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CONDUCTED BY

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deposit that in its earlier stage is seen to be pierced by a very small pore opposite the cell-mouths, this pore or opening being afterwards filled up in the later stage in many of the specimens.

XXX.—*Are there Deep-sea Medusæ?*

By J. Walter Fewkes *.

In a Report on the Medusæ collected by the 'Albatross' in 1883–84 † I have already considered the question whether there are zones of Medusan life in the depths of the sea. I have not, however, from the nature of that paper written all that may be said, even in the present condition of our knowledge, of the facts bearing upon it. It is hoped that the present paper will at least point out the great interest attached to a scientific answer to the question which is taken as the title of this communication.

A study of the fauna of the deep sea is of comparatively modern growth. It is barely thirty years ago that naturalists almost universally believed the abysses of the ocean to be deserts as far as life is concerned. Deep-sea exploration has, however, not only revealed the fact that the ocean-bed at great depths is peopled by a rich and varied fauna, but also that the animals which constitute that fauna are peculiar and markedly different from those found in shallow waters.

It would seem a most extraordinary exception if, after the floor of the ocean at great depths had been found to be inhabited, the fathoms on fathoms of water through which the sounding-weight passes to reach those depths are destitute of life. In mid-ocean, where there is a highly varied nomadic life upon the surface and where the dredge has brought up from the ocean-bed a characteristic assemblage of animals, are we to suppose that between these places there is not a representative fauna, or must we conclude that after we sink a few fathoms below the surface life ceases, and that it is not until we come to the floor of the ocean that life again appears? If between these two limits there is a fauna, is that fauna the

* From the 'American Journal of Science,' February 1888, pp. 166–179.

† "Report on the Medusæ collected by the U. S. Fish Commission steamer 'Albatross' in the region of the Gulf Stream in 1883–84." Annual Report Comm. Fish and Fisheries, 1884, pp. 927–977, pls. i.–x. 1886. Many of the ideas there presented are also noticed in this paper.

same as that found at the surface, or is it characteristic? Can the animals which compose it be circumscribed in bathymetrical zones, out of which they cannot pass with impunity? Do we, in short, have in the nomadic oceanic life a change of fauna as we sink below the surface?

Naturalists have been led to suppose that since we find peculiar modifications in animals living upon the sea-bottom at great depths we should necessarily look for the same variation among nomadic animals at intermediate depths. It would then seem probable that there are bathymetrical zones for free-swimming animals, and that these animals are characteristic as compared with others which live at the surface. An investigation of the character of this fauna, if such there be, has an interest to the evolutionist, for it might be supposed to acquaint him with facts bearing on the general characters of the ancestors of certain genera of surface-life.

I can imagine few places on the earth's surface where the uniformity of physical conditions is greater than in the depths of the sea. I do not mean, as might be supposed, necessarily on the floor of the ocean, but at the depth of say 1000 fathoms separated from the ocean-bed by a wall of water of the same depth. Here, if anywhere, we may look for uniformity of conditions, and if environment has anything to do with modifications in the generic forms of animal life, here we may expect to discover animals which preserve ancestral features. On the surface of the ocean there are changes of temperature and of light and climatic variations; at the floor of the ocean there may be reactions of the interior of the earth upon its crust, perhaps lava-flows or geological oscillations*; but midway between these two places, equally removed from both, disturbing causes only rarely penetrate, and conditions remain more constant year by year. May we not expect to find here a corresponding uniformity in the fauna as compared either with the highly organized animals of the surface or with those of the depths of the ocean? Is that fauna more uniform than any other in the ocean?

No group of animals is better suited for a study of the questions which suggest themselves concerning the bathymetrical zones of characteristic animals, free-swimming at different depths in the ocean, than the Medusæ. The group is a large and very variable one. It is confined, with but few exceptions, to the ocean. Moreover, it is probable that its ancestors were oceanic animals. No group of marine

* Such changes might take place even if the oceans have practically been the same in past geologic times as at present.

animals presents fewer difficulties in studying the questions which we have stated than this.

