zittel and Sollas*, and the singularly felicitous method of examination employed, convey a striking impression in favour of this very unexpected view; and the only doubt that remains results from the supposition that the skeletal arrangement being simulated by a horny sponge in the recent fauna, a corresponding texture may have existed in *Siphonia*. The dredging up of a new sponge in the North Atlantic, *Cœlosphæra tubifer*, W. T., and its examination, led to the following statement by its describer:—"There is something very characteristic in this peculiar form of junction between the sponge and tube-body which is not easy to define, but which almost forces the conviction that there is the closest relation between these recent forms and the tube-bearing fossil sponges such as *Choanites*." The minute examination of the skeleton of the *Cœlosphæra*,—the *Histioderma appendiculata*, Carter,—explains that it is allied to the *Halichondriæ*, while *Choanites*, a true Lithistid, is a synonym for *Siphonia*. It has been pointed out in a late research on *Siphonia*, that the tubes of *Choanites* are internal to the sponge-body, and those of the *Cœlosphæra* are external. *Choanites*, of Jurassic origin, instead of being brought down to the fauna of the deep sea, became extinct before the Tertiary age.

Very lately *Hyalonema Smithii*† has been again carefully described: and it is found that many of its fragmentary spicules, from the decomposed Carboniferous Limestone, present all degrees of transition from the siliceous material of which they were originally composed to calcspar. The calcspar has often become dissolved, and its rhomboidal spaces left. This is pretty conclusive evidence in support of the unlooked for independent determination of Zittel and Sollas, that siliceous Spongida have had their

* Sollas, Quart. Journ. Geol. Soc. vol. xxxiii. 1877, pp. 250, 252, & 813.
† Carter, Ann. & Mag. Nat. Hist. Jan. 1878.

mineralogy altered, the calcareous element being more or less pseudomorphic after the siliceous.

The zoology and morphology of the recent Echinoidea have made great progress of late years, and have singularly influenced the method and exactitude of the description and classification of fossil forms. The elaborate criticism of the genera and species which form the present fauna has, to a certain extent, been applied to those of the past; and although there is still much to be desired in the classification of the class as a whole, the relation of many fossil forms to those in consecutive formations and to the recent is much better understood. Palæontologists acknowledge that the restriction of certain groups of genera to definite geological horizons has been proved in many instances; that the limitation of genera and species to certain ancient and modern distributional provinces cannot be supported so frequently as formerly; and that the persistence of some families and genera has been extraordinary. These generalizations have followed upon the disproof of the restriction of recent genera and species to limited areas, and upon the positive fact that many genera are world-wide in their distribution*.

The evident persistence of some subfamily and generic types, through the Mesozoic ages to the present, has always magnified the biological break between the Palæozoic and subsequent *Echini*; and no advance has been made towards bridging it by the discovery of intermediate forms. All that can be said is, that the Triassic *Cidarides* were remotely foreshadowed, and that instances, fairly attributable to atavism, or to a persistence of form of part of the organism, exist. But the sequence of forms, since the earliest Mesozoic age, has been shown to be marked; and it must be admitted that the evolution has been generally progressive and frequently retrograde. The Echinoid break at the close of the Secondary period was apparently great; but as the indefiniteness of the geological line of demarcation between the Upper Cretaceous and Lowest Eocene strata became evident, and the possibility of so-called Eocene deposits in one part of the world being contemporaneous with the Cretaceous in another was apparent, the correct interpretation of Eocene Echinida become of great importance. It was anticipated that their critical examination might prove the direction of the genesis of the subsequent faunas, and bridge over the supposed biological gulf. The typical Eocene faunas, exhibited in the Nummulitic series of south-western and southern Europe and Sindh, were shown, years ago, to contain numerous Jurassic and Cretaceous genera, and the gap between the two periods was thus diminished. The discovery of the Maltese Miocene Echinoidean fauna, and its elaborate description and classification, by our Wollaston medallist, formed an epoch in science. It proved the persistence of several genera from the Secondary period, established the considerable generic relationship and specific distinction between the Eocene and the subsequent faunas; and it formed the basis of comparison of all

* A. Agassiz, 'Revision of the Echini.'

