ROYAL DUBLIN SOCIETY.

FRIDAY EVENING, NOVEMBER 25, 1859.

Dr. M'Donnell read the following paper:—

About a year and a half ago, two living specimens of this rare and interesting animal arrived in this country,—one sent to Dr. Carte by Lieutenant Edward Trevor Dunne, the other to me by my friend Francis Davis, Esq., R.N. Dr. Carte and I each kept his own specimen for some months under immediate observation, and thus a good opportunity was afforded us of watching some of the habits of the creature, while we have been able to learn some further particulars from the gentlemen to whom we are indebted for them.

After a time both of these Lepidosirens passed into the possession of the Royal Zoological Society of Ireland; and one* of them having lately died, an opportunity has been afforded me of carefully anatomizing it. I now seize the present occasion to lay before this Society the results of my own and Dr. Carte's observations—first, as to its habits; secondly, as to its anatomy.

It may be premised that the Lepidosiren is invested with a peculiar interest in consequence of its, as it were, standing upon the boundary line between two great compartments of the animal creation. It is in itself a proof of how almost imperceptible are the transitions from one class to another, as we ascend in the great scale of nature. Indeed, the names of some of the known species (*Lepidosiren paradoxa*, *Lepidosiren annectens*) sufficiently indicate its paradoxical nature, as well as its position as a connecting link between Fishes and animals of reptilian character. "It may be truly said," observes Professor Owen, "that since the discovery of the *Ornithorhynchus paradoxus*, there has not been submitted to naturalists an animal which proves more forcibly than the Lepidosiren the necessity of a knowledge of its whole organization, both external and internal, in order to arrive at a correct view of its real nature and affinities." In spite, however, of the knowledge which we at present have of the organization of the Lepidosiren, systematizing naturalists still find it a stumbling-block: those who still hold that a distinct line can be drawn between the class of Fishes and that of Batrachians, find difficulty in determining upon which side of this line the Lepidosiren

* This was a remarkably fine specimen, one foot and a half long, in weight 8 lbs., and was that originally sent by Lieutenant Dunne to Dr. Carte, by whom it was placed in my hands for dissection. The present paper is indeed to be regarded as a joint communication from myself and Dr. Carte, to whom, as Director of the Museum of the Royal Dublin Society, I am much indebted for his kind aid in the pursuit of a science in which he is himself so distinguished.

is to be placed. Thus, while Fitzinger,* Natterer,† and Bischoff‡ referred the *Lepidosiren paradoxa* to the class Amphibia, Hyrtl§ placed the same species among Fishes, and both Owen|| and Peters¶ have been led to place in the same class the *Lep. annectens.*

Van der Hoeven, as an order Protopteri, places the Lepidosiren as the final order of fishes; while the Comte Fr. de Castelnau, in his lately published and beautifully executed work on the "Animaux Nouveaux ou Rares de l'Amerique du Sud," makes an order Ichthyosirens, connecting Fish and Batrachians, and under which he enumerates five species:—

1st. *Lep. paradoxa*, discovered by J. Natterer. One of those obtained by this traveller measured upwards of three feet in length, and was found in a swamp on the left bank of the Amazon, above Villa Nuova; another, two feet long, was taken in a pond near Borba, on the River Madeira, a tributary of the Amazon.

2nd. *Lep. annectens* (African or Gambian?) first anatomized and described by Professor Owen, who received it from T. C. B. Weir, Esq., by whom it was taken from the River Gambia. This species was also described by William Peters, who found it in the morasses of the Quellimane, the northern branch of the Zambesi, on the east coast of South Africa; and I have learned from my friend Mr. Davis, that it is likewise abundant in the Kivóra (Niger) and its tributaries.

3rd. *Lep. dissimilis*, discovered by Castelnau in the Ucayale, or Beni, a tributary of the Amazon, in South America, and described by him as being very rare.

4th. *Lep. Tobal*, found by Adanson, Oualet, Africa.

5th. *Lep. Arnaudii*, found by Arnaud in the White Nile.

There does not seem to be sufficient grounds for describing the last two as distinct species.

Two large Lepidosirens have been lately sent to the British Museum; one of these is thirty-two, the other twenty-two inches in length; they are stated by Dr. Gray to have been found at the "Embouchure du Nil," possibly at the confluence of the White Nile and other Nile tributaries; for we can hardly fancy that up to the present time these animals should have remained undiscovered in the Delta.**

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* Froriep's "Notizen," vol. i., p. 90, and Wiegman's "Archiv," 1837, p. 232.

† "Lepidosiren Paradoxa." Von Johann Natterer, Annalen des Wiener Museums der Naturgeschichte, 1837, vol. ii., p. 165.

‡ "Lepidosiren Paradoxa." Th. L. W. Bischoff, Anatomisch untersucht und beschrieben. Leipzig, 1840.

§ "Lepidosiren Paradoxa: Monographie." Von Dr. J. Hyrtl. Prag. 1845.

|| "Description of the Lepidosiren annectens." By Richard Owen, F. R. S. "Transactions of Linnean Society," vol. xviii., p. 327.

¶ W. Peter's "Ueber einen dem Lepidosiren Annectens verwandten Fisch." Von Quellimane. Müller's "Archiv," 1845, § 1-14; Taf, 1-111.

** I have since learnt that the specimens in question were obtained by a French collector, who resides at Alexandria, and Dr. Gray supposes them to have been obtained from one of the Mediterranean mouths of the Nile. At least, there is nothing to lead him

Dr. J. E. Gray,* however, does not think they differ from the Lepidosirens of Western Africa in any other respect than in being larger than the specimens which have come from thence. I am told, however, that they are met with in the Niger two or three feet in length, and that examined by Peters measured two feet. It is probable that only one species (*L. annectens*) exists on the continent of Africa, or at least has yet been discovered there, although some slight differences, to be noticed subsequently, are found among the specimens which have reached us from that part of the world. The outline of the head and anterior limbs (Plate IV., Figs. 1 & 2) is alone sufficient to show that the species met with in South America (*L. paradoxa* and *L. dissimilis*) are at least distinct from each other.

Before going on to speak of the habits of the animal, it may be observed that the Lepidosiren is excellent as an article of food, being described to me as highly palatable, somewhat resembling turbot; a considerable quantity of yellow granular fat is diffused among the muscles, to which, no doubt, is due, in some degree, its savoury qualities.

