XXXI.—*Professor Claus and the Classification of the Arthropoda.* By E. Ray Lankester, M.A., LL.D., F.R.S., Jodrell Professor of Zoology in University College, London.

A translation appeared in the Ann. & Mag. Nat. Hist. for February 1886, p. 168, of a note published by Prof. Claus of Vienna, in the 'Anzeiger' of the Imperial Academy of Sciences of Vienna, December 17, 1885.

The article in question astonished me, since I found that it consisted chiefly of an exposition by Prof. Claus of those views on the classification of the Arthropoda, and especially on the relationship of the Eurypterina and *Limulus* to the Arachnida, which I formulated in 1881, and have for nearly five years defended single-handed. My astonishment was due to the fact that Prof. Claus makes no allusion whatever to my writings on the subject, but puts my views forward as his own. I have in consequence addressed to the Secretary of the "Mathem.-naturwiss. Klasse" of the Imperial Academy of Sciences of Vienna a communication which I wish to place before English readers, inasmuch as Prof. Claus's statement, to which it refers, has been translated and published in this Magazine. The communication is as follows :—

My attention has been called by my colleague Prof. Moseley, of the University of Oxford, to a note by Prof. Claus, of Vienna, published in the 'Anzeiger der kais. Akad. d. Wiss. in Wien' of Dec. 17, 1885, p. 250.

In this communication (as Prof. Moseley has pointed out to me) the views which I published in 1881, in my memoir "Limulus an Arachnid," as to (1) the relationship of the Arachnida to the Gigantostraca and to the Xiphosura, and as to (2) the classification of the Arthropoda, also as to (3) the unnatural character of the divisions Branchiata and Tracheata, and (4) the nature of the antennæ of Hexapoda, Myriapoda, and Peripatus, and the absence of corresponding organs in Arachnida, are adopted and reasserted by Professor Claus.

Professor Claus makes use of the facts adduced by me in order to sustain the theoretical conclusions which he has also taken from me, and he does not add any argument to those which he has thus appropriated. Nevertheless Professor Claus does not mention my name in connexion with this matter, and appears to put forward these views as originating with himself.

I am gratified to find that my learned colleague of the

University of Vienna has at length come to the same conclusion on this subject as that which I published in 1881, and have taught for many years. But I do not think that it is right that he should present these views to the Imperial Academy of Vienna as originating with him when they are well known to the zoological world as having originated with me, and are totally opposed to the views which he himself has hitherto held and taught in his well-known text-book of Zoology.

I appeal therefore to the justice of the members of the Imperial Academy of Sciences of Vienna to permit me to publish in the pages of the same Journal in which Prof. Claus has appropriated my views to himself a statement of my claims to the origination of those views.

I am not able to suppose that Prof. Claus has *independently* come to the same conclusions on this subject as those which I have advocated, inasmuch as he received a copy of my memoir, "Limulus an Arachnid," at the time of its publication four years ago, and has lately, in one of his own publications, referred to statements of mine in an essay on the structure of *Apus cancriformis*, which appeared in the same journal in which that on "Limulus an Arachnid" was published. This memoir was also issued in conjunction with the latter essay under the separate title "Studies on Apus, Limulus, and Scorpio," and was sent by me to Prof. Claus in that form. Apart from the fact that these memoirs were separately and specially sent to Prof. Claus by me, I have good reason to believe that he does not neglect to make himself acquainted with the contents of the 'Quarterly Journal of Microscopical Science,' in which periodical they were first published. I must therefore conclude that my essay "Limulus an Arachnid" was known to Prof. Claus.

I will now proceed to quote certain passages from Prof. Claus's recent note in the 'Anzeiger' of the Academy, and compare them with passages from my memoir of four years since.