It was with the impetus of a new enthusiasm for the study of these questions that I undertook, by the advice of Prof. Verrill, the examination of the rich collections of deep-sea Medusæ made in the Gulf-stream by the 'Albatross.' It seemed to me that the examination revealed much of general scientific interest.

I shall not consider in this discussion the Hydroida, as the members of this group are for the most part attached to the ground, and the problems connected with them are the same as those which pertain to all deep-sea animals attached to or partially living on the ocean-bed. We shall also pass by in silence the Ctenophora, no genus of which has yet been ascribed to the deep sea. I propose to consider a few of those jelly-fishes which are known as the *Acraspeda*, and incidentally the *Siphonophora*.

The history of the study of the deep-sea Medusæ belonging to these divisions is a very brief one. In many of the monographs on these groups we have isolated mentions of Medusæ which are ascribed to the deep sea. The jelly-fishes thus mentioned were commonly washed into shallow water by ocean-currents, by storms, or unusual events in the ocean, and the depths at which they were supposed to live could only be conjectural. The specimens themselves were, for the most part, in a mutilated condition.

The first and only paper on the *Siphonophora* of the deep sea is by Prof. Studer *, who describes new species and genera of these animals which were found twisted on ropes and wires used in deep-sea dredging and sounding. All of these are closely related to a genus called *Rhizophysa*, which is itself allied to a Medusa called *Physalia*, or the "Portuguese man-of-war," which habitually floats on the surface of the ocean.

The most important work which we have on the *Acraspeda* (the ordinary jelly-fishes found in shallow waters) of the deep seas is a report † by Prof. E. Hæckel on a collection made by H.M.S. 'Challenger.' No one has done more than he to elucidate the structure of the jelly-fishes, and he stands without an equal in his contributions to a knowledge of the deep-sea members of the group. This work of Hæckel is, up to the

* 'Zeitschrift für wissenschaftliche Zoologie,' vol. xxi.

† "Report on the Deep-Sea Medusæ dredged by H.M.S. 'Challenger' during the years 1873–76." Report on the Scientific Results of the Voyage of H.M.S. 'Challenger' during the years 1873–76, vol. iv. no. ii.

present, the greatest contribution of any naturalist to the study of the Medusan representatives of the deep-sea fauna.

If space permitted one or two other smaller contributions might be mentioned; but these two works are the most important additions to our knowledge of the deep-sea *Acraspeda* and *Siphonophora.*

We have no complete account of the deep-sea jelly-fishes of the Gulf-stream. That great body of water, which sweeps along our coast from the Straits of Florida northward, bears a nomadic life, of the wealth of which no one has yet a just conception. Those who have studied the stream in all latitudes have spoken of this fact, and one needs but to lower a drag-net in its waters for a few minutes to become convinced of its truth. The surface of the Gulf-stream has been but partially explored, the inhabitants of its depths, except on the very bed, are unknown.

The means which have been used for the collecting of animals from intermediate depths are not all that could be wished for. There is a call for greater refinement in this kind of collecting. A common way of obtaining this life is as follows. The dredge, trawl, or drag-net drawn up from a great depth is found to bring with it a Medusa. That Medusa is recorded from the depth of the trawl. What then is the possibility that it entered the dredge on the passage up through the water? I think every one will acknowledge that the possibility is very great, and that the Medusa may or may not have come from the deep sea. A drag-net attached to a dredge-rope or wire is sometimes lowered to a certain depth and then drawn up. Here also we may ask, how is it known that the Medusa found in the net entered it at the recorded depth? A Siphonophore clinging to a wire-rope used in sounding or dredging may or may not, as shown by A. Agassiz, have become twisted upon it at the depth at which the animal appears to be found when brought on deck. "In most cases," writes Prof. Verrill, "it is impossible to say whether the novel forms of Medusæ taken in the trawl and trawl-wings are inhabitants of the bottom waters or the surface, or of intermediate depths. Eventually those that belong to the surface-fauna will doubtless be taken in the surface-nets; but this will require much more extensive collecting of the surface animals than has yet been attempted."

