CONTRIBUTIONS

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BY

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IN FIVE PARTS.—I. ACALEPHS IN GENERAL.—II. CTENOPHORÆ.—III. DISCOPHORÆ.—IV. HYDROIDÆ.
—V. HOMOLOGIES OF THE RADIATA; WITH FORTY-SIX PLATES.

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PART I.

ACALEPHS IN GENERAL.

ACALEPHS IN GENERAL.

CHAPTER FIRST.

HISTORY OF OUR KNOWLEDGE OF THE ACALEPHS.

SECTION I.

PERIOD OF ARISTOTLE AND THE ROMAN NATURALISTS.

It is one of the most instructive studies to trace the efforts of the human mind in its successive attempts to understand the phenomena of Nature. This study is particularly attractive when it is pursued in connection with a subject which has taxed the ingenuity of man for a long series of ages; and it may well be said, that, except Astronomy, no other field affords so much material for such investigations as Zoölogy, on account of the early attention paid by philosophers to the study of animated beings. From Aristotle to this day we have an uninterrupted series of writers who have recorded their views of the nature of animals, and thus enable us to ascertain what successive steps have been made towards a more extensive acquaintance with, and a more accurate appreciation of, the nature, the affinities, the structure, and the mode of development, of the whole animal kingdom. And while thus following up the long record of the progress of human knowledge in this direction, an attentive observer cannot fail to be struck with the similarity noticeable between the earlier views presented by the older writers on these topics, and the impression he himself is likely to have received when contemplating for the first time the same objects. Not less striking is the coincidence between the sum total of the information gradually obtained in course of time, and the successive steps made by those who have approached these studies without a previous acquaintance with the labors of their predecessors. The study of the Acalephs, under which name naturalists now include the so-called jelly-fishes or sea-blubbers or sun-fishes, and the animals allied to them, affords a striking example of this correspondence between the gradual progress every one must make who attempts to understand their nature, and the successive stages of the science relating to these animals as recorded in the works of the authors of past ages. When we first observe a jelly-fish, it appears like a moving fleshy mass, seemingly destitute of organization; next, we may observe its motions, contracting and expanding, while it floats near the surface of the water. Upon touching it, we may feel the burning sensation it produces upon the naked hand, and perhaps perceive also that it has a central opening, a sort of mouth, through which it introduces its food into the interior. Again, we cannot but be struck with their slight consistency, and the rapidity with which they melt away when taken out of the water. But it is not until our methods of investigation are improved; and when, after repeated failures, we have learned how to handle and treat them, that we begin to perceive how remarkable and complicated their internal structure is; — it is not until we have become acquainted with a large number of their different kinds, that we perceive how greatly diversified they are; — it is not until we have had an opportunity of tracing their development, that we perceive how wide the range of their class really is; — it is not until we have extended our comparisons to almost every type of the animal kingdom, that we can be prepared to determine their general affinity, the natural limits of the type to which they belong, the distinctive characteristics of their class, the gradation of their orders, and the peculiarities that may distinguish their families, their genera, and their species. We cannot, therefore, expect to find, in the older writers upon Zoölogy, any thing like a natural classification of these animals. Even Aristotle, whose keen mind has thrown so much light at such an early period upon the natural affinities of the higher animals, has failed entirely to recognize the relations which exist between them and the star-fishes and sea-urchins. All that he, and other naturalists, up to a very recent period, tell us about them, amounts to little more than the first impression they make on those who see them for the first time, without attempting to compare them with other animals.

For this reason I have thought it desirable to introduce a brief account of all that has been written upon the subject of Acalephs, as far as the condition of the libraries in this part of the world will permit it, not only with a view of thus recapitulating the successive stages of our knowledge of these beings, and comparing them with our daily experience in attempting to unravel all the mysteries connected with their history, but also with a hope of accounting for the very questionable terminology used at present by all naturalists in describing the parts of these singular beings.