I. Prof. Claus says, "the Mites are degraded members of the class Arachnoidea." This view I had already advocated in my little book 'Degeneration' (Macmillan & Co., London, 1880), p. 50. It is also expressed in the memoir "Limulus an Arachnid," where I have classified the Arachnida* in three grades, viz.:—1, Hæmatobranchia, including the Gigan-

* I have since proposed (Trans. Zool. Soc. vol. xi. p. 379) to modify these terms as follows, viz.:—1, Delobranchia; 2, Embolobranchia; 3, Lipobranchia.

tostraca and Limulus; 2, Aerobranchia, including the Scorpions and Spiders; and 3, Lipobranchia, including the Pseudoscorpiones, Galeodes, the Opiliones, and Acarina.

II. Prof. Claus says, "the class Arachnoidea, the starting-point of which must probably be sought in the great Palæozoic Gigantostraca with their resemblance to the Scorpions, hitherto regarded as Crustacea upon insufficient grounds."

It would be more correct to say, "hitherto regarded by Professor Claus as Crustacea upon insufficient grounds," since the close affinity of *Limulus* and the Gigantostraca to the Scorpions was demonstrated in my memoir "Limulus an Arachnid," published as long ago as 1881. The whole purpose of that memoir was to establish this close affinity. That purpose was effected by a detailed comparison of segment with segment and organ with organ in the two series of Arthropods compared. I showed not only that the segments agreed with one another in *Limulus* and the Scorpion, but that the position and modification of such important parts as the genital opercula is actually coincident, and that the chilaria (metastoma) of *Limulus* and the Gigantostraca (often erroneously reckoned as modified limbs) are identical with the metasternum of *Scorpio*. I was able to show that the gill-books of *Limulus* agree in structure and position with the pectines and the lung-books of *Scorpio*. I have since, in other memoirs, demonstrated the exact equivalence in minute structure and general relations of (1) the internal cartilaginoid sternum or entochondrite of *Limulus*, *Scorpio*, and *Mygale* (Quart. Journ. Micr. Science, January 1884); (2) of the lateral and central eyes of *Limulus* and *Scorpio* (Quart. Journ. Micr. Sci. January 1883); and (3) of the coxal glands of *Limulus* with the similar glands discovered by me in *Scorpio* and *Mygale* (Quart. Journ. Micr. Sci. 1884, and Proceed. Roy. Soc. 1882). Other points of agreement I have also insisted upon in the above memoirs, and in one just published by the Zoological Society of London (Trans. Zool. Soc. vol. xi. 1885), which I will not here further enumerate.

It seems to me an extraordinary thing that Prof. Claus should omit all reference to these published researches and the conclusions formulated by me, and should declare that "hitherto" (that is to say until the publication of his Note in the 'Anzeiger' of the Imperial Academy) the Palæozoic Gigantostraca have been regarded as Crustacea.

III. Professor Claus proceeds further to say:—"Hitherto, evidently, far too much stress has been laid upon this last agreement [viz. branchial respiration] in the division of the Arthropoda into Branchiata and Tracheata, without taking

into consideration that the breathing by air-spaces may have been developed in different ways and at different times in the terrestrial forms, and that consequently no primarily decisive morphological value is to be ascribed even to the possession of tracheæ." Here again Prof. Claus is simply repeating a statement made four years ago by me in the following words; his "hitherto" is totally without justification, excepting so far as it applies to his own systematic treatises.

In "Limulus an Arachnid" I say, "Whatever may be the conclusion arrived at in the future in reference to the affinities of the Hexapoda and Myriapoda, the result of the recognition of the intimate relationship of Scorpio and Limulus must be, I think, to break up the artificial group of Arthropoda Tracheata by the separation of the Scorpions, Spiders, and Mites from any special connexion with it." And again, in another passage of the same essay, my words run: "It seems to be in the highest degree probable that there is no such a group to be recognized as the Tracheata. Tracheæ have probably developed independently in Peripatus, the Insecta, and again in Arachnida."

IV. Proceeding to formulate the conclusions which he has taken bodily from me as to the probable genealogy of the chief groups of the Arthropoda, Prof. Claus states that the stem of the Crustacea and that of the Arachnida are united at the base, whilst the Insecta Hexapoda and Myriapoda form a third series, "for the derivation of which the remarkable Annelid-like Onychophora (Peripatus) appear to be so significant."