It will thus be seen that the means of determining the depth at which the collecting of free oceanic animals takes place are too imperfect for any accurate knowledge of the bathymetrical limits of so-called deep-sea Medusæ. We are, in fact, on the very threshold of this kind of research, and

what is now most needed in the study of bathymetrical zones of marine life are improvements in the method of collecting at any depth, so that we can tell exactly at what distance below the surface a nomadic animal is captured. Devices have been suggested, one of which, the so-called "gravitating-trap" of Lieut. Sigsbee, has been described in the 'Bulletin' of the Museum of Comparative Zoology at Cambridge. I am not aware how extensively this apparatus, or others of similar kind, has been used by those who are in charge of deep-sea exploration, or whether it has been sufficiently tried to test its usefulness *. If Medusæ were always as abundant at great depths as they sometimes are at the surface, a device might easily be invented for the successful capture of at least a few specimens. It seems more probable that Medusæ are not common enough to warrant one in supposing them very numerous, and the difficulty in their capture thus becomes greater, rendering it necessary that some modification of the gravitating-trap be invented †.

In a letter to Mr. C. P. Patterson (Bull. Mus. Comp. Zool. vol. vi. no. 8) Mr. A. Agassiz calls attention to the uncertain methods adopted for ascertaining at what depths free-swimming animals live, and from experiments with the "Sigsbee Trap" concludes (p. 153), while he does not deny that there are certain genera of deep-sea Medusæ, that "the above experiments appear to prove conclusively that the surface-fauna of the sea is really limited to a comparatively narrow belt in depth, and that there is no intermediate belt, so to speak, of animal life between those living on the bottom or close to it and the surface-fauna."

This statement from such a high authority in the study of marine zoology would seem to effectually crush any murmur of belief in intermediate zones in the distribution of oceanic forms of life. While I have the highest respect for this view, I cannot help entertaining an opinion that more observations are necessary before we can accept the proposition that there

* "Results of Explorations made by the Steamer 'Albatross' off the Northern Coast of the United States in 1883," Annual Report Comm. Fish and Fisheries, 1883.

† The small amount of water which enters the Sigsbee gravitating-trap is one great objection to it. Negative results with this apparatus do not necessarily show that life does not exist at the depth at which the door is opened, and the instrument does not collect from a large enough area for a successful determination of the abundance of life which it is intended to capture. From what has been published, and statements of those engaged in deep-sea exploration, I am led to suppose that the "Sigsbee Gravitating-Trap" has given only negative data in regard to the problem of the existence of characteristic nomadic life in intermediate depths of the sea.

are not characteristic belts of pelagic animals at different depths.

With the question whether the recorded depths at which the Medusæ which we shall consider are found are accurate or not we cannot deal. Indeed at this stage of this kind of deep-sea exploration an examination of these methods would be foreign to the purposes of this paper. We take the data as given by the collector and at present leave the improvement of the collecting-apparatus to others.

Can we not approach this subject from another side? Are there any characteristics in the Medusæ themselves which show that they are preeminently fitted to live at the depths or approximate depths from which they are reported? Has their habitat left any traces in the modification of their anatomy? Has the uniformity of conditions in their habitat led to a corresponding simplicity in their structure, and are they nearer the ancestral forms than others with a more varied environment? An account of the singular structure of one or two typical genera may help us to answer this question, or at all events present certain facts which bear upon it. Let us therefore for illustration consider one or two representatives of the Acraspeda and Siphonophora discovered by the 'Albatross' in the depths of the Gulf-stream.