The Lepidosiren is only suited for locomotion in water; out of water, it is helpless, but does not die. In it we perceive a very beautiful arrangement, by which it is enabled to meet a certain emergency to which in its lifetime it may be often liable. Inhabiting pools, morasses, and streams, apt in dry weather to become entirely dried up—or living in rivers, which, not fed by melting snows during the dry season of the year, are swollen to extraordinary dimensions by periodic rains—these animals are liable to be left, by the retreating inundations, or drying up of the pools, entirely without water. To meet this emergency, they are provided with lungs as well as gills—they can support life by either an aquatic or an aërial respiration. Those that have not the good fortune to get back into the bed of their native river, when the inundations are subsiding, would die, if not thus prepared by nature to meet this annual danger.

Some hundreds of miles up the Niger, at Bida, that river begins to fall in December, and its rise commences in May, being at its height in August or September. Those Lepidosirens, then, that have the ill-luck to be left in the mud, may be imprisoned in it for a period of from four

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to believe that they came from the White Nile. There is no indication of difference of species, being, except in size, exactly like those from Gambia. One of those from Gambia, indeed, attained nearly the dimensions of Dr. Gray's largest specimen; for, although only ten inches long when received at the Crystal Palace, and placed in the glass vessel, yet, after escaping from thence to the warm-water tank, it there grew to near three feet in length.

It seems somewhat surprising that this creature should have remained in Egypt undiscovered up to the present time,—the more so, as it is an interesting creature not only to naturalists, but to gourmands.

I have been informed that there exists in Egypt a prejudice against the fish of the Nile, which are said to be poisonous; and this may possibly have rendered the natives less willing to taste an animal the appearance of which is not prepossessing.

* "Annals and Magazine of Natural History." January, 1860.

to six months of the year, during which time, sunk some inches below the surface, rolled up in a ball, with the tail drawn over the nose (Plate III., Fig. 1) having a small aperture to breathe through, they remain without food or power of movement, baked up in perfectly dry mud, respiring air by the lungs, until the next inundation sets them free.

This Lepidosiren* was sent to me still enveloped in its case of mud; it had been dug up on the banks of the Gambia, near Macarthy's Island, in May, 1858: mud and all wrapped in a piece of sail-cloth, leaving the air-hole uncovered, and, packed up in a box, was forwarded to me *viâ* London and Belfast, spending *en route* seventy-six days, from the time it left Macarthy's Island.

On receiving it, I was, of course, very anxious to know whether it was alive. I accordingly, having opened the box, pushed a straw into the air-hole, so as to touch it, whereupon it squeaked so loudly, as not only to give unmistakable evidence of its existence, but to make me quickly draw back my hand, in fear lest I might be bitten. I next proceeded to exhume it. The mud was as dry as a brick, and so hard, that (as I desired to preserve the case), it was necessary to saw it and cleave it open, as one would the mould of a plaster-of-Paris cast. During this process, the animal repeatedly produced vocal sounds, unquestionably voluntary, no doubt less musical than the fabled syren-song, but to my ears very agreeable. Inside of the mud, immediately investing the body, was a sort of slough, very much resembling dried beech leaves; but, on examining it microscopically, it was found not to be vegetable matter, but a slough formed by the animal itself, no doubt preventing evaporation from the surface of the body. Peters has probably mistaken this covering for dried leaves, when be says, that "the animal from Quellimane lives during the dry time of the year *in einer Hülle von Blättern.*"

On being placed in a large vessel of water, at a slightly elevated temperature, it unrolled itself, and swam about vigorously, using its tail principally, but also moving the filamentary limbs in alternate strokes, first right, then left, and so on.

At first it used to come to the surface for air every three to five minutes, and, taking it in with open mouth, sink from the surface; some small bubbles then generally escaped from the gill apertures, and frequently, before again coming up for more air, a large quantity was expelled, bubbling up from the branchial outlets. That the Lepidosiren has the power of voluntarily closing the opercular opening, was proved by the following manœuvre, which I often saw it perform. The animal, burying its nose in the fine gravel in the bottom of the vessel, used rapidly to gulp up the gravel, and throw it out through the gills with a strong stream of water. It could at will vary this operation by throwing the jet from the right or left gill aperture.

The Lepidosiren seems to live upon vegetable as well as animal food; it eats (at times voraciously) bread, tadpoles, worms, minnow, &c.

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* The living animal, its mud-case, &c., were exhibited to the meeting.

I have seen an active little minnow, an inch and a half or two inches from the mouth of the Lepidosiren, suddenly sucked in and devoured. The prey is drawn into the mouth with immense rapidity, by depressing the hyoid bone, and making a gulp rather than a snap.

After I had had the animal for some months in my possession, and it had again become used to the aquatic respiration, it did not come to the surface for air oftener than from ten to twenty minutes.

After having been placed in water, it was not again heard to produce any vocal sound: on being taken occasionally out of the water, it made no other sound than the smacking made by eels and other fishes.

Dr. Carte and I have had opportunities of examining, more or less carefully, eight specimens of the Lepidosiren of Western Africa. Although varying considerably in size, and probably in age,—the largest being eighteen inches, the smallest five and one-quarter inches in length,—they all, in their general character and proportions, nearly correspond with that described as the *L. annectens* by Professor Owen.

The total length of the animals includes from six and a half to seven times the length of the head, measured from the end of the mouth to the gill openings; and in this proportionate length of the head to the body, which is independent of age or growth, appears the most prominent feature of difference between this species and the *L. paradoxa*, where the whole length includes eleven lengths of the head. The anterior extremities, also, are relatively shorter in the *L. paradoxa*, as compared with the entire length of the animal, than in the *L. annectens*; in the former being only one-twelfth, in the latter generally one-fourth of the entire body. The species described by Castelnau as the *L. dissimilis*, judging from his figure of it (Plate IV., Fig. 1, outline), somewhat resembles the *L. annectens* in the form and proportion of the head, but has the short anterior limb, as the *L. paradoxa*.

Immediately above the root of the anterior limb are seen (Plate V., Fig. 1) the remains of leaflets of external branchiæ, which in seven of the eight examined remained permanent; these leaflets are three in number on each side, one having usually all but disappeared; possibly these permanent traces of external branchiæ do not exist in the *L. paradoxa* and *dissimilis*, as neither Bischoff nor Castelnau have figured them in their representations of these species; they were probably wanting in that delineated by Professor Owen, as they were in one of those examined by myself.

These appendages, however, did not escape the notice of Peters, who was inclined to consider the animal he described as a different variety from the *L. annectens*. "It agrees," he says, "so completely with that of the Gambia in outer form, that one would take it for the same animal; but differs in some points," which, however, have been shown, by further research, to be less numerous than was at first supposed. One of those which I have examined corresponds in every particular with that found in the Quellimane; yet the points of difference do not seem sufficient to establish a species; it may be regarded as a variety of the

African species, in which the posterior extremities* exceed in length the anterior,—the latter having along their inferior margin a membranous, fin-like border (Plate III., Fig. 2). The general form of this variety is thicker in proportion to its length, and the scales differ in their minute structure from the others examined. The distance from the root of the anterior to that of the posterior limb is about equal to the distance from that to the tip of the tail, a relation which does not hold in the South American species.