The earliest accounts extant, relating to Acalephs, are contained in a few passages of the History of Animals by Aristotle; but these are very meagre, and show that the great Greek philosopher had no very clear idea either of their affinities or of their structure.[1] He speaks of them under three names; calling them, in some of his passages, Acalephæ, in others, Knidæ, and in another, Pneumones. A careful comparison of all the passages in which these animals are mentioned, shows that the names of Acalephæ and Knidæ were probably applied to Actiniæ and to Medusæ indiscriminately, and that Aristotle himself did not distinguish these animals accurately, or, at least, did not know in what their essential differences consist, for, speaking of Acalephæ as well as of Knidæ, he only says that there are two kinds, one of which is attached to the rocks, while the other may free itself and seek its food by night; which seems to indicate that he believed the free Medusæ to be at times attached like the Actiniæ, and capable of freeing themselves at will, or that the Actiniæ, freeing themselves, become Medusæ.[2] Taking into consideration, however,

[1] The best edition of the Zoölogical works of Aristotle is that of IO. GOTTLOB SCHNEIDER; Aristotelis de Animalibus Historiæ, Lib. X., Græce and Latine, Lipsiæ, 1811, 4 vols. 8vo. The best translation is that of DR. FR. STRACK into German: Aristoteles Naturgeschichte der Thiere übesetzt und mit Anmerkungen begleitet, Frankfurt am Main, 1816, 1 vol. 8vo. The French translation by Camus, Paris, 1783, 2 vols. 4to., is less accurate. There is no good English translation.

[2] As the account which LESSON gives of the views of Aristotle relating to Medusæ, in his *Histoire Naturelle des Zoöphytes: Acalèphes*, Paris, 1843, is far from accurate, I deem it necessary to introduce here a literal translation of all the passages of the original text relating to that subject.

The name *Acalephe* appears in six different passages in Aristotle. First, in Book I. Chap. I. Sec. 6, when, speaking of the habits and functions of animals, he says, that "there are some which get their food in the water, and are unable to live out of it; they do not, however, take in either air or water, as the Acalephe and the Ostrea." Next, in Sec. 8, speaking of the ability of animals to change their place, he says, "some both attach and detach themselves, as a genus of the so-called Acalephæ, for some of these, detaching themselves by night, go about to feed." In Book IV. Chap. VI. Sec. 4 and 5, when speaking of the structure of the marine animals, he mentions that "there is also the genus of the Acalephæ, which is peculiar; they cling to the rocks, like some of the shell fishes, but occasionally free themselves. They have no shell, but their whole body is fleshy, and they feel, and seize the hand approaching them, and then hold it, as the Polypus" (which is the Octapus of modern systematic writers) "does with its feelers, in such a manner as to cause the flesh to swell. They have the mouth in the middle, and live from the rocks as from a shell" (which probably means that the rocks afford them the same protection as the shell gives to the oyster). "If any one of the small fishes falls in their way, they hold to it, as to the hand; so also if any thing eatable falls in their way, they devour it, and one genus frees itself and feeds upon scallops and sea-urchins, whenever any thing falls in its way. They seem to have no visible excrements, but in this they resemble the plants. There are two genera of Acalephæ, one of which is smaller and more eatable, the other large and hard, like those found about Chalcis. During the winter their flesh is firm, wherefore they are caught, and are eatable; during summer they perish, for they become soft, and, if touched, are easily torn, and cannot be taken off at all that is said about Acalephæ and Knidæ, it would seem as if the name of Knidæ applied more particularly to Medusæ, as these are the only ones of which he seems to have known that they possessed burning properties, the nature of which could not have been very clearly understood by him, for he says, when speaking of the Sea Scolopendra (probably some Nereis), that it does not bite with the mouth, but produces with the whole body a painful sensation like that caused by the Knide. The description he gives of the Acalephæ applies particularly well to the Actiniæ, and but for the statement that they free themselves could not be applied to any Medusa. Of the Pneumon, he only states, that they are formed out of themselves.

Neither Pliny[1] nor Aelian nor Oppian nor Galenus, nor the writers of the middle

all; and, suffering from the heat, they retire further among the rocks." In Book VIII. Chap. 1. Sec. 3, when, speaking of the intensity of life and its gradations, he considers the marine shells and the Ascidians as intermediate between the higher animals and plants. "The transition from them to the animals is uninterrupted, as has been said before; as to some of those in the sea, one might doubt whether they are animals or plants, for they are attached, and many of them, when separated, are destroyed. In some, the nature of the body is fleshy, as in the so-called Tethya (our Ascidians) and the genus of the Acalephæ. The sponge, however," he adds, "is entirely like the plants"; and in Chap. III. Sec. 3, he says that "the Acalephæ live upon whatever small fishes fall in their way, and that they have the mouth in the middle, which is most evident in the largest ones. They have also, like the oyster, an opening where the food passes out, and this is upward. In a general way the Acalephæ resemble the internal fleshy part of the oyster, and it uses the rock as a shell."