Every one familiar with the anatomical structure of the Siphonophores will recognize how difficult it is to find in those genera like *Rhizophysa* anything to point to an adaptation to a deep-sea life. The 'Albatross' has discovered new Physophores closely allied to *Rhizophysa*, one of which, *Petrophysa*, reaches the enormous size of 20 feet in length in alcohol. The float of this animal is larger than that of any true Siphonophore except *Physalia*. The large size of the float in these Physophores would seem an effective argument against their adaptation to a life in deep water, especially as their nearest ally, *Physalia*, is preeminently a surface form.

It is extremely difficult to gather from the structure of the known Siphonophora ascribed to the deep sea anything to indicate an adaptation to such a life. The group can afford little satisfaction in our answer to the question of whether there is a nomadic deep-sea life or not.

The nature of the argument for the existence of Medusan life in bathymetrical zones may be best illustrated by considering a few examples of the Acraspeda. These are not the only instances which might be chosen, and possibly are not the best. They are thought to be as suggestive as any among the Acraspeda which have been ascribed to great depths.

One of the most characteristic families of Acraspeda is called the Collaspidæ. The family is supposed to belong to the deep-sea and is represented by two genera, *Atolla* and *Collaspis*, which differ from each other rather obscurely in the regular or irregular arrangement of the sexual glands. It is a question whether we have more than specific differences in the features which have been pointed out by Hæckel as separating the two.

Up to the present the genus *Atolla* is represented by a single species collected by the 'Challenger' (*A. Wyvillii*, Hæck.) and two species from the Gulf-stream (*A. Bairdii* and *A. Verrillii*, Fewkes).

The structure of *Atolla* is thought to be more primitive than that of the ordinary inshore genera, *Cyanea* and *Aurelia*. It is so characteristic that I repeat from my paper on the anatomy of this genus a condensed notice of some peculiarities *.

If we compare *Atolla* with our common surface Medusæ, such as *Aurelia*, we notice many marked peculiarities.

In the former we have a coronal furrow, which is not represented in *Aurelia*, although found in a well-known surface Medusa (*Periphylla*). We have in *Atolla* a variable number (generally twenty-two) of sense-bodies or peduncles of the same. In *Aurelia* we have always eight sense-bodies. The coronal muscle is peculiar to *Atolla*.

The sense-bodies of *Atolla* are spoken of by Hæckel as rudimentary, and it is supposed that we have in a deep-sea Medusa an adaptation for a life in the depths into which the

* The umbrella, when seen from the upperside, is found to be divided by a deep ring-shaped groove into a central and a peripheral region. The groove is called the coronal fossa, the central region the *discus centralis*, and the periphery the corona. The corona is formed of a number of wedge-shaped gelatinous blocks, joined together and bearing on their outer rim alternately tentacles and sense-organs. These gelatinous blocks are designated by the term socle, taken from architectural nomenclature, and are of two kinds—those which bear the tentacles, called the tentacular socles, and those which carry the sense-bodies (if such exist), the socles of the sense-bodies. The socles of the sense-bodies bear two thin flaps, called the marginal lappets. On the underside of the disk we have, below the corona, a large ring-shaped muscle, called the coronal muscle, which is highly characteristic and larger in this genus than in any other known Medusa. Axially to this muscle there is a zone formed of eight kidney-shaped sexual glands and a simple mouth, which opens into a bag-shaped stomach. In the interior of the body there is a circular cavity filling the central disk, which opens by four orifices into a ring-shaped sinus, which lies in the gelatinous body of the corona. From the outer edge of this ring-shaped sinus simple, unbranched, peripheral tubes extend through the bell-substance, passing into the cavities of the tentacles and rudimentary marginal sense-bodies.

light never penetrates. We may have here what we so often find in deep-sea animals, a reduction in the size and efficiency of the special organ of sense to fit the Medusa for the conditions under which it must live at great depths. Stated in a startling way, we might speak of *Atolla* as a blind Medusa. This statement would hardly be justifiable, and we can at present go no further than to say that the special sense-bodies of sight * are supposed to be rudimentary. It must, however, be borne in mind that nowhere among Acraspeda do we have so many, twenty-two, sense-bodies as here. In some specimens there are twenty-eight sense-bodies in this genus.