The cloacal vent is an elliptical aperture, placed a little behind the ventral extremities, and, in all the known species, situated to one side of the median plane.

Except the part in the immediate vicinity of the mouth and eyes, the rudimentary limbs, and the membranous caudal fin, the entire body is covered with scales; these present the characters of the cycloid scales of Agassiz. Their general structure and disposition are similar in all varieties. Viewed with a moderate magnifying power (Plate V., Fig. 5), the scale is seen to be intersected by a number of apparent tubes, giving it a reticulated appearance, and is again cross-marked by concentric circles, becoming less apparent towards the more superficial part. The scale of the variety (of Peters?), already indicated as having a membranous, fin-like border on the anterior limbs, differs somewhat from that delineated in Plate V., Fig. 5; it does not present the concentric circles of growth; the meshes of its network are larger and less regular; and the lines constituting this reticulation are dark, and not apparently tubular.

The scales lie under an epidermis, which adheres closely to the more superficial margin of the scale; the other margin, which is slightly crenate, is firmly embedded in a peculiar matrix of the cutis.

The skeleton of this remarkable animal presents features of the greatest interest. Its gelatinous chorda dorsalis, the articulation of the scapulæ with the occipital bone, and the presence of opercular bones, are indeed characters so unquestionably fish-like, that, were we called upon to determine the class to which it belongs from the osseous system alone, there could be no hesitation about ranging it among Fishes.

In all the species hitherto dissected, the chorda dorsalis has been found, not only unossified, but without any sign of segmentation or constriction of the fibro-membranous sheath; it retains permanently its cylindrical form, and shows no indication of division into vertebral bodies. It consists of, 1st, a fine external membrane, elastic and fenestrated; 2nd, a proper fibro-membranous sheath, white, strong, and unyielding, to which the heads of the ribs and bases of the neurapophyses are firmly attached; 3rd, the true chorda, being within this sheath, and in general very easily raised from it, if the sheath be slit open. The chorda itself consists of an outer elastic, and central gelatinous portion.

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* With two exceptions, all those examined by Dr. Carte and myself had the anterior longer than posterior extremities, which was not so in that figured by Professor Owen.

The anterior limb is attached as an appendage to the scapular arch (hæmal arch), formed by the articulation of the scapulæ with the occiput above, and completed below by the coracoid bones meeting in front of the heart.

This one simple ray, or rudimentary limb, by its connexion with the hæmal arch of the occipital bone, forms the key to the position held by Owen, in his beautiful and masterly generalization concerning the homology of the anterior extremity of the higher Vertebrata.*

The lower jaw is very strong; indeed, the entire masticatory apparatus is powerful and well developed; the temporal muscles, which are large, have in the projecting coronary processes extensive surface of attachment; while the articular surface of lower jaw is of a more complicated form than is usually met with in either fishes or reptiles.

With the exception of two small conical teeth, which project downwards from the intermaxillary bone, the entire dental apparatus springs from the upper and lower jaws, and consists above, as below, on each side, of three bony plates, capped† with enamel, and forming a very formidable arrangement for cutting and crushing the animal's prey, and in this respect differing from any known dental apparatus in the class of Fishes. Neither do these dental plates resemble, in their microscopic structure, the teeth of those extinct cartilaginous fishes to which they are very similar in their relative size, and mode of being fixed to the maxilla.‡

In the *L. paradoxa* fifty-five ribs exist; in the *L. annectens*, thirty-six.

The labial cartilages spoken of by Peters are not peculiar to the Lepidosiren of Mozambique.

No marked features of difference present themselves in the digestive system between the *L. paradoxa* and *L. annectens*. Each species, hitherto anatomized, has the same characters as regards stomach, intestine, with its spiral valve, accessory glands, and cloacal vent. Some discrepancy, however, exists concerning the glandular body found lying on the dorsal aspect of the stomach, and so overlapped by the liver,

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* See "On the Archetype and Homologies of the Vertebrate Skeleton," by Richard Owen, F. R. S. p. 108, and following pages, and Plate II., Fig. 7, Vertebra occipitalis Lepidosiren, which compare with Fig. 8, Vertebra occipitalis *Amphiuma didactylum*.

† Very beautiful sections of the teeth and jaws, both transverse and vertical, have been made by Henry T. Vickers, Esq.

‡ For a very full and accurate description of the teeth of this genus, see Owen's "Odontography," p. 166, and Plate LIX., which compare with Plate XXVIII., Figs. 4–8, of Chimæra.

"These teeth (of the Lepidosiren), in their paucity, large, relative size, and mode of adaptation to the jaws, resemble the dental plates of the Chimæroid and some of the extinct Hybodont cartilaginous fishes, as Cochliodus and Ceratodus (Agassiz); but they are unlike these in microscopic structure, approaching in this respect nearer to the teeth of many osseous fishes. The maxillary armour of the Lepidosiren surpasses any known dental apparatus in the class of fishes in the modification of the working surface, by which a single tooth is at once adapted for piercing, cutting, and crushing the alimentary substances" that in specimens long preserved it is with difficulty distinguished from this organ. This body escaped the notice of Professor Owen, in his description of the *Lep. annectens* in the Linnean Transactions,* because in the specimen there described, as having been dissected by him, the stomach was partly decomposed, apparently by the action of the gastric juice; and in his Hunterian Lectures (vol. ii.,† on Fishes), he there speaks of the absence of a pancreas in the Lepidosiren, as though he did not regard the body in question as one, but alludes to it as an organ which some have called a "spleen," but which is more like the recognised remnants of the vitellicle in osseous fishes.

Peters notices this body, but takes it for a spleen; and, regarding it as such, he even mentions the absence of a pancreas. Hyrtl, in his admirable monograph, describes it very accurately; but, failing to find any excretory ducts, he took it at first for a spleen, but finally concluded that it was more justly placed in the category of *retia mirabilia*.

Bischoff, not having examined the digestive organs, does not allude to it.