other Miocene groups of *Echini*, and even of the recent forms which exist in the tropics, and where no great physical change is believed to have occurred since the close of the mid-Tertiary period. Many important additions have been made to these Tertiary faunas, and additional information has been obtained, relating to the distribution, persistence, and foreshadowing of forms, in consequence of advanced morphological comparison. An interesting discovery was made, in the Biarritz Nummulitic series, of a species of true *Salenia*; and Cotteau's description was brought before British palæontologists in the works of the Palæontographical Society some years since by Dr. Wright. There is no doubt that from the position of the subanal plate, and the number of ambulacral pores, it is a good species of the genus. Again, a little fauna of Echinoidea has been described by the French palæontologist just alluded to, which introduces the Eocene type of the New World more completely than before. The Eocene of St. Barthélémy and Anguilla in the West Indies has yielded 13 genera, and when those of Cuba are added, the whole fauna comprises 17 genera and 25 species. The assemblage is eminently synthetic, and there are Cretaceous and some peculiar genera, associated with the majority, which have, at the present time, a world-wide distribution. It contains the genera *Cidaris*, *Echinolampas*, *Echinanthus*, *Schizaster*, *Spatangus*, *Metalia* (*Plagionotus*), and *Clypeaster*, which are found in all the great oceans. The genus *Periaster*, a Cretaceous genus, had a world-wide distribution through the Eocene and Miocene until the Pliocene of Java; and *Prenaster*, a Cretaceous type, lasted out the Nummulitic age. The genus *Breynia* and the Spatangoids recall the Australian recent and fossil fauna; and several of the genera unite the West-Indian Eocene to that of Sindh and Europe. The relations of this fauna, which has such wide affinities, are thus very remarkable. A Miocene Echinid fauna also exists, and it has eleven genera, and seven are common to it and the Nummulitic; and six of these have a world-wide distribution at the present day. Nine genera of the eleven are still represented, and not one of them is Caribbean. This Miocene fauna, moreover, has a Maltese facies*.

These consecutive Caribbean faunas are associated with reef-building coral faunas, of which the Eocene have been described and compared with those of the Nummulitic and Oligocene of the Vicentin†. The Miocene associated coral fauna, is allied to that of the Faluns and the Vienna basin, North Italy, and Malta, and is not without affinity with the Cretaceous forms of Gosau in Austria. Thus there is evidence of a continuance of the same great groups of living things, with more or less modification, all through the Tertiaries; and, as might be expected by any naturalist who has studied fossil forms and their bearings, many had a persistence from previous ages.

Knowing how old-fashioned looking all Australian objects of

* Cotteau, Echinid. Test., Bull. Soc. Géol. de France, 1876, p. 126.

† Quart. Journ. Geol. Soc. vol. xxix. 1873, p. 548 *et seq.*

natural history are, and remembering the existence of very old types in and about the area, the acquisition of a good series of Echinoderms was much desired, in order to assist in the comprehension of the Tertiary deposits of that great land. The seas around had been dredged slightly, and a goodly number of genera of Echini had been described, some being remarkable and endemic. Even from the results of the examination of the few Tertiary Echini, the foreshadowing of a portion of the fauna during the Cretaceous age could be demonstrated; and when a more comprehensive essay on the subject was able to be written, the alliances of the remarkable assemblage became well explicable. A set of specimens of a beautiful *Salenia* (*S. tertiaria*, Tate) brought down that group to an age later than the Eocene. The Echinid is a true *Salenia*, so far as its apical disk is concerned; but as is the case with all the species after the Nummulitic, the number of ambulacral pores is much diminished in relation to the number of ambulacral tubercles. The other *Echini* yielded by the Cainozoic of Victoria and of the province of Adelaide had among them forms with the Dysasteroid arrangement of the apex. Such well-known genera, which were so fully represented in the Secondary periods, as *Rhynchopygus*, *Echinobrissus*, *Catopygus*, and *Micraster*, were associated with one of the Ananchytidæ, *Holaster australiæ*, nobis, whose nearest ally is found in the Cretaceous of Southern India. Nearly all the other genera are remarkable for their vertical and horizontal range in time; and there are Nummulitic genera present, and others which give the whole a greater affinity of facies with the Maltese assemblage than with that of the Caribbean. The recent Echinid fauna of the neighbouring seas has not any very great resemblance to that of the Cainozoic deposits, and the especially Australoid genera are not as yet found fossil.