It is extraordinary that one of the known species of *Atolla* (*A. Wyvillii*, Hæck.) comes from the Antarctic Ocean, while our two species were both from the *warm* (?) water of the Gulf-stream. In the southern hemisphere its lowest limit is about 2000 fathoms, while north of the equator it comes from the surface or within a few hundred fathoms.

Among the Medusæ collected by Lieut. Greely in the icy waters of Lady Franklin Bay is an interesting jelly-fish allied to *Atolla*. This genus (*Nauphanta*) has been found but once before, and then by the naturalists of the 'Challenger' in the neighbourhood of the island of Tristan d'Acunha in the South Atlantic. In the latter locality it is recorded from about 1500 fathoms, while in Lady Franklin Bay it is found at the surface. From several differences in these two specimens, those from the Arctic and those from the South Atlantic, I have supposed the boreal form to be new and have called it by the specific name *polaris* †. The 'Challenger' specimens were placed under a new genus, called by Hæckel *Nauphanta* ‡.

Before we consider the relationship between *Atolla*, *Nauphanta*, and other related Medusæ ascribed to the deep sea,

* Whether the "eye" of the jelly-fish can distinguish form or not has not been demonstrated. Simple experiments made by passing rays of light through dishes in which they are confined, or the simple fact that they almost always congregate on the illuminated side of the same, are not conclusive to me that they distinguish *form*. Experiments with sensitive plates to show the depths to which light penetrates the water are most suggestive in this connexion. It seems pertinent to the whole inquiry to ask whether looked at from the physical side there are not rays of light of such a nature that the vertebrate eye is not able to perceive them, but which may act upon the visual organs of other animals.

† *Nauphanta polaris* has a central disk as in *Atolla*, a coronal fossa, and a corona, which, however, is formed of sixteen socles, eight of which bear tentacles, tentacular socles, and eight sense-bodies. The outlines of these socles is more clearly marked than in *Atolla* on the upper surface of the corona which they form, on account of the deep sculpture which separates them.

‡ The name *Nauphanta* was preoccupied in 1879, when applied to this Medusa, having been given to a worm in 1864.

let me mention another new Medusa collected by the 'Albatross' in the Gulf-stream. The genus *Nauphantopsis* is of interesting affinities, since it has the same central disk as *Nauphanta* and *Atolla*, the same coronal fossa and coronal socles. It is most closely allied to *Nauphanta*, but has thirty-two socles instead of sixteen, eight sense-bodies (?), and twenty-four tentacles *. These tentacles are therefore arranged in threes, the series of three alternating with the eight sense-bodies—all with gelatinous socles.

It is easy to interpret the three deep-sea Acraspeda, *Atolla*, *Nauphanta*, and *Nauphantopsis*. At first sight they closely resemble gigantic young *Aureliæ* or *Cyaneæ* in a stage which is called the Ephyra. This is especially true of *Nauphanta*, which has the same number and arrangement of tentacles as the young *Cyanea* or *Aurelia* in the Ephyra stage. It is so close in fact that at first sight they seem identical. In *Nauphanta* we have mature ovaries, and this would seem to indicate the adult form. The existence, however, of ova and a sexual maturity is by no means an indication of the acquisition of the adult form among Medusæ, and many instances might be mentioned of a jelly-fish with mature ova even before embryonic appendages have been dropped. There is nothing then to prove that *Nauphanta* is not the young of some other Medusa, and on the other hand there is no proof that it is not an adult. If it is an adult, it is a mature Medusa with likeness to embryonic conditions of other Medusæ. It would then be nearer the ancestral form of Acraspeda than any of the more common Medusæ like *Cyanea* and *Aurelia*.