I had a good opportunity of examining this body in a specimen quite recently dead, and carefully injected; it is represented of two-thirds the natural size in Plate VI., where it is seen on the dorsal aspect of stomach, between the muscular and peritoneal coats of this organ. The head of it, or its lower extremity, is the thickest part, and lies imbedded in the posterior part of the first turn of the intestine. Its position, its structure, and finally its ducts, show it to be a pancreas. The ducts are very delicate in texture; they proceed from the margin of the gland, which lies under cover of the liver, and converge towards one channel, which opens below the pyloric valve, close to the liver duct, and probably could only have been discovered in a very recently dead animal. Dr. Carte and I have since examined this organ with care in other specimens; and we feel satisfied as to the existence of these ducts, and consequently as to the fact that the organ in question is a pancreas.

The termination of the intestinal tract is, in its relations with the genital and urinal outlets, of piscine character.

No trace of spleen is discoverable; nor are there pyloric appendages present.

The respiratory organs consist of lungs, organized for breathing atmospheric air directly, and gills, which are contained in a branchial chamber; and in almost all the specimens examined by Dr. Carte and myself, there remained persistent traces of external gills immediately above the root of the anterior limb.

The lung of the Lepidosiren has served very beautifully to solve the problem concerning the analogies and homologies of the respiratory organs of fishes, concerning which anatomists and physiologists were so little unanimous. An examination of some of our common fishes (gurnard, eel, herring) is sufficient to show the anatomical student, and a

* 1841. † 1846.

comparison of the various degrees of bifurcation in the series, from the undivided swim-bladder of Lepidosteus to the cleft one of the Polypterus, is sufficient to prove to him convincingly, that through the aid of the lung of the Lepidosiren the swim-bladder of the fish is recognised as the homologue of the lung of the higher vertebrates, and the ductus pneumaticus as that of the trachea. The same interesting fact is proved by the development of the lung of the Batrachia; and, indeed, I have elsewhere shown that during the progress of development of the tadpole of the common frog, if kept in jars of some depth, they are seen mounting to the surface every now and then, without any movement whatever, merely buoyed up by the gas secreted in the lungs, which at this period perform the function, to a certain extent, of air-bladders.*

In the lung of the Lepidosiren, although the comparative anatomist perceives the homologue of the air-bladder, the physiologist recognises an organ well organized to perform the functions of respiration, and, consequently, analogous to the reptilian and other lungs. So closely does the lung of the Lepidosiren, as to its vascular structure, resemble that of a serpent, that it would be hardly possible to distinguish an injected portion of the one from the other.†

In the gills which lie within the branchial chamber, some difference exists between the *L. paradoxa* and *L. annectens*. In the former there are four branchial apertures or slits, in the latter, five. There are, therefore, in the *L. paradoxa* five branchial arches; in the *L. annectens* six; but in the Annectens the first of these does not contain any supporting cartilaginous arch.‡ In the *L. paradoxa* the first and last branchial arches are naked and *gill-less*. The second still bore gill leaflets on its posterior part in Hyrtl's, but was quite smooth in Bischoff's specimen, but the third and fourth arches bore them on their entire length.

In all the specimens which I have examined (*L. annectens*), branchial filaments exist, as described by Professor Owen, on the first, fourth, fifth, and sixth arches, while no trace is found on the second and third, even in the specimen only about five inches long. Hence, while it seems that Hyrtl has good grounds for saying, with regard to the *L. paradoxa*, "I am convinced that in the earlier period of the animal's life all the branchial arches carry gill leaflets," there does not appear to be any evidence that in the *L. annectens*, in early life, filaments are borne on the second and third arches. The gill filaments represented on the first arch by Professor Owen in the plate which ac-

* "Journal de la Physiologie," &c., de Dr. E. Brown-Séquard, tome ii., p. 631.

† In the fresh-water Amia, Cuvier describes the air-bladder as being as cellular as the lung of a reptile. Broussonet has found it very cellular in some Diodons, and has compared it to the cellular lung of a frog. But in the Polypterus it is that the most remarkable approach is made towards the lung of the Lepidosiren, its air-bladder being double, and formed of two lobes, extending along the entire length of the abdomen. Geoffroy St. Hilaire describes the ductus pneumaticus of the Polypterus as opening into the œsophagus by a fissure provided with a constrictor muscle.

‡ As stated by Professor Owen, "Lin. Trans.," vol. xviii., p. 345.

companies his paper in the Linnean Transactions (Plate XXVI. 2) much exceed in size any that I have seen on that arch.

In seven of the eight specimens examined by Dr. Carte and myself, the persistent external gills were found. These appendages are noticed by Peters, but not by those who have described or delineated the *L. paradoxa* or *L. dissimilis*, nor are they figured by Professor Owen in his paper in the Linnean Transaction, but he elsewhere* observes that "three filaments are retained on each side for a long period in the *L. annectens*." In the young specimens already alluded to, those filaments, still three in number, are proportionately longer than in those of greater age, or, at least greater dimensions, and, indeed, I should venture to express my belief that further research will prove that these external branchial filaments are persistent traces of the outer gills of the larva of the *Lepidosiren*. Should this conjecture turn out correct, the existence of similar branchial filaments in the embryonic condition of the dog-fishes and sharks would not prevent one from regarding the persistent filaments of the *L. annectens* as indicating marked amphibian affinities.

Speaking of the glottis, Hyrtl remarks that it appears to him rather striking that, in the delineation given by Owen and Bischoff, the glottis does not occupy the middle line of the ventral wall of the œsophagus, but lies to the right of it, yet that this position to one side is not mentioned by either of these authors. I have examined the glottis with the greatest care, and must say that it always appears to occupy the middle line, and that the rudimentary thyroid cartilage, the rima, and trachea correspond in every particular with the description and figure given by Professor Owen, except that the rima glottidis does not open through the lower extremity of the rudimentary thyroid cartilage, but is surrounded by a reddish mucous membrane, containing muscular fibres, and is embraced by two descending cornua from the thyroid which does not surround it. Thus far Hyrtl is correct that, if a vertical line be drawn through the middle of the rudimentary thyroid cartilage, the rima will be found to the right side of such a line.

The blood-disks of the Lepidosiren are of large size. They are represented in Plate V., Fig. 3, as compared with the blood-disks of the Frog, Fig. 4, and Haddock, Fig. 2, all viewed with the same magnifying power. It is curious, in a small point of this kind, to see an inclination towards the Amphibians, the Siren and Amphiuma,† having the largest blood-disks yet discovered.

The heart of the *L. annectens* does not materially differ from that of the *L. paradoxa;* indeed, the description of this given by Hyrtl, in his elaborate treatise on the *L. paradoxa*, might almost be equally well applied to the *L. annectens*. In each species there are two auricles, a ventricle, and bulbus arteriosus, contained within a very strong fibrous

* "Lectures on Vertebrate Animals (Fishes)," p. 267.