Before passing to the consideration of some members of the recent Echinoidean fauna which are stated to have a resemblance, sufficiently close, to forms which lived in the later Secondary age, to suggest their descent, without any great change in their physical surroundings, it is necessary to examine the morphology of the Tertiary forms with antecedent and posterior alliances. The species found in the Australian Cainozoic deposits which are fairly comparable with those now living are as follows:—*Echinanthus testudinarius*, Gray; the fossil form is larger than the recent. *Arachnoides Loveni*, nobis, is not named *A. zelandiæ*, Gray, nor *A. placenta*, Gray; for it has deeper incisions at the ambitus, and there is some variation in the position of the periproct. Referable by some critical observers to the recent species, it has some morphological distinctions which are not noticed in varieties of the recent forms. A *Maretia* is separable from the recent genus by possessing a delicate and extremely thread-like fasciole along the ambitus; and the *Lovenia*, formerly called *Hemipatagus*, departs from the recent group in some unimportant structures only. With regard to the genera with resemblances to those of former periods, it must be remarked that the *Salenia*, in these Tertiaries, differs from

the Cretaceous type by the small number of its pores; it is a specific distinction and not a generic. The genus *Rhynchopygus*, as represented in the Australian Tertiaries, has the characters of the genus, and resembles the modern forms, which really have a much greater ancestry than *Salenia*. But it has the Dysasterian apical arrangement; and as this does not appear in the previous or later species, it may be taken as a degenerative rather than as a progressive evolution. It may be gathered from these details, that when we talk of such and such a fossil having affinity with, or being even of the same species as, those of the previous or later faunas, we must admit a slight morphological distinction. The occurrence of identical species in consecutive deposits and in their living habitat, so far as the Echinoidea are concerned, is invariably accompanied by some modification of details which necessitates the formation of a variety, or separation into a very closely allied species. When it is stated that the same genera are found in different formations, the truth is, that in the later deposits there is some particular subgenus which cannot quite be placed with the so-called ancient representative. The notion of the persistence of families of Echinoidea is not worth following out, as the affinities of the compared types are so remote in generic essentials; and the only value of such comparisons is to excite unscientific marvelling. Finally, the occurrence of one particular structural arrangement, resembling that of forms long since extinct, as Ananchytic elongation of the apical system for instance, does not prove the descent from the well-known Cretaceous genus in the face of other anatomical characters. The peculiarity occurs in very diverse forms, and is clearly some adaptation which is not to last, and which has its history in the past.

Great interest has been excited by the discovery of what have been called Cretaceous types on the floor of the deep sea, and the presence there of species of *Salenia*, and of genera of the family Ananchytidæ, has formed the basis of curious speculations. The first species of *Salenia* was dredged up, some years ago, off Florida; and its able describer was not slow to perceive that there was a difficulty about placing it in that genus*. It occupied a place in a new genus for a while, and then was relegated to *Salenia* under the name of *S. varispina*, A. Agassiz. It does not resemble exactly any fossil species of the genus *Salenia*. The exceptional characters are the small number of pores and the position and shape of the subanal plate. After this form had been discovered, another was described by the Scandinavian naturalist to whom all who are engaged in the study of the Echinoidea are under great obligations†. And this species, *Salenia Goesiana*, which has escaped the memory of some investigators, is a true *Salenia* with respect to the position and shape of the subanal plate; but it has the paucity of pores which characterizes the Miocene and

* A. Agassiz, Bull. Mus. Comp. Zool. vol. i. p. 244.

† Lovén, "Études sur les Échinoïdes," Kongl. Svenska Vet.-Akad. Handl. Bd. ii.

later species, and which distinguishes them from the Cretaceous and Nummulitic forms. Another beautiful *Salenia* resembling *S. Goesiana* in its generic peculiarities, but departing from it in some specific details, is *S. profundi*, nobis; and the last published species is delineated in a beautiful drawing, by the Director of the 'Challenger' Expedition. This species, which is there called *S. varispina*, does not resemble the American type, and has the subanal plate placed as in a true *Salenia*; but it has the exceptional character of possessing an ocular plate within the anal ring. The small number of pores appears to prevail. These details indicate that the recent *Salenia* are avariable group, and that their line of descent is through those which lived on the Miocene sea-floors, and they exemplify, if any thing, the continuity of the mid-Tertiary period.