At first study I was inclined to regard *Atolla* as a giant Ephyra of some unknown Medusa. Its affinities are certainly very close to *Nauphanta*, and through the latter genus it is connected with Ephyra, the young of *Cyanea*. We may therefore regard both these genera as embryonic in their structure and as close allies of the young of a higher jelly-fish. It is a most interesting fact that two genera with such marked characters are considered deep-sea genera. Exactly what the

* *Nauphantopsis* is an interesting genus in its relationship to the surface-genus *Periphylla*, which has four sense-bodies and twelve tentacles in four series of three each. We likewise have in the same genus marked coronal socles, sixteen in number, while *Nauphantopsis* has thirty-two. *Nauphantopsis* then appears to be a connecting genus between *Nauphanta* and *Periphylla*. I believe we are justified in regarding *Nauphanta* as an adult, although when I first studied it I was strongly inclined to consider it an immature animal. It must be confessed that, with the exception that it has eight sense-bodies, while *Periphylla* has but four, there are strong resemblances between a young *Periphylla* and the genus *Nauphanta*.

evolutionist would expect from the uniformity of conditions which exist in deep water we find manifested in the simple anatomy of two of the more characteristic deep-sea genera of Acraspeda, a simplicity of structure of embryonic and therefore of ancestral nature. It is certainly strange that these two facts are associated. It is an extraordinary coincidence if the deep water at which the Medusæ were found and the embryonic affinities in their anatomy have not the relationship of Cause and Effect. The discovery of a *Nauphanta* in the icy waters of the Arctic zone *, while it shows that the genus may approach the surface when the temperature of the depth at which it lives becomes a surface-temperature, would also indicate that the genus is not confined to the great depth at which it is reported from the South Atlantic. If *Nauphanta* cannot rise to the surface in the latitudes of Tristan d'Acunha, it may be that the elevation of temperature above its habitat keeps it at great depths. At the higher latitude of North Greenland, however, the cold zone, in which *Nauphanta* lives in the South Atlantic, is about the surface-temperature. Here then, as far as thermal conditions go, the Medusa can rise to the surface. We here encounter what I believe will be found to be an influence of more important character in the modification of Medusan life at great depths than the depth of water itself. Medusæ are sensitive to changes of temperature in the ocean; so sensitive, in fact, that for many genera the lines of demarcation between warm and cold oceanic currents are often dead lines to these delicate creatures. It is well known that certain genera can be frozen without being killed by the change, and that Medusæ suffer less from a diminution in temperature than from an elevation of the same. This is particularly true of those genera, like *Aurelia*, *Sarsia*, and others, which habitually inhabit cold water. A temperature of $+70^{\circ}$ F. is fatal to them, while many tropical forms will easily live even in higher temperatures. Temperature in the ocean has drawn invisible lines in the distribution of Medusæ in depth as well as latitude; and it is at present very difficult to separate this cause from that of pressure in the bathymetrical limits of the jelly-fishes. The poverty of our knowledge of the ranges of temperatures which jelly-fishes can endure is too great to admit of any generalizations of value on this question. Still there are no facts of more vital importance in the discussion of the question of whether there are deep-sea Acraspeda than those

* 'Report on the Medusæ collected by the Lady Franklin Bay Expedition,' Lieut. A. W. Greely commanding. Appendix no. xi.

which bring information of the thermal limits at which the Medusæ can live.

It would be profitable, if space permitted, to consider other genera of Acraspeda made known by the 'Albatross' in their bearings on the question which is the title of this paper. The three genera already considered present us the strongest arguments which can be found in the modification of external and internal anatomy, as indicative of a deep-sea habitat.

"Those Medusæ," writes Hæckel, "may be regarded with greater probability as permanent and characteristic inhabitants of the deep-sea, which have either adapted themselves by special modifications of organization to such a mode of life, or which give evidence by their primitive structure of a remote phylogenetic origin." He then enumerates those which he places in this category, among which are the two remarkable genera *Atolla* and *Nauphanta*. "It is by no means certain," writes Hæckel, "that all the eighteen Medusæ described below (Report on 'Challenger' Medusæ) are constant inhabitants of the deep sea." We have discussed the argument drawn from two of the most characteristic of the Acraspeda, viz. *Atolla* and *Nauphanta*, and can readily subscribe to this statement as far as these are concerned.