† In the "New York Medical and Surgical Journal," January, 1859, Professor Riddell announces that the dimensions of the blood-globules of the *Amphiuma tridactylum* are one-third larger than those of the Proteus.

pericardium. All the venous blood of the body is received into the venous (right?) auricle, through an ascending and two lateral descending cavæ. The ascending cava is the largest, and enters by piercing the pericardium at its most inferior part, and very near the middle line; the lateral cavæ bring the blood from the head and lateral parts in the vicinity—that on the left side being much larger than that on the right, in consequence of the former being joined by the renal vein on the corresponding side. The openings of the lateral venæ cavæ are placed opposite to each other, at symmetrical points within the auricle; and are not provided, any more than the cava ascendens, with valves. There are connected with the venous (right?) auricle two appendices, nearly symmetrical, which, when inflated, present a cellular appearance (their walls being very thin), and conceal all the rest of the heart.

The arterial (left?) auricle lies immediately on the dorsal aspect of the venous, receives its blood from the lungs through one pulmonary vein, which runs for some way along the back of the pericardium, and pierces it obliquely, then dilating so as to form the auricle. When inflated gently from the pulmonary vein, after the venous (anterior or right?) auricle has been opened, the arterial auricle is seen as a capacious flask-shaped dilatation, the ventral wall of which is the inter-auricular septum, a delicate but perfect membrane. Both auricles open together into the ventricle, behind a "cartilaginous valvular tubercle."* An injection thrown into the venous auricle does not pass to the lungs through the pulmonary vein.

The ventricle is small, thick, and muscular, and opens by a small round orifice into the bulbus arteriosus, which is short, curved in a curious manner, and contains two valvular folds, similar to the apparatus existing in the bulbus arteriosus of the Siren.

The aorta divides abruptly, giving five branches on each side of which the anterior, passing forwards, itself divides, thus making six arterial branches on each side. Of these, that which goes to the first branchial arch is very small, and in the specimen injected was not filled on either

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* Professor Owen mistakes when he says "that Hyrtl errs in stating that the fibro-cartilaginous tubercle below the auriculo-ventricular aperture was 'weder von Bischoff noch Owen angegeben.'" Hyrtl is speaking, and speaking quite correctly, of a different thing when he says, "An der oberen Wand des ventrikels läuft sie weiter gegen die Vorkammeröffnung als an der unteren, und geht in einen weder von Bischoff noch Owen angegebenen 3 Linien breiten und 2 Linien dicken Eiförmigen, harten Faserknorpel über, der *vis-a-vis* von der Insertionsstelle der Kammer-Scheidewand die Tendinösen Fäden aufnimmt die das Ende der genetzten Vorhof scheidewand vorstellen," Tab. I., Fig. 3. On the following page (36) Hyrtl shows that he is very well aware of Professor Owen having described the cartilaginous valvular tubercle in question, for he alludes to the description of the heart of the *L. annectens* given by Professor Owen; but from which, after careful and repeated examinations, we are led to differ. "Nach Owens Schilderung weicht das Herz von *L. annectens* wesentlich von unserem Befunde ab. Das Herz der *L. annectens* hat nur eine Vorkammer, und die Lungenvene entleert sich durch eine von der Atrio-ventricular-öffnung getrennte Apertur in die Kammer wo ein Knorpeliger Höcker die Stelle einer Klappe vertritt (*cartilaginous valvular tubercle*). Die Spiral-klappen des Bulbus stimmen mit jenen der L. Paradoxa überein."

side, while the leaflets on the other leaflet-bearing branchial arches were perfectly injected. The 1st, 4th, 5th, and 6th branchial arches being furnished with branchial fringes, the vessels going to them are true branchial arteries; while the vessels passing round the 2nd and 3rd arches are like the aortic arches of the reptilian circulation; and at, or very near their convergence, arises the pulmonary vein.*

The anatomical relations of the circulatory system of this remarkable genus with that of the Protean Reptiles forms, unquestionably, one of its most striking features; and the comparison between the heart of the Lepidosiren and that of the larva of the frog, in the progress of its development, is in the highest degree interesting.

"In the Aquatic Reptiles having gills," says Professor Allen Thompson,† "such as the larvæ of the frogs and salamanders in their transitory condition, and the Protean animals, which are very similar to them, but which do not undergo, so far as is known, any further metamorphosis, the branchial organs are formed by an extension or minute subdivision of branches of the aortic trunk, supported upon the arches of the hyoid bones. In all of these reptiles, the ventricle consists of a single cavity, which propels its blood into the bulb or commencement of the aortic trunk. The aortic trunk divides into two branches, each of which subdivides again into three or four vessels on each side of the neck. These vessels, passing round the gullet or upper part of the alimentary canal in the form of lateral arches, unite again together behind, and form the descending aorta. The branchial apparatus of the animals now under consideration is formed entirely upon these lateral arches of the aortic trunk. In the larva of the Salamanders, in the Proteus, Axolotl, Menobranchus, and Siren, the small branches of each gill are formed by the minute subdivision of a loop of vessels prolonged from the outer part of three of the arches on each side into leafed processes of the cuticular system attached to the hyoid arches. The larva of the Frog has, in the earliest stage of its existence, gills of the same kind as those just described; but in its more advanced condition, these external gills disappear, and the larva of the frog breathes by internal gills, more resembling those of fishes than the external branchiæ of the Newt or Proteus. The gills of the tadpole of the Frog are covered by the skin, and consist of a great number of small leaflets, receiving the minutely subdivided loops of vessels given off for some way along each of the four vascular arches, as they pass round the neck along the cartilaginous hoops of the hyoid bone. The vascular arches are double in that part of their course where they are connected with the gill, the blood being transmitted from one branch to the other in passing through the leaflets of the gill. In the larva of the Batrachiæ, from a very early period of their existence, as well as in the Protean Reptiles, there are lungs which seem to be used as adjuvant respiratory organs, for they are generally filled by

* I am happy to have learned that Professor Huxley has also satisfied himself of the bi-auricular character of the heart of the Lepidosiren.

† Article "Circulation."—Cyclopædia of Anatomy and Physiology.

the animal with air from time to time. These lungs, more or less perfectly developed in different kinds of Protean Reptiles, and at different stages of the existence of the Batrachian larvæ, all receive a pulmonary vessel from the vascular arch of the aorta which is nearest the heart, whether this arch is connected with a branchial apparatus or not. In all these animals the anatomical relations and the mode of development of the blood-vessels of the gills proves distinctly their returning vessels to be, as much as those which conduct the blood into them, branches of the arterial system; but the lungs, on the other hand, however rudimentary, are almost always furnished with proper pulmonary veins, which lead to the auricle of the heart.