The name Knide occurs twice. First, in Book V. Chap. XIV. Sec. 1, where it says that "the Knidæ and the Sponges, which are found in the clefts of the rocks, though without a shell, multiply in the same way as the shell fishes. There are, however, two genera of Knidæ: one in the hollows, which never frees itself from the rocks; and another, living upon flat, smooth bottom, which detaches itself and moves from place to place." And in Book IX. Chap. XXV. Sec. 4, when speaking of the sea-snakes, he says of the Sea Scolopendra (our Nereis), that "when it has swallowed the hook, it turns itself inside out until it expels the hook, and then turns itself back again; it does not bite with the mouth, but its whole body produces a painful sensation, like that of the Knidæ."

The name Pneumon occurs but once (Book V. Chap. XIII. Sec. 10), when, speaking of the reproduction and growth of animals, he only says that the so-called Pneumon "is formed from itself," meaning that it is spontaneously generated. From this passage it could hardly be inferred that Aristotle designated an Acalephe under the name of Pneumon. But when we consider how the Grecian colonies were scattered along the shores of the Mediterranean, and that the name Pulmo Marinus was early applied to the large Rhizostoma of the Mediterranean, and even figured under that name by Mathioli; that the Rhizostoma may aptly be compared to a floating lung; and further, that this largest Medusa of the Mediterranean is commonly called Poumon de Mer by the French fishermen, — the conclusion is irresistible, that, if the Latin and French names are not a translation of the Greek "Pneumon," this name is likely to have been given to that large Medusa for the same reason for which the French call it sea-lung. It is singular, however, that Rondelet, who first represented the Rhizostoma, should have failed to recognize it as the Pneumon of the Greeks, and applied the name to a compound Ascidian.

[1] The best edition of the Natural History of Pliny is that published in Paris in 1828 by Lemaire, under the supervision of Ajasson de Grandsagne:

ages,[1] added any important information to that already contained in Aristotle; and we must come down to the sixteenth century, before we find authors who have observed Medusæ in nature, and given rude outlines of their external appearance. Among them Bélon and Rondelet deserve particular mention, for they were the first who published wood-cuts representing several species of Actiniæ and Acalephæ; and, though their knowledge of these animals is not more accurate than that of Aristotle, a new era in the natural history of animals begins with them and Gessner.

SECTION II.

THE NATURALISTS OF THE SIXTEENTH AND SEVENTEENTH CENTURIES.

The connection between the extraordinary impulse which the natural sciences received in the second half of the sixteenth century, and the preceding momentous

Caii Plini secundi Historiæ Naturalis libri xxxvii. The third part, devoted to Zoölogy, contains notes and dissertations by G. Cuvier.

Most of what is contained in Pliny respecting the Acalephs (Lib. ix. cap. 45) is compiled from Aristotle, though it appears from his description, that he must have observed these animals himself, as he mentions the manner in which they move about, and seize their prey. As the name Zoöphytes has been applied to the lower animals by most writers on natural history since Pliny, it is not out of place to mention here, that that word was first used by Sextus Empiricus, and no doubt suggested by a passage of Aristotle quoted above (note on p. 6), in which the gradation from the higher animals to the plants is alluded to. But, far from constituting a progress in science, that designation introduced only confusion, or at least served to propagate a false impression that there were living beings truly partaking at the same time of the nature of animals and plants. Nothing can be further from the truth than to ascribe such a view to Aristotle as his commentators Gaza and Budæus have done; for, though Aristotle alludes to a gradation among animals, and to a sort of transition from them to the plants, which he considers as inanimate, he nowhere regards those animals which are immovable, like plants, as ambiguous in their character, but everywhere speaks of them as living animals, and alludes to the Sponges as plants. These erroneous notions have been entertained for nearly two thousand years, until Peyssonel demonstrated the animal nature of the expanded individuals of these so-called Zoöphytes, in which some of his predecessors had fancied they saw real flowers.