The discovery of *Pourtalesia*, and its description by A. Agassiz, was followed by its classification with the family Ananchytidæ. The disjunct apical system, the deep anterior groove, and the other ambulacra flush with the test, brought it, doubtless, within that very widely comprehensive group. But in the morphology of the new form, and of all its curious allies from the Southern Seas, there is the smallest morphological resemblance to the members of the genus *Ananchytes* of the Chalk. They have a superficial and unreliable resemblance to an *Infuluster*, and possess an apical peculiarity, whose classificatory value has already been doubted. They must be associated together in a new family, which has infinitely small structural relations with the past, and which will include degraded and not progressive forms. Under any circumstances the presence of Ananchytidæ in the form of *Holaster* in the Miocene, stops the necessity of relegating fossils with very scant Secondary facies to the Cretaceous age.

Before considering some recent palæontological researches in the Palæozoic rocks, it is necessary to notice that the elaborate studies of one of our former Presidents on the Crocodilia, studies that are of the truly inductive kind, have led to the final settlement of the old vexed question relating to the age of the reptiliferous rocks of Elgin. The geological succession in that district, so curiously puzzling to former stratigraphists who had great experience in Palæozoic formations, was certainly less so when the rules laid down for the determination of physical breaks, by geologists who had laboured in the later Secondary and Tertiary rocks, were applied. The occurrence of a conglomerate, often passed over as of no great importance in the older rocks, cannot but strike the true follower of Hutton as implying previous change in the physical structure of the surface of the region. Such geological evidence led many palæontologists to accept *Stagonolepis* as a Mesozoic form, and this old Parasuchian crocodile is now associated with the Lacertilians in a division of the Trias which had its representative in Hindostan*.

The extraordinarily wide distribution of many of the Inverte-

* Huxley on "The Crocodilian Remains found in the Elgin Sandstones," Mem. Geol. Survey, Monogr. III. 1877.

brates of the Carboniferous age has been acknowledged for years; but a late elaborate study of the fauna of the epoch in South Australia, Tasmania, and Queensland has shown that the community of antipodean species is remarkable in its extent and character. M. de Koninck* has considered the researches of Morris, Dana, Etheridge, and M'Coy on the palæontology of the Carboniferous rocks of those distant regions, and he has associated them with his own, so that a fauna of 249 species is offered to science for generalization. Not less than one third of these species are identical with those which are found in Europe, and many are common to North America. It appears from some later† researches in South America that a few of the commonest forms are found in the northern part of that continent. The commonest British species are found in the Australian deposits. Species of corals, Brachiopods, Gasteropods, Pteropods, Cephalopods, and Trilobites are common to the Antipodes, and a few Lamellibranchs also. And it will be noticed in studying this list that most of the genera of the majority of the great groups had a considerable vertical distribution in Europe, before the commencement of the Carboniferous age; and it is evident that some had a most extraordinarily wide distribution at some time during that epoch.

A remarkable grouping of the sporadic species is to be noticed; and little sets of species, of several orders, which are associated in Ireland, Scotland, or Belgium, are found together in the Australian province. Some of the sporadic forms are noticed by De Koninck to be stunted in their growth; and he states that most of the Gasteropoda are in this condition, some not attaining one half of the dimensions of their fellows in Europe.

On the contrary, *Spirifer glaber*, Martin, attains a great size, and this inordinate dimension is characteristic of one peculiar Australian genus, *Aphania*, and of the endemic species of *Cyathocrinus*, *Pachydromus*, *Aviculopecten*, and *Conularia*.

It could hardly be expected that such a remarkable fauna could be without some special and characteristic forms, and they are very curious. The genera *Tribrachiocrinus*, *Clarkia*, *Eurydesma*, *Aphania*, and *Urosthenes*, are especially Australian.