The resemblance of *Nauphantopsis* and *Atolla* to Ephyra is believed to have a morphological significance; Ephyra is thought to be the ancestral form of the Acraspeda, and these so-called deep-sea Medusæ still preserve the ancestral form with small modifications, except in size, repetition of organs, and certain other characters. Of the development of *Atolla* or of the Collaspidæ we know nothing, and yet a knowledge of this subject is possibly to reveal the solution of important questions. If the mode of growth should prove to be a direct development without a Scyphostoma, it would certainly increase my belief that these Medusæ somehow resemble the ancestral forms. I have already elsewhere shown that among the Hydromedusæ with alternation of generations and those with a direct development, the latter method is normal, while the former is a secondary modification. Among Acraspeda also the direct development of *Pelagia* is the ancestral method, while the formation of a Scyphostoma is a secondary modification. We should expect to find in *Atolla* a direct development if it be an ancestral genus. From its mode of life in the high seas we should also expect the same *.

* I believe the Lucernarians are degenerate adult Acraspeda, which have attached themselves to the bottom much in the same way as *Cassiopea frondosa*, and become modified in consequence. While it may be said that they are homologous to the Scyphostoma stage, it is not thought

Abandoning for the present as insufficient any evidence which might be adduced from the structure of the Medusæ themselves, and passing to the recorded facts in relation to bathymetrical distribution, we find no more satisfaction from this consideration. It would appear that the strongest arguments for the existence of nomadic deep-sea Medusæ of the Acraspeda are found by Hæckel in the following genera*. The names in brackets are authorities for distribution.

1. *Pectanthis.*—Surface (Hæckel).
2. *Pectyllis.*—200–600 fath. (Hæckel).
3. *Pectis.*—1260 fath. (Hæckel).
4. *Cunarcha.*—"Possibly captured in drawing up the lead" (Hæckel).
5. *Æginura.*—"2150 fath. apparently" (Hæckel).
6. *Periphylla.*—Surface (Fewkes).
7. *Periphema.*—1975 fath. (Hæckel).
8. *Tesserantha.*—2160 fath. (Hæckel).
9. *Atolla.*—2040 fath. (Hæckel); surface (Fewkes).
10. *Nauphanta.*—1425 fath. (Hæckel); surface (Fewkes).

Of the above genera the 'Albatross' has collected many specimens of *Periphylla* and *Atolla* from the surface of the ocean. Greely collected a species of *Nauphanta* from the icy waters of the surface of Lady Franklin Bay; *Periphema* is so closely allied to *Periphylla* that we may well hesitate to accept its limitation to the great depth at which it is recorded (1975 fath.); *Pectyllis* is recorded from 200 to 600 fath. In the present use of the word deep-sea this genus can hardly be regarded as preeminently a deep-sea Medusa. There remain† *Pectis* (1260 fath.) and *Tesserantha* (2160 fath.) as

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that they are ancestral. They are in reality secondarily modified, for the ancestral method of development is direct, without an attached young, in Acraspeda as in Craspedota.

While the primitive structure and relationship of *Atolla*, *Nauphanta*, and *Nauphantopsis* would seem to ally them closely to Ephyra, and stamp them as less modified than such genera as *Cyanea*, in certain anatomical details they might be regarded as higher even than the last mentioned. We cannot consequently draw from their simple relationship to an embryonic form the conclusion that they have retained that likeness on account of the simpler conditions of deep-water habitat. Nor is the argument drawn from the supposed abortion of the sense-body conclusive as far as these Medusæ are concerned, although it looks plausible.

* *Op. cit.* Introduction, p. ii.

† *Cunarcha* was "possibly captured in drawing up the lead," and *Æginura*, 2150 fath., "apparently."