[1] The readers who may wish for more information respecting the progress of science during this and the following periods, in which the natural history of the Acalephs made comparatively less advance than that of other classes, are referred to G. CUVIER, Histoire des sciences naturelles depuis leur origine jusqu'à nos jours, Paris, 1841–1845, 5 vols. 8vo., and Histoire des progrès des sciences naturelles depuis 1789 jusqu'à nos jours, Paris, 1829, 4 vols. 8vo. — DEBLAINVILLE, Histoire des sciences de l'organisation et de leurs progrès, Paris, 1847, 3 vols. 8vo. — Also, SPIX Geschichte und Beurtheilung aller Systeme in der Zoologie nach ihrer Entwickelungsfolge von Aristoteles bis auf die gegenwärtige Zeit. Nüremberg, 1811, 1 vol. 8vo., and for the middle ages in particular: POUCHET, Histoire des sciences naturelles au moyen age, Paris, 1853, 1 vol. 8vo.

historical events, is not difficult to trace. The establishment of the Mahometans in Spain, and, some centuries later, the Crusades, had brought the West into direct contact with the East, where the Arabs had kept alive the traditions of Greek learning, and the foundation of the great universities of Europe in the twelfth and thirteenth centuries was the result of the intellectual impulse which this intercourse aroused. The institution of the mendicant orders, which were established at the same time, and whose office was chiefly to teach, stimulated this activity still further; while the overthrow of the Byzantine Empire, in the middle of the fifteenth century, sent westward many of the most learned Greeks of that age. Then came the Reformation, with its all-embracing discussions upon the most important problems of mental activity, — the introduction of the arts of printing and engraving, multiplying a thousand-fold the influence of thought, — the invention of gunpowder and of fire-arms, bringing brute force under the control of intellectual energy and foresight, — the discovery of America, and of a passage into the Pacific Ocean around the Cape of Good Hope and the southern extremity of America, opening new worlds to the investigations of the learned.

The extraordinary activity then prevailing manifested itself in the most striking manner also among those whose inclination tended towards the study of nature, and of man as an intellectual being. Besides philosophy and mathematics, we see human anatomy taught in the public schools, and extending its influence over the investigations of the whole animal kingdom; so that the great anatomists of the sixteenth century, Vesalius, Fallopius, Eustachius, Fabricius ab Aquapendente, and Harvey, had their peers among the naturalists in Wotton, Bélon, Salviani, Rondelet, Gessner, Aldrovandi, and Fabio Colonna. Among these, we are chiefly indebted to Rondelet for contributions to the natural history of the Acalephs. He was, indeed, not only better acquainted with the inhabitants of the Mediterranean than all his predecessors, but he knew them even more accurately than any naturalist that lived before the present century. Professor of Anatomy in the University of Montpelier, where he had the best opportunity for studying the marine animals of the Mediterranean, he has published a work upon the fishes inhabiting that sea, which challenges our admiration even now;[1] and if his account of the soft-bodied animals is far inferior to his descriptions of the other types of the animal kingdom, it is simply to be ascribed to the mode of investigating which has too long prevailed, and from which even some of the living naturalists are not yet altogether free, — that of removing the animals to be examined from their natural element in order to describe them. While there is hardly a naturalist at present who does not know

[1] GUIL. RONDELETII libri de piscibus marinis, Lugduni, 1554, 1 vol. fol. The 11th Chap. of the 17th book is devoted to the Acalephs, which he calls *Urticæ* (nettles).

that neither Polyps nor Acalephs nor Mollusks will exhibit their natural appearance when taken out of the element in which they live, it is still to be lamented that both the star-fishes and sea-urchins are everywhere represented as they appear when taken out of the water, and all their soft appendages, so numerous and diversified, are drawn in or so contracted and collapsed as no longer to give the slightest idea of their natural beauty.[1] Like Aristotle, Rondelet still unites the Actiniæ and Acalephæ under the name of sea-nettles (Urticæ marinæ), distinguishing the former as the fixed sea-nettles and the latter as the free sea-nettles. Even Cuvier, in his earlier works, allows these animals to remain together, though it was he himself who separated them afterwards, for the first time, as members of two distinct classes. Rude as are the illustrations published by Rondelet, it is hardly possible to mistake in his fifth species the Rhizostoma of Cuvier, although the disk is too small and the arms too straight, and in the sixth the Chrysaora of Péron, although Linnæus refers that figure to the Aurelia aurita.