Whilst the Corals, Crinoids, *Fenestellæ*, the large number of *Producti* and Spirifers, and the Cephalopoda and Trilobites, give a decidedly Carboniferous facies to this fauna, the student of the Mesozoic rocks is struck with the comparatively Secondary facies of the great mass of the Lamellibranchs and Gasteropoda. Strictly analyzed, this impression is erroneous, so far as details are concerned; but the groups plainly foreshadowed the Mesozoic species, and their facies would appear to diminish the great biological break.

De Koninck considers that the bulk of the Carboniferous rocks of New South Wales belong to the Upper series of the formation; that one portion, principally containing *Spirifer convolutus* and *S.*

* Recherches sur les foss. Pal. de la nouv. Galles du Sud, 1876–77.

† "Notice of the Palæozoic Fossils of the Titicaca Region," by Derby and Agassiz, Bull. Mus. Comp. Zool. iii. n. 11–14, 1876.

pinguis var. *rotundatus*, may belong to the Middle series; and that if the Inferior are represented, it is only by some insignificant strata which are very poor in fossils.

This appears to be a most logical and consistent deduction, and it is consonant with the relative age of the Palæozoic Carboniferous flora in Australia; for any facts or reliable theories which can place it later in the world's history than that of Europe, remove many difficulties in philosophical geology. De Koninck declines to enter into the broad question, but confines himself to some very important observations on the bearing of his work. He considers that the ocean was continuous between Australia and that part of Europe where are now Belgium about Visé and Namur, England in Yorkshire, Scotland about Glasgow, Ireland about Dublin, and Silesia; but he infers that this vast sea existed after large tracts of land had emerged in the regions of North America, Russia, the north of Ireland, and parts of Belgium.

Every student of palæontology must be impressed at the commencement of his studies with the excessive variety of form displayed by the Tetrabranchiate Cephalopoda; and when informed that it is produced by natural selection, wonder is felt that the shapes assumed had a curious resemblance during the same geological age over the whole world, and that the genus *Nautilus* should have remained so little altered in spite of the struggle for existence, the survival of the fittest, sexual selection, and adaptive modification.

A slight experience enables the tyro to state, from the facies of an Ammonite, derived from Australia, India, America, and Europe, where external conditions could not have been the same, that it is Triassic, Jurassic or Cretaceous in its age. It may be reasonably doubted whether the different ornamental and septal details are the evidence of a struggle; for it does not appear that they are of any vital importance. Cold-blooded and living like snails, probably often feeding at a depth beyond the glare of much light, beauty of person could hardly have entered into the Cephalopodous imagination; and as for the adaptive idea, the technology of the varieties could hardly be of the least importance. If the mutations of the Ammonites were so great, and indicative of so many important changes in external conditions, how was it that the *Nautilus*, exposed to all the mutations from within the Silurian age to the present time, has retained all its generic and specific peculiarities?

Classifications of those Nautilidæ apparently closely allied by structural resemblances to the genus *Nautilus*, have been made with a view of generalizing upon the descent of this persistent group, and explaining its modifications. They have the disadvantage of the criticism of the industrious palæontologist who introduced the idea of colonies to geological science, and whose labours amongst the Cephalopoda have been now summarized*. The derivation by selective modification of *Goniatites* from *Nautilus* is

* Barrande.

tempting; for it resembles its forerunner in many of the structural details of the shell, differing, however, decidedly in the submarginal position of the siphuncle. The examination of the earliest-formed portion of the shell of *Nautilus* and *Goniatites* indicates embryological distinctions, and therefore it is necessary to seek in the remoter Palæozoic Nautilidæ for the ancestor of *Nautilus* and *Goniatites*. But the earliest stage of the oldest Nautilidæ differed in its structure from that of the *Goniatites*, and they had a different form of embryo, so that according to the great biological law of the persistence of embryonic form in phylogenic descent, these Tetrabranchiates were not from the same stock. The same able observer notices the fact that no palæontologist can admit the geological succession of the groups of *Nautili* founded by D'Orbigny, but must insist upon their having been found together in small vertical series. But he explains that there have been well-known variations of the lateral sutures, which must be considered in relation to the earliest and latest *Nautili* in reflecting on any theory which can account for the geological succession of certain forms. The Palæozoic faunas have only furnished a doubtful species with lateral lobes, and one has them perfectly in the Muschelkalk: in the Upper Trias about one third of the species have a well-developed lateral lobe, but this peculiarity is less seen in the Jurassic species, being, however, in excess again in the Tithonian stage. The Cretaceous species of Europe are rarely thus lobed, but the character is common amongst the Indian forms. Four of the Tertiary species have a decided lateral lobe, and hence their separation into the subgenus *Aturia*; but when this number is compared with that of the contemporaneous non-lobed kinds, it shows that the structural peculiarity was on the decline. Finally the existing species have not this peculiarity, and their suture is as simple as that of the Silurian species.