This is a simple and direct description in words of the genealogical tree of the Arthropoda given at the end of my article "Limulus an Arachnid," with this difference, that whilst I have represented the Crustacea and the Arachnida as two main stems with a common base, and *Peripatus* as a third and independent stem, I have indicated a hesitation to decide on referring the Insecta Hexapoda and Myriapoda to the stem of *Peripatus* absolutely, and have considered the possibility of their derivation from either the Arthrostracous Crustacea or the tracheate Arachnida.

In the text of the essay I have, however, weighed the three possibilities suggested, and have given the reasons for considering the Insecta Hexapoda and Myriapoda to be derived from *Peripatus*. The most important of these reasons is pointed out by me to be dependent on the character of the antennæ of the Crustacea on the one hand, and of those of *Peripatus* and of the Insecta Hexapoda and Myriapoda on the other hand—the latter being apparently identical with the

prostomial tentacles of Chætopod worms, and not (as I suggested, in 1873, are the antennæ of the Crustacea) truly postoral appendages which have acquired a secondary præoral character by the backward shifting of the oral aperture. This view as to the Chætopod affinities of the antennæ of *Peripatus* and Insecta, and as to the contrasted and totally distinct origin of the Crustacean antennæ, is adopted from my writings by Prof. Claus. My words in "Limulus an Arachnid" are: "The antennæ of Hexapods and of Myriapods may be, as probably are those of Peripatus, non-appendicular prostomial antennæ." And again, "The antennæ of Peripatus probably are identical with the similar organs of Chætopoda, and are *not* originally postoral appendages." Further, in the memoir on the "Appendages and Nervous System of Apus," published in the Quart. Journ. Micr. Sci. in 1881, I say (p. 368):—

"I have long been of the opinion which Professor Claus appears to hold, that the appendages of the Arthropoda are homologous (or, to use a more distinctive term, 'homogeneous') with the appendages of the Chætopoda; and on this account I consider it a proper step in classification to associate the Chætopoda with the Arthropoda and Rotifera in one large phylum, the Appendiculata (see "Notes on Embryology and Classification," Quart. Journ. Micr. Sci. 1876, and Preface to the English translation of Gegenbaur's 'Elements of Comparative Anatomy').

"At the same time I have not been led to conclude, as does Prof. Claus, that only one pair of the Crustacean antennæ are to be regarded as primarily postoral in position and as representing the appendages of an originally postoral somite*; but I think it probable that *both* antennæ are in this case, and that in the Crustacea there is no representative of the antennæ or tactile processes of the cephalic lobe of Chætopoda. Whilst this appears to me probable in regard to the Crustacea, it yet seems to me very possible that the antennæ of Peripatus and of Hexapod and Myriapod insects may represent true processes of the cephalic lobe or prostomium, as seen in Chætopoda."

I have independent reason for concluding that Professor Claus has read the passage just quoted. He makes use of it in giving the characters of the three stems of Arthropoda, which he now adopts in accordance with my views as follows, so far as the question of antennæ is concerned.

He gives as characters:—"Series I. (Crustacea). Two

* By an error of the press the original here quoted reads "two originally postoral somites."—E. R. L.

pairs of antennæ, the second of which represents the first pair of trunk-members removed forwards.—Series II. (Gigantostraca, Arachnoidea). Absence of the anterior antennæ.—Series III. (Onychophora, Myriapoda, Insecta). With an rior pair of antennæ, representing the frontal tentacles of the Annelida."