In the writings of Aristotle a single part of the Acalephe is distinguished by name, — the *mouth*, which occupies the centre of the body, of which nothing is stated except that it is fleshy. The passage already quoted from Pliny (Lib. IX. ch. 45) speaks of *leaves* ("ac prænatante pisciculo *frondem* suam spargit"), no doubt meaning by *frons* the thin, expanded margin of the disk, and the appendages about the mouth, which he considers as a *root* ("ora ei in radice esse traduntur"), thus carrying out a comparison of these beings with plants. Rondelet, on the contrary, vindicates especially their animal nature when he says, that since they alternately expand and contract their blade, which serves as feet, and since they absorb food through the mouth and thus show themselves provided with the senses of touch and taste, which are essential to the animal life, he considers them as imperfect animals, and not as Zoöphytes, as Pliny does.[2] Speaking of the small sea-nettle, which is his first species, he mentions its short tentacles, and its resemblance to the large intestine, thus distinctly pointing to the genus Actinia, of which, he says, there are several varieties, some green, some blue, some blackish, with blue, yellow, or red spots. His second species seems to be a Tubulibranchiate Annelid, for he says it bites. His third species is another Actinia, with which he confounds the Æquorea of the Mediterranean.[3]

[1] In my next Monograph I shall have an opportunity of representing the North American Echinoderms as they appear in life.

[2] Cum igitur Urticæ frondem suam, quæ pedum vice est, modò dilatent modò contrahant, cum ore cibum accipiant, id est, cum tactu gustuque, qui duo sensus ad vitam animalium sunt necessarii, præditæ sint, non inter Zoophyta, ut Plinius, sed inter animalia non omnino perfecta, eas numerabimus. Rondeletius. Lib. XVII. p. 527.

[3] It can hardly excite surprise to find, that, with as little knowledge as Rondelet possessed upon the subject of Acalephs in general, he should have confounded a Medusa and an Actinia, especially when it is remembered that the numerous radiating tubes of the Æquorea give it a greater resemblance to an

The fourth species is unmistakably the Actinia senilis. Speaking of the fifth species, which is the Rhizostoma, he compares the disk to a hat, and the eight pendant appendages to the feet of the Octopus. Of the sixth species, he says that the four feet may be compared to Acanthus leaves.[1]

Gessner, in his great Natural History of the Animals, has followed Rondelet for the Acalephæ, as he did for most of the other productions of the Mediterranean; and also copied his figures and those of Bélon, adding only such remarks as exhibit his vast erudition, but in no way a better acquaintance with the animals themselves.[2]

It has been a source of constant delight for me, while perusing the works of the earlier naturalists, to sympathize with the genial spirit and the earnestness that pervade their writings, so free from egotism, and animosity against their fellow-students. Their devotion to their studies is equal to the spirit of reverence with which they look upon nature; and it is disgraceful to our age, that we must contrast with such dispositions the ill-will, the jealousies, the quarrels for priority, and the profanation, which pervade the discussions of certain modern authors. Moreover, in a systematic point of view, the great naturalists of the sixteenth century deserve to be studied more fully than they have been thus far. It is astonishing, for instance, to see how near Rondelet, in discussing the views of Aristotle upon the affinities of animals, came to perceiving their true affinities, and their natural classification under four great types. In the 1st Chapter of the 17th Book of his great work, "*De Piscibus Marinis*," after describing the fishes of the Mediterranean, he says, that having thus described the *Enaima*, — that is, the animals provided with blood, — he now proceeds to describe the *Anaima*, among which he distinguishes the *Malakia* in contradistinction to the *Sklero-derma*. These Malakia are the Cephalopoda, to which unfortunately the Medusæ are added on account of the appendages around the mouth, which were compared by him to the feelers of the cuttle-fish. In Book 18th he treats of the Crustacea under the name of *Malakostraca*, and distinguishes from them the *Ostrakoderma*, or shell fishes,

Actinia than any other Medusa has; but that he did confound the two is plain from the following words: "Saxis aliquando hæret, aliquando soluta vagatur." The purple color of the Æquorea may also have contributed to mislead him.

[1] Here, then, we have for the first time the word *pileus* (hat) introduced to designate the disk of the Medusæ, an expression that has been retained by most later writers, while some zoölogists have substituted for it the name of *umbrella*, or *disk*; while the word *feet* stands for the appendages around the mouth, to which the name *arms* was afterwards more generally applied.