In endeavouring to trace the evolution of the genus *Nautilus* during the vast geological succession in which its remains are found to the present day, the biologist will find that the same results will follow should he begin with the *Nautilus pompilius*, and study in a downward and retrogressive path. Moreover, in investigating the siphuncle of *Orthoceras*, *Cyrtoceras* and *Nautilus* it does not appear that its varying position, shape, and size follow any determinate rule, or that there has been any geological factor which can have influenced the irregularity. The ornamentation of the external surface of the test does not appear to have varied gradually and progressively or consecutively in a determinate direction from the Silurian to the present epoch inclusive; and the consideration of the relative size of the Palæozoic, Mesozoic, and recent species of *Nautilus* does not favour any hypothesis of progressive evolution. These thoughts which have been so interestingly stated by the greatest authority on the Palæozoic Cephalopoda, must have entered the minds of most of us; and it is indeed a remarkable, but by no means a singular, fact that a highly organized group whose modern representative has a nervous system

which places its possessor at the top of the Invertebrate series, should have existed without modification from the Silurian age to the present. The old stock, the last expression of a progressive evolution, appears to have persisted, and the successive lateral offshoots, which may be supposed to be evolved by natural selection and the survival of the fittest, died out, and did not exhibit their superior fitness over the long-lasting form. The strata in which the Nautilidæ first appear, old as they undoubtedly are, cannot receive the title of extreme antiquity, after the results of the researches in the oldest known sedimentary rocks of America and this country. It was quite possible for an early series of forms to develop up to the Nautilidæ and *Nautilus* especially, and then this inhabitant of the ocean lasted on, the great seas never having been broken up suddenly. Probably the littoral and shallow-sea dwellers became necessarily modified, some members of the ocean-type persisting.

Of all the careful research that has influenced the palæontology of late years none is equal in importance to that which has partly settled the question regarding the morphological value of tabulæ in Corals.

Louis Agassiz described Hydractinian-looking polyps on *Millepora*, a tabulate coral; and General Nelson (the Lieut. Nelson whose classical description of the geology of Bermuda has had such a good influence on our science) made drawings of similar organisms, and investigated the peculiar tubular character of the corallum. M. Pourtales confirmed the researches of Agassiz, but the later investigator did not publish his sketches. Mr. Moseley took up the subject during the voyage of the 'Challenger,' and has satisfactorily proved that the calices of *Millepora* are occupied by two kinds of polypes, a large one with a mouth being more or less in definite relation with others that are mouthless and which act as servitors. He has shown that the canal-system is analogous to the hydrophyton of Hydroids, and that the soft parts of the animal are only in contact with the upper tabulæ and the superficies of the coral. The corallum appears to be developed from the outer skin of the polyps or the ectoderm, in contradistinction to the usual method in corals, which owe it to their intermediate layer*.

Suspicions that *Millepora* was not a Madreporarian, arising from the entrance of cœnenchymal cells into the gastral cavity above the upper tabula, had been stated in a Report on the British Fossil Corals (1871). But the necessity of the relegation of this aberrant tabulate form to the Hydroida is evident after Mr. Moseley's admirable work. From the same excellent source we have proofs of the Alcyonarian nature of the polype of *Heliopora cærulea*, a tabulate coral, which is now, therefore, a well-known beautiful tabulate Alcyonarian. Verrill and some others have asserted, and probably correctly, that *Pocillopora*, a Tertiary and Recent massive tabulate coral, is a true Zoantharian or Madre-

* Moseley, Phil. Trans. vol. clxvi. 1877, p. 112.

porarian. Thus there are three of the great groups of the *Cœlenterata* with tabulæ, viz. *Madreporaria, Alcyonaria, Hydroida.*