The following is the course which the blood takes in this interesting class of animals. The heart receives the whole venous blood of the body by the right auricle, and a small quantity of arterial blood from the lungs by the left. These two kinds of blood, mixed together in the common ventricle, proceed from thence into the aortic bulb and its branches. In the larva of the Salamander and Protean Reptiles, a part of the blood is sent by pulmonary vessels to the lungs, from which it is returned by the pulmonary veins to the heart; a part passes directly round the arches, and gains the descending aorta; the greatest quantity passes out into the gills, and, after being arterialized, returns to be mixed with that in the aorta, so that a mixed blood must permeate all the vessels of the systemic circulation. In the Siren, according to Cuvier and Owen, the whole blood goes at once to the gills, from the want of any communicating twigs across the roots of these organs. It is interesting to remark that the arteries of the head and upper extremities are not given off by the aortic arches until after they are joined by the returning branchial vessels,—a disposition which is in some respects similar to what we find in higher Reptiles, and which seems to have for its object the supply of a more pure arterial blood to the cerebral organ. In the larva of the Frog the course of the blood is very similar to that of Fishes. The whole of the venous blood propelled through the heart is sent into the gills, and is made to pass through them before reaching any other part. From the posterior parts of the first arches are given off the vessels of the head; the second form the right and left roots of the descending aorta; and the fourth are continued upon the lungs in the form of a pulmonary artery. There is, however, also in the larva of the Frog a short anastomosis between the outgoing and returning artery of each of the gills, which allows of a direct passage of some blood round the arches of the aorta."

The accuracy of these observations I have lately had an opportunity of verifying by the dissection of a large tadpole, the larva of a great Frog of Demarara, presented to the Museum of the Royal Dublin Society by Professor Haughton, F. R. S. This tadpole measured six inches and a half in length from the nose to the tip of the tail, and was in that state of development in which the posterior limbs had made their appearance, but the anterior extremities as yet were subcutaneous. The heart consisted of a large venous (right) and a small arterial (left) auricle; a small strong ventricle, above and between the auricles; and a bulbus arteriosus, which at first dividing into two, ultimately supplies four branchial arteries on each side to the four gill arches. The anterior limb seems in the progress of its subcutaneous growth to come forward on the gills, and, as its development advances, may retard by its pressure, as it comes forward into the branchial chamber, the circulation through the gills, and thus be instrumental in destroying the gill leaflets, or in setting agoing the absorption of those at least in the posterior branchial arch, from the arteries of which the pulmonary veins proceed.

As the lungs progress, the pulmonary arteries and veins increase; and, with the latter, the corresponding auricle (left), at first a mere dilatation, becomes enlarged, so as to equal in size its venous (right) companion; and, finally, the ventricle, also increasing, descends from its position above the auricles, and comes to form the apex of the heart, in the manner with which all are familiar in the Frog's heart.

There is, then, a particular period when the closest possible similarity exists between the circulatory and respiratory systems of the larva of the Batrachians and those of the Lepidosiren,—a similarity made even more striking by the existence in each of external gills.

It has been already stated that the termination of the intestinal canal and its relation with the renal and genital outlets are decidedly piscine: indeed, Hyrtl considers this to be so much so, that he says that in the *L. paradoxa*, four lines behind the opening of the urinary bladder, lies the puckered mucous membrane of the rectal outlet,—a thoroughly anatomical characteristic of all Fishes, through which all the Amphibian resemblances are completely neutralized. In the urogenital sinus of the *L. paradoxa* are* seen three openings—one, the united mouths of both oviducts; the other two, the openings of the ureters. In the *L. annectens*, the ureters open just along with and into the common termination of the oviducts.

The brain consists of two cerebral lobes, a single optic lobe, a medulla oblongata, and a fold representing the cerebellum. There is a well-developed pineal gland, and a two-lobed pituitary body. The optic nerves are remarkably small, and do not decussate. The brain, says Professor Owen, bears a closer resemblance to that of Perennibranchiate Reptiles than to the brain of any fish which has yet been described, and he gives plates of the brains of the Menopoma and Menobranchus to illustrate this resemblance, which, as regards the latter, is very striking. He further observes that in the low development of the cerebellum, and in the large size of the pineal gland, the Lepidosiren deviates in a marked degree from both the osseous and cartilaginous fishes.

The olfactory nerves are more than twice the size of the optic, and pass forwards through the ethmoid foramina to the nostrils, where they

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* Bischoff, however, describes and figures, Plate VII. of his Monograph on the *L. paradoxa*, an arrangement nearly identical with what I have met with in the *L. annectens*.

terminate upon a pituitary membrane arranged in transverse folds, which much resemble the arrangement of folds met with in the nasal pouches of the common skate,* I have here dissected for the sake of comparison. Professor Owen at first supposed that the nasal sacs of the *Lepidosiren annectens* had no communication with the mouth, but fancied them to be shut sacs, in consequence of the specimen which served for his description of its anatomy in 1839 having had the membrane which forms the floor of the nostril destroyed by decomposition. This error is, however, corrected in his work on Fishes, where he provides for the case of the Lepidosiren by thus defining the organ of smell in fishes:—"The essential character of the organ of smell in fishes is that the pituitary membrane lines the concave wall of a sac with one or *more* apertures upon the *external* surface; and that in the few exceptions in which it is extended into a canal communicating with the mouth or fauces, such naso-palatine canal is never traversed by the respiratory medium in its course to the respiratory organs."

The Lepidosiren, I believe, forms in itself *the exception*† in which the nasal sac extends into the mouth; a probe passed into the anterior opening of the nasal sac of this animal, and run backwards and outwards, enters the mouth by a slit half an inch distant from the anterior nostril, and in this respect the organ of smell presents as striking a resemblance with that in the Proteus and Siren, as its internal structure does with the internal structure of the organ of smell in the Ray.

So important did this opening of the posterior nerves into the mouth appear, as a mode of determining between Fishes and Reptiles, that Cuvier, as well as the accomplished naturalist, Oken, regarded it as a distinguishing character between them, and so did Professor Owen, when, in ignorance of its occurrence in the Lepidosiren in 1839, he wrote thus on the point:—"In the organ of smell we have at least a character which is absolute in reference to the distinction of fishes from reptiles. In every fish it is a shut sac communicating only with the external surface; in every reptile it is a canal, with both an external and internal opening.

"According to this test, the Lepidosiren is a fish; by its nose it is known not to be reptile; in other words, it may be said that the Lepidosiren is proved to be a fish, not by its gills, not by its air-bladders, not by its spiral intestine, not by its unossified skeleton, not by its generative apparatus, nor its extremities, nor its skin, nor its eyes, nor its ears, but simply by its nose: so that at the close of our analysis we arrive at this very unexpected result, that a reptile is not characterized by its lungs, nor a fish by its gills, but that the only unexceptionable distinction afforded is by the organ of smell."