With the exception of the fact (to which I will return below) that Professor Claus regards only the second instead of both pairs of Crustacean antennæ as representing trunk-members which have been removed forwards, this statement is identical with that made by me as follows in "Limulus an Arachnid," and is contrary to the views advocated by Professor Claus prior to my publication. Speaking of the probable ancestral history of the three great stems of Arthropoda recognized by me and now adopted without acknowledgment by Professor Claus, I say:—"In the interval between the giving off of Peripatus and the production of the Phyllopod-like ancestors of the Crustacea from the aquatic Pro-Arthropoda a vast change had to be effected in regard to appendages, as well as in the fusing of the nerve-cords, abolition of nephridia, production of a compound eye, striation of muscular tissue, &c. The *prostomial antennæ disappeared*, and their place was taken first by one, then by two pairs of postoral appendages, which gradually acquired a præoral position, as actually occurs in their individual growth in the embryo at the present day. . . . The other appendages probably all acquired at one stage a development of their basal portion, which served as an accessory organ for the purpose of bringing food to the mouth and, in some degree, in crushing such food (as seen in Apus). . . . The definite Crustacean character was attained when two pairs of appendages had become præoral and at least three pairs specialized as jaws and no longer locomotor. . . . Probably none of the known Merostomata suffice to give us a true picture of the structure of the ancestral Merostomata from which they were all derived. Probably these ancestral Merostomata were *devoid of the prostomial antennæ*—the non-appendicular antennæ. At the same time none of their postoral appendages had become definitely præoral in position and nerve-supply, though not less and probably not more than six pairs of pediform appendages were closely set round the mouth, their bases acting as powerful manducatory organs."

I then proceed to state the probable mode of the derivation of the Xiphosura, the Eurypterina, and the living Arachnida from these primitive Arachnids, destitute both of the prostomial antennæ characterizing *Peripatus* and its descendants,

and of the migrated substitutional antennæ (postoral appendages which have become præoral) of the Crustacean series.

V. With regard to the fundamental theory on which these views as to the difference of the nature of the antennæ in Crustacea on the one hand and in *Peripatus*, Hexapods, and Myriapods on the other hand depend, namely the theory that a forward movement of limbs or appendages belonging to body-segments has taken place in the Crustacea, so as to make appendages which were originally postoral actually præoral, it appears that my publication in 1873 in the Ann. & Mag. Nat. Hist., entitled "The Primitive Cell-layers of the Embryo as the Basis of Genealogical Classification of Animals," contains its first expression, and is anterior to the adoption of any such view by Prof. Claus even in regard to the limited sphere of application offered by the second pair of Crustacean antennæ. I do not find this theory of the movement forwards of a pair of postoral limbs so as to become præoral antennæ expressed in the editions of Prof. Claus's 'Grundzüge der Zoologie' which preceded the publication of my suggestion on this subject, nor has he clearly formulated it until the present occasion. In the Ann. & Mag. Nat. Hist. for May 1873, p. 336, I wrote:—"Much more likely, it seems, is the explanation that the oral aperture shifts position, and that the ophthalmic segment alone in Arthropoda represents the prostomium, the antennary and antennular segments being aboriginally metastomial and only prostomial by later adaptational shifting of the oral aperture."

VI. With regard to the one point in the morphology of the Arthropoda in regard to which Professor Claus has refrained from adopting my views I may say a few words. The difference between us is this: I have suggested that both the first and second pairs of Crustacean antennæ were originally postoral appendages (limbs of the body-segments), and have nothing to do with the prostomium. Professor Claus holds that the first pair of Crustacean antennæ are truly prostomial and comparable to the Annelids' prostomial tentacles, whilst he has adopted my theory of 1873 in so far only as the second pair of antennæ are concerned.

There are reasons for and against each of these views as to the nature of the first pair of Crustacean antennæ. But I will here only observe that, in accordance with my view of their nature, the fact that the first pair of appendages must have shifted forward at an earlier period in ancestral history than the second explains in a large measure the closer and more constant association of their nerve-supply with the cerebral ganglion and their somewhat greater departure from