[2] An interesting notice of the life and writings of Gessner, by Cuvier, may be found in the Biographie universelle, vol. 17, and in the Histoire des sciences naturelles, vol. 2, p. 83. I would gladly also refer to the notice by Blainville in his Histoire des sciences de l'organisation; but that chapter is so interwoven with jesuitical insinuations as to be utterly unpalatable to a sober thinker. The chapter on Acalephæ in the Historia animalium of Gessner is contained in Book 4, De piscium et Aquatilium animantium natura, page 1239, published in Zürich in 1558. — Bélon's book, de Aquatilibus, Lib. II., was printed in Paris in 1553.

associating erroneously, however, the sea-urchins with the former. But again, in the second part of his work, which appeared one year later than the first, discussing the characteristics of the *Ostrakoderma*, or Conchifera, and comparing them to the *Entoma*, or Insects, he unites the bivalve and univalve shells into one great division. In this arrangement, Rondelet is already as far advanced as Lamarck, who separates the Cephalopoda as a distinct class from the Conchifera. With reference to the *Entoma*, or Insects, which he characterizes as animals having incisions above or below or on both sides and no bony parts, he unites the Worms and the Annelids with a small Crustacean, and associates also the Star-fishes and Holothuriæ with them, a combination which even Oken has thought natural.

Among the other naturalists of the sixteenth and those of the seventeenth century, there are a few more who deserve to be mentioned as contributors to the natural history of the Acalephs. Matthioli, for instance, while commenting upon the plants of Dioscorides,[1] introduces some remarks upon Acalephs and other Zoöphytes of which he gives wood-cuts. In part second of the same work, published in 1555, there is a figure of a Beroid Medusa, in a short paragraph "De Cucumere marino," p. 131; and another of the "Eschara," p. 133. Wotton, also,[2] speaking of Zoöphytes, mentions the sea-lungs and sea-nettles; and, somewhat later, Aldrovandi,[3] in his gigantic Cyclopedia of Natural History, published in fourteen large volumes, folio, partly by himself and partly from his papers after his death, mentions also some of these animals, without, however, adding any thing that would throw new light upon their nature. The same may be said of the work of Jonston.[4] It would lead me too far were I to attempt here to give ever so short an account of the rather indifferent notices relating to Acalephs that are scattered in the writings of the other naturalists of this period. It may suffice to quote their works, and refer the reader to the originals.[5] One remark, however, applies to most of them, and characterizes the spirit

[1] Matthioli (P. A.), Commentarii in sex libros Dioscoridis de medica materia; adjectis magnis ac novis Plantarum ac Animalium iconibus, etc., Venetiis, 1554, fol. fig. — Compare also Cæsalpinus (A.), De plantis Libri XVI. Florentiis, 1583, 4to.

[2] Wotton (Edw.), De differentiis Animalium, Libri X. Parisiis, 1552, fol.

[3] Aldrovandi (Ul.), Historia Naturalis, Bononiæ, 1599–1640, 14 vols. fol. fig.

[4] Jonston (J.), Historiæ Naturalis de Exanguibus aquaticis Libri IV. Francofurti ad Moenum, 1650, fol. fig. — Book IV. p. 72 is devoted to the Zoöphytes in general, among which he includes, with Rondelet, the Actiniæ and Medusæ, the Holothuriæ, the Ascidiæ, and the Halcyonoid Polyps. His figures are copied from Bélon, from Rondelet, from Aldrovandi, and from Matthioli.

[5] Salviani (Hipp.), Aquatilium animalium Historia, Romæ, 1554, fol. fig. — Imperato (Ferr.), Historia naturale, nella quale si tratta della diversa condizione de Minere, Pietre preziose e altre curiosità, con varie istorie di Plante e Animali, Napoli, 1559, fol. — Clusius (Car.), Exoticorum libri decem, quibus Animalium, Plantarum aromatum aliorumque peregrinorum fructuum historia describuntur, Anvers, 1605, fol. fig. — Colonna (Fab.), Aquatilium et terrestrium aliquot animalium aliarumque naturalium rerum observationes, Romæ,

of the age. They are full of discussions upon the animals known to the ancients, mixed up with a few original observations, showing plainly the influence exercised by the revival of letters even upon the cultivators of science.