With reference to the question whether the respiratory medium

* Exhibited at the meeting.

† Although the Lepidosteus, Polypterus, and other fishes, have double apertures to each nasal sac, neither of these apertures can be said to open into the mouth. According to Müller, the myxinoids also have double nasal canals.

traverses the nasal canal of the Lepidosiren in its course to the respiratory organ (lung), it seems very probable that it does, during the period when this creature, baked in the mud, with its gill apertures sealed up by the slough-like envelope which invests its body, breathes atmospheric air. It is quite certain that if a tube be introduced into the anterior opening of the nasal canal, and the mouth held firmly shut, air can be blown into the mouth, and may be seen escaping from the gill-apertures. It is not likely that when in a torpid state, the mouth is constantly opened for the purpose of admitting air, when the same office can be performed by the nostrils, the posterior openings of which seem also to be capable of a valvular action, preventing the escape of air when, the gills being closed up, the respiratory medium is to be forced into the trachea.

In attempting to estimate the physiological value of the respiratory apparatus and function of the Lepidosiren, as bearing upon its affinities, the precise mode of its aërial respiration, its perforating nostrils, thyroid cartilage, trachea, and lungs, and indeed its power of producing vocal sounds, must all be taken into consideration: and it should be remembered that in the Climbing Perch, and other allied amphibious fishes, the Cuchia, the Singio, and others, that their power of living out of water depends upon an accessory respiratory organ, probably homologous with the opercular gills, and at all events not, as in the Lepidosiren, the homologue of the lungs, as well as analogous to them in function.*

In concluding this imperfect sketch of the anatomy of this remarkable animal, it may be remarked that our present knowledge of its anatomical and physiological characteristics lead us to regard it as a form so transitional as to support the view taken by some systematizing zoloogists in later days, that no distinctly defined line of demarcation exists between Fishes and Reptiles.

Unquestionably, some important points in its organisation, especially those connected with the skeleton, digestive system, and the relation of the uro-genital system to the latter, indicate a close affinity to the higher cartilaginous fishes; on the other hand, a full consideration of the entire mechanism and function of respiration, bearing in mind the external branchiæ, perforating nostrils, and powers of vocalization, and the entire circulatory apparatus, with the bi-auricular heart, show a closer approach to the perennibranchiate reptiles than is elsewhere met with.

To regard this interesting genus, then, whether under the title Syre-

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* In a note, at page 258, of his "Lectures on the Comparative Anatomy and Physiology of the Vertebrate Animals" (Fishes), Professor Owen observes "that Dr. Bischoff, believing that the Lepidosiren was a reptile, overlooked many things that were, and saw some things that were not, in its organization, as e. g. two distinct auricles and a nasal meatus, communicating with the mouth." In the present state of our knowledge respecting the anatomy of the Lepidosiren, it seems that the learned Professor has thrown himself open in this to a very just retort, inasmuch as Bischoff is unquestionably right as regards these points.

noids, Icthyosirens, or Pneumonicthyi, as the only known genus of an order uniting fishes with the amphibian reptiles, seems to be the true mode of giving it its proper place in the great scale of organized beings. So far as we can learn, there is not sufficient grounds for describing more than three species:—

1st. *L. annectens*, or that of the African continent, common to many of the great rivers of Africa, and presenting some slight variety of outward form as in that described by Peters.

2nd. *L. paradoxa* of South America, anatomized so carefully by Hyrtl and by Bischoff.

3rd. *L. dissimilis*, also of South America, described by Castelnau, but of which the anatomical peculiarities are as yet unknown.

EXPLANATION OF THE PLATES.

Plate III.

Fig. 1. *Lepidosiren annectens*, from the Gambia, rolled up in the form which it assumes when enveloped in the mud. The tail is drawn over the head; the anterior nostrils are seen just under the upper lip. The animal is seen from the ventral aspect.

Fig. 2. Anterior limb with fin-like membranous border, from that Lepidosiren which resembled the variety described by Peters.

Fig. 3. Transverse section, made midway between the posterior limbs and tip of the tail. Above and below the membranous caudal fin is seen in section:—

a. neural canal and spinal cord.
b. chorda dorsalis.
c. Hæmal canal and aortic trunk.

A considerable quantity of yellow fat is mixed with the muscles.

Plate IV.

Fig. 1. Outline of head of *Lepidosiren dissimilis*, after Castelnau.

Fig. 2. Outline of head of *Lepidosiren paradoxa*, after Bischoff.

Fig. 3. Portion of chorda dorsalis, showing the attachment of the ribs to the fibrous investing tunic. Within this tunic, which separates readily, the true chorda presents no trace of segmentation.

Plate V.

Fig. 1. Outline of head of *Lepidosiren annectens*, sent by Lieutenant E. T. Dunne to Dr. Carte, from Gambia. The remains of external branchiæ are seen above the root of the anterior limb.

Fig. 2. Blood disks of Haddock.

Fig. 3. Blood disks of Lepidosiren.

Fig. 4. Blood disks of Frog.

All as seen with the same magnifying power, × 300.

Fig. 5. Scale of the *Lepidosiren annectens*, magnified 10 diameters. The slightly crenate semicircular margin is the portion which lies imbedded in the cuticular matrix. The dark portion is epidermis, strongly adherent to the posterior margin and superficial part of the scale.

Fig. 6. Scale of *Lepidosiren paradoxa*, after Hyrtl, magnified 20 diameters.

Probably by a typographical error, Hyrtl describes the dark part as "the torn-off place of union of the scale with its matrix."

Plate VI.

This Plate represents the abdominal viscera, the stomach and intestine tied and inflated; turned round, so as to be viewed from behind, as evident from the posterior mesentery along the dorsal aspect of the intestine.

a, the stomach; posterior aspect.

b, liver, with its vessels and ducts, raised by dissection from the stomach and pancreas.

c, pancreas, partly raised from the stomach by removing the peritoneum. This gland lies along the entire posterior wall of the stomach; but its thickest portion (lower extremity or head) is imbedded in the first turn of the spiral intestine: its ducts lead from the margin next the liver, and open immediately below the pyloric valve, and through that thickened part of the intestine which forms the very summit of its spiral valve.

d, intestine marked by the coils of its spiral valve, and longitudinally by the attachment of the posterior mesenteric mediastinum.*

f, probe, indicating the cloacal vent.

g, kidneys.

h, testes.

l, allantoid bladder.