the normal form of somatic appendages than is observed in regard to the second pair. I do not think it improbable that at some future date Professor Claus may adopt the view which I have advocated as to the first, just as he has adopted it in regard to the second pair of Crustacean antennæ; and I am therefore anxious to take the present opportunity of insisting upon an important piece of evidence in its favour which has come to light through my researches on the relationship of *Limulus* to the Arachnida. Packard, as is well known, discovered the "brick-red glands" of Limulus, the structure of which I have since investigated (Quart. Journ. Micr. Sci. January 1884). These glands are similar in essential structure to the "shell-gland" of the Entomostracous Crustacea. I discovered that they exist in *Scorpio* and also in *Mygale* in a highly developed condition, and have given to them the name "coxal glands," on account of their relation to the coxæ of the prosomatic appendages. In none of the Arachnids (*Limulus*, *Scorpio*, and *Mygale*) do these glands open to the exterior in the adult animal. But Mr. Gulland, in my laboratory in London, and Mr. Kingsley, in Boston, Mass., have independently ascertained that in the young Limulus *the coxal gland opens to the exterior on the basal joint of the fifth pair of appendages* (Quart. Journ. Micr. Sci. 1885). Now in the Crustacea Entomostraca the shell-gland opens to the exterior at the base of the second pair of maxillæ. If we reckon the first pair of Crustacean antennæ as the equivalent of the first pair of appendages of the Arachnida, as is the case according to my long since published view of their nature, then we arrive at the striking result, pointed out by Kingsley, that the Crustacean shell-gland and the Arachnidan coxal gland *open in both cases at the base of the fifth pair of appendages*. On the other hand, if Professor Claus is right in considering the first pair of Crustacean antennæ as essentially prostomial, and in regarding the first pair of Arachnidan appendages as the equivalent of the second pair of Crustacean antennæ, then the shell-gland of Entomostraca loses its agreement in position with the coxal glands of Arachnida, and has to be assigned to the fourth pair of true somatic appendages instead of the fifth. The argument is, I admit, not a conclusive one, since the Pro-Arthropod must have been, like *Peripatus*, provided with a nephridium (from which shell-gland and coxal gland are derived) at the base of each pair of appendages. Nevertheless it has weight in a question which can only be decided by the accumulation of converging evidence; and it is, *cæteris paribus*, more likely that the coxal glands and the shell-

gland are identical nephridia than that they represent those of different segments.

VII. Lastly, I wish briefly to point out that Professor Edouard Van Beneden of Liège was the first naturalist since Straus-Dürckheim to insist upon the necessity of regarding *Limulus* as an Arachnid. In 1871 (Société Entomologique de Belgique) he briefly expressed this view as the result of an examination of the embryos of *Limulus*; but he did not attempt to support it by any detailed comparison of the organization of the Xiphosura, Eurypterina, and Arachnida.

Had Professor Claus done justice to his predecessors in the discussion of the classification of the Arthropoda, he would have cited the views of the professor of Liège as well as my own detailed observations and speculations, which, I am glad to acknowledge, owe their existence to the brief but suggestive publication of my friend Edouard Van Beneden.

XXXII.— *Contributions towards the Knowledge of the Nervous and Muscular Systems of the Horny Sponges.* By Dr. R. von Lendenfeld*.

One of the Australian species of *Euspongia*, which is identical with *Euspongia anfractuosa*, Carter †, shows in many respects remarkable differences from the known structure‡ of the common bath-sponge, *Euspongia officinalis*. The sponge is massive, and has short, rounded, finger-like processes. Each of the latter contains a wide cylindrical cavity running in the direction of its length, and which externally looks very like a wide oscular tube. These wide tubes open below into a system of anastomosing lacunæ. The whole dermis is rich in pores. A very elegant sand-net is diffused between the regularly distributed pore-sieves. On closer examination it is seen that the tubes in the digitiform processes are lined with a membrane of exactly the same structure. This applies also to the lining of the lacunose cavities in the interior of the sponge. The tubes and lacunæ are not oscular tubes, and do not belong to the true sponge-body, but form a vestibular

* Translated by W. S. Dallas, F.L.S., from the 'Sitzungsberichte der königl. preussischen Akademie der Wissenschaften zu Berlin,' 1885, pp. 1015–1020.

† Ann. & Mag. Nat. Hist. ser. 5, vol. xv. p. 316.

‡ F. E. Schulze, "Untersuchungen über den Bau und die Entwickelung der Spongien.—VII. Mittheilung. Die Familie der Spongidæ" (Zeitschr. f. wiss. Zool. Bd. xxxii. pp. 591 *et seqq.*).