As a bit of positive evidence that *Atolla* is a deep-sea Medusa, Mr.

the only genera in the above list which can be regarded as purely deep-sea in their habit. Each of these is described from *single* specimens, and the former is closely allied to well-known surface-genera. The foundation in observation for a belief in the existence of nomadic deep-sea Medusæ, as far as recorded depths go, is certainly not all that might be desired.

Possibly a stronger argument for the existence of deep-sea Acraspeda may be drawn from the structure of the interesting free genus of Lucernaridæ (*Lucernaria bathyphila*, Hæck.). This species is recorded from 540 fath. The fixed *Lucernariæ* are found in shallow water. The argument drawn from the structure of the free Lucernarian would be stronger if the so-called attached species had been brought up from great depths or if Scyphostoma had been reported from the ocean bed. It is suggested that those who have in charge the collecting of deep-sea animals observe with care the contents of the dredges for attached Scyphostoma and Lucernarians, and it is particularly desirable, from a morphological standpoint, that the development of such genera as *Atolla* be known. If it can be shown that this and related Medusæ have an indirect development, with an attached Strobila living in great depths, they may rightly be called deep-sea Medusæ. A nomadic jelly-fish, limited in bathymetrical habitat, could best fulfil its conditions of life by having a direct development without attached larval conditions.

Why cannot we suppose that deep-sea Medusæ can live at the surface and also at great depths? Why look for bathymetrical zones in the ocean for nomadic animals? The main reason seems to be the exceptional nature of such a wide distribution in places so widely separated in physical characteristics. It may be possible for a Medusa to live equally well at the surface and under a pressure of 2000 fath. of water, and in the different temperatures of these two regions; but if they can endure these widely different conditions, they do not resemble other animals and their own relatives from the shallow waters. The logical inference from what is known of the differences between the facies of deep-sea animals on the ocean-bottom and those from the littoral zone would seem to be true of animals which are not fixed to the ground nor

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Thomas Lee, who has seen the genus when collected, informed me, after I had shown him a specimen of *Atolla*, that he remembers it in deep-water trawls. In new collections made by the 'Albatross' in 1885–86, *Atolla* in several instances is recorded from the "surface," and one of those described in the collections of 1883–84 is recorded from the surface.

dependent upon it, viz. that there are bathymetric limits in the ocean, even to nomadic animals apparently as helpless as the Medusæ.

In closing my short discussion of the question of deep-sea nomadic Medusan life it may be said that, as far as the data thus far gathered go, neither the recorded depths nor the structure of the genera considered demonstrates that we have a serial distribution of free Medusæ in bathymetrical zones. While our present information is insufficient to answer the question, *it seems* to me that the case is much stronger than the arguments which can be advanced in its support. There is little doubt that Medusan life has bathymetrical limitations. Our well-known surface Medusæ probably cannot live at great depths, and their places are probably taken there by others; still, until there are more exact data bearing on this conclusion, it cannot be demonstrated to be true. What is now needed is, in the first place, an accurate determination of the depth at which Medusæ of different genera are captured, and secondly a more accurate study of the peculiarities of anatomy and development of those which are supposed to be thus limited in habitat. It is also equally necessary that the surface-fauna should be better known for comparison. There are at present a few marine stations in the Mediterranean and North Atlantic where the study of surface-life is zealously prosecuted; but it is only when the Müller's net has been used with equal zeal in the South Atlantic, the Indian Ocean, and Pacific that we can have a basis to work upon. An exploring vessel on a cruise through these waters is not enough. It is a reconnaissance. There must be established permanent marine stations where the study will be carried on year after year for a long time in one locality.

XXXI.—*New Species of* Lucanidæ, Cetoniidæ, *and* Buprestidæ *in the British Museum.* By Charles O. Waterhouse.

Lucanidæ.

Hexarthrius Davisoni, n. sp.

Color *Lucani cervi* et eodem sat similis, capite thoraceque magis rugosis; mandibulis elongatis, nitidis, nigris, apicem versus inclinatis, intus quadridentatis, dente basali valido. ♂.

Long. 23–26 lin.; mandib. 11½–13 lin.