The annexed notes, kindly made by Professor Melville of Galway, did not unfortunately come to hand until it was too late to add them to this paper, otherwise than in the form of an Appendix. In this form, however, I feel certain that any observation coming from such an authority will be highly prized by those interested in this subject, although I am not prepared to say that I, in all points, can agree with the views of Professor Melville:—

In all the examples from the Gambia, sent to Sir Andrew Smith, the anterior limb was possessed of the fin-like hinder edging.

In 1850, in London, I showed the spleen and pancreas to Professor Hyrtl, having dissected these organs in a recent specimen, most generously placed at my disposal by Sir Andrew Smith; Dr. M'Donnel has not isolated the two from each other, the upper part of the presumed glandular body being the spleen.

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* There are a greater number of gyrations marked than in the specimen from which Professor Owen's drawings were taken.

There is no homology whatever between the external gills of Amphibiæ and the branchial filaments of fœtal sharks.

In the tapdole of the frog the external gills do not disappear in the manner commonly believed, but are withdrawn into the branchial chamber by the development of the opercular folds, and thus coexist with the internal branchiæ produced on the lower portion of the arches. In the Lepidosiren, on the contrary, the opercular fold only includes the internal branchiæ as in the other perenni-branchiate Amphibiæ, the external branchiæ being exposed.

As to the general question of the position of the Lepidosiren, I may refer to a brief abstract of my remarks on this subject at the Oxford Meeting of the British Association, 1847. The subsequent observations made on this animal, which I exhibited alive to the Zoological Society of Dublin ten years ago, lead me to think, that not only is the Lepidosiren an Amphibia, for I still regard it possible to distinguish the two types of the anallantoid vertebrata, even in the most anomalous cases, but that it is higher than the proteidea,—undoubted Amphibia.

The Sauro-batrachian group represents, as it appears to me, the phase of the development of the tadpole of the Batrachians, in a restricted sense.

The first stage of the tadpole is permanently represented by the perenni-branchiate Amphibia, such as the Siredon, Siren, and Proteus.

The Lepidosiren is the permanent representative of that stage of the tadpole in which the external gills coexist with internal branchiæ; as I pointed out at Oxford, the representative of the tadpole of the *Rana paradoxa*, with *piscine udaptive* characters;—higher in its essential organization than the Proteidea, however, as it is a representaoive of a higher stage of development of the tadpole of the most specialized group of Amphibia, the Batrachia.

The Derotremata (Müller) and Myctodera (Stannius) exemplify the remaining stages prior to the final assumption of the batrachian characteristics:

Ophio-morpha,	Perennibranchia.
Sauro-batrachia,	Lepidosirenidea.
	Derotremata.
Batrachia,	Myctodera.

Such are the types of the present Amphibiæ.

From the known development of the tadpole, the existence of the Lepidosiren could have been predicated.

"The smaller characters carried conviction against the showing of the larger and more catching ones." "The reasons afforded by some small and inconspicuous parts outweighed the first impressions from more obvious appearances."* As smaller characters in the Lepidosiren, the posterior internal nostril, and the external branchiæ, are sufficient for the naturalist as to its amphibian nature; and the number of the external branchiæ is significant, three being the invariable number in the Amphibia whether perenni-branchiate or caducibranchiate, as far as is yet known. Look even at the mode in which the Lepidosiren uses its limbs, as limbs, and *not as fins*.

The habits of the Lepidosiren are identical with those of the Proteus, and I have had them both for months under observation.

The structure of the skull, as yet imperfectly analyzed, of the brain, of the heart, and of the vascular system, are as decisive of its amphibian character as the outward manifestation already alluded to.

If the phases of development in the higher members of a type be a guide to the relative position of the permanent representation of those transitory conditions, which constitute the lower groups of that type, then is the Lepidosiren higher than the Proteidea.

I know no animal more calculated to throw light on the philosophy of Natural History, and better fitted as an antidote to the doctrines coming into fashion regarding transitional forms, or leading to the adoption of the theory of Darwin, than the Lepidosiren.

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* Owen's "Palæontology," p. 322.

The more obvious appearances, as the scales, piscine form in the trunk (in the head the aspect is truly amphibian), "which first catch the eye and indicate a conformable conclusion, are deceptive."

The persistent notochord exists in the corresponding stage of the *Rana paradoxa*, and in the higher organized extinct genus, Archegosaurus (Goldf.). The spinal intestine existed in the Ichthyosaurus, a true reptile.

The structure of the scapular arch, as figured by Professor Owen, and copied in this paper, does not represent the actual condition; and the presence of the opercular bones is in relation to the persistent internal branchiæ.

Even in fishes the mode of attachment of the scapular arch to the occipital bone is teleological, not morphological.

The significance of the mode of termination of the urogenital apparatus is yet unknown.

WEDNESDAY EVENING, JANUARY 11, 1860.

E. W. Davy, A. B., M. B., M. R. I. A., read the following paper:—

ON SUPERPHOSPHATE, AND A SIMPLE AND EXPEDITIOUS METHOD OF DETERMINING THE AMOUNT OF SOLUBLE AND INSOLUBLE PHOSPHATES IN THIS AND OTHER MANURES.

I purpose bringing under your notice a simple and expeditious method of determining the amount of soluble and insoluble phosphates in superphosphate; but before I do so, allow me for a few moments to refer to this manure itself. Chemists and vegetable physiologists have ascertained that phosphoric acid (a compound of phosphorus and oxygen) is one of the substances which are essential to the growth of our cultivated plants and important crops; and as they can only obtain this substance from the soil, which in many cases does not contain (at least in an available condition) a sufficient quantity for their luxuriant growth; it is usual to supply this deficiency by the addition of some manure containing phosphoric acid; and the greater number of our ordinary kinds of manure, amongst other beneficial effects which they produce, add more or less of this substance to the soil.

But bones and coprolites (the fossil excrement of marine animals) are at present the great sources of phosphoric acid in the manufacture of phosphatic manures, or those in which the phosphates are the principal constituents; and their well-established fertilizing effects are chiefly due to the large proportion of phosphoric acid they contain.

The effects, however, of bones, coprolites, and other insoluble forms of phosphoric acid, unless they are brought to a fine state of division, are very slow and gradual; and where the agriculturist requires the manure applied to produce immediate results on a particular crop, are not so applicable as guano and other manures, which, from their containing much phosphoric acid in a soluble condition, are more rapid in their effects. Baron Liebig was the first to propose that bones, previous to their being used as manure, should be treated with sulphuric acid or oil of vitriol, in order to convert the insoluble phosphate of lime which exists in them into the soluble super-phosphate of lime, which would enable the plant to take up and appropriate the phosphoric acid more readily.