The relation of the so-called Tabulate corals to the Hydroida being partial, it is impossible to admit that those Rugosa which are more or less tabulate, belong of necessity to that Cœlenterate division. Probably what was written many years since regarding the value of the tabula in classification, still holds good, and it is only a development of the usually curved dissepiment. Seen now and then in recent undoubted Madreporaria, as in *Astræopora*, for instance, the tabulæ are absent in many Palæozoic forms, and appear suddenly in the midst of curved tissue in closely allied species of Zoantharia. Often combined with an exterior mass of curved tissue, the tabulæ are frequently grooved, and by their general arrangement depart from the typical form.

In the Rugosa the dissepimental tissue is greatly developed as a rule, and it replaces to a certain extent the true wall, for it strengthens the epithelial wall within by cross beams. It is variable in quantity in the same species, and often in different parts of the same individual, and as an element highly vegetative and influenced readily by growth-processes, it is much too variable for classificatory purposes. All genera, and their names are legion, which are founded primarily on the endothecal structures, are worthless.

The Rugosa, an ill-defined group, but still feebly represented in the recent fauna, must be disassociated from all others, until the researches are completed which are still in progress regarding the operculated nature of some of the forms. If it is strange for a Hydroid to form a stout enduring massive corallum and to build reefs, it is no less strange for a Zoantharian to form a lid, which necessitates the existence of two sets of muscles at least.

It will be the privilege of a future President of this Society to enlarge upon the results of the two national expeditions which have returned during the last two years, laden with facts having a geological bearing, and with multitudes of valuable specimens. The examination of the Arctic fauna and of the Mollusca of the raised beaches of the far north has produced interesting papers; but the details of the older formations of that remote district are not yet published. The facts within our reach have enlarged our ideas regarding the numerous Postpliocene shell-bearing beds of our own country; and the study of the Echinodermal fauna recalls the statement of my first teacher in natural history, that the Ophiurida of old would be received within a classification which defined, philosophically, the recent genera. The consideration of the results of the examination of the Miocene plants, confirms the former existence of a broad and general forest-land where ice now reigns supreme; and the persevering palæontologist * who has laboured over the more ancient and Palæozoic faunas of the region has

* Report of R. Etheridge, Esq., F.R.S., on Arctic Fossils, kindly submitted to me before publication.

enabled us to extend, still wider, the former range of many Palæozoic species. A gneissose rock underlies Lower Silurians of Caradoc or Upper Llandeilo age; a series representative of our Wenlock is in superposition; there is a Devonian in N. lat. 82; and a Carboniferous on the same area with a host of well-known species. As a whole, Mr. Etheridge considers the fauna to be more American than European.

It may be hoped that, in time, the earnest students of nature in this metropolis, who labour in science for truth's sake, and to whom the increase of knowledge is a sufficient reward, may be able to see, handle, and compare a few of the specimens obtained by the greatest and most costly natural-history expedition that ever sailed. To notice the published results of that expedition in any other way than has been attempted in this Address, is unfortunately at present impossible; but it is necessary to remark very briefly upon some theories relating to the movement of the great waters which arose from the results of the earlier deep-sea dredging expeditions, and which have received attention during the voyage of the 'Challenger.' The ideas of persistence of generic and specific forms, and of the wider distribution of sporadic species from all the bathymetrical zones, involve others relating to the former and present currents of the ocean. The abundance of food, the sameness of temperature, and the means of locomotion, passive or active, all enter into the subject of the migration of species. Hence the subject of oceanic circulation is of vast importance. This has been recognized by all who are advanced in our science. The factors of gravitation, and varying specific gravity depending upon salinity and temperature, have been ably associated with the physical peculiarities of sea-water in regard to the influence of radiant solar heat, evaporation, and convection, in producing vertical and horizontal movement, by the initiator of all the national dredging expeditions. The theory elaborated by Dr. Carpenter before the Geographical Society, depending on these physical conditions, commends itself, as it is the result of careful inductive reasoning from well-observed facts. Its application to the present distribution of marine organisms is interesting and explanatory, and doubtless when the former limits of land and sea are better known by the geologist, the determination of the influence of current action on sporadic forms will be possible by inference.