The naturalists of the second half of the seventeenth century gradually turn their attention more exclusively to nature, and are less engrossed by mere questions of erudition. This salutary change is no doubt owing to the influence of the discovery of America, and the progress of navigation around the Cape of Good Hope and in Asia, upon the study of Natural History. The animals and plants brought back to Europe by travellers, and still more the observations published by physicians and naturalists who explored the new world, must early have impressed on every one the conviction, that the productions of these countries could not be illustrated by references to the writers of past ages. No expedition contributed more powerfully to strengthen this impression, and to extend the range of human knowledge respecting the animals and plants of foreign lands, than that of Count Maurice of Nassau to the Brazils. The work of Marcgrave,[1] who was naturalist to that expedition, remained until the beginning of this century the principal source of information respecting the animals of South America; but it contains nothing relating to Acalephs. Dutertre[2] and Martens[3] have only a few remarks about them, while Boccone's[4] investigations relate chiefly to the Corals. At home, both naturalists and zoölogists, as well as philosophers generally, apply themselves with increased zeal to the investigation of minute objects and abstruse questions requiring improved methods of study; and, of course, the advance made in one branch leads to new researches in other branches, so that it may well be said, that there never was a time when the aspirations of men for knowledge were higher and more intense than during this period. This intellectual movement naturally gave birth to the scientific academies founded with a special view to the promotion of experimental researches. The principal of these academies were, that of the Lyncei in Rome, the Philosophical Society in London, the Academia Naturæ Curiosorum in Germany, and the Académie des Sciences in Paris.

1616, 4to. — Scilla (Agost.), La vana speculatione desingarata del senso, Napoli, 1670, 4to. fig. Though many of the works quoted are insignificant for the study of Acalephs, their value is very great in other respects. Scilla, for instance, opens that series of investigations upon fossil remains which has made Palæontology a distinct science. The works of Clusius, Matthioli, and Cæsalpinus, are essentially botanical, and that of Salviani is entirely ichthyological.

[1] Marcgrave (G.), Historiæ Rerum Naturalium Brasiliæ Libri VIII., a Joh. de Laët in ordinem digesti, Lugduni-Batavorum, 1648, fol. fig.

[2] Dutertre (J. Bapt.), Histoire générale des Antilles, etc., Paris, 1656–1671, 4 vols. 4to.

[3] Martens (Fr.), Spitzbergische und Grönländische Reise-Beschreibung, im Jahr 1671, Hamburg, 1675, 4to. fig.

[4] Boccone (P. Silv.), Recherches et observations d'histoire naturelle touchant le Corail, etc., Paris, 1670, 12mo. fig.

SECTION III.

THE NATURALISTS OF THE EIGHTEENTH CENTURY.

Travellers,[1] observers,[2] and compilers[3] continue their work during this period in nearly the same spirit as towards the close of the preceding century, with this difference only, that the field of inquiry is gradually enlarging and extending. It is no longer the mere existence of curious animals and plants which attracts the attention: a desire of appreciating their relations to one another has evidently taken hold of the naturalists, and this aspiration reaches soon a climax in the publication of the "*Systema Naturæ*," the great work of this age, and the foundation of the lasting fame of Linnæus.

Though Linnæus himself added comparatively little to the general stock of information respecting the Acalephs, he had, nevertheless, as great an influence in preparing the way for their systematic arrangement as in other classes of the animal kingdom, by extending to them his binominal nomenclature. Yet, in the "*Systema Naturæ*" the members of the class of Acalephs are so far removed from one another as to show that Linnæus did not even dream of the true relations that unite the

[1] Rumphius (G. Ev.), D'Amboinsche Rariteitkammer, behelzende eene Beschryvinge van allerhande 200 Weeke als harde Schaalvischen, etc., Amsterdam, 1705, fol. fig. — Sloane (Hans), A Voyage to the Islands of Madeira, Barbados, Nieves, St. Christopher's, and Jamaica, with the Nat. Hist. of the last of these Islands, etc., London, 1707–1725, 2 vols. fol. fig. — Tournefort (Jos. Pitton de), Relation d'un Voyage du Levant, Paris, 1717, 2 vols. 4to. fig. — Feuillée (Louis), Journal d'observations faites sur les côtes orientales de l'Amérique et dans les Indes occidentales, Paris, 1714, 2 vols. 4to. fig. — Journal d'observations faites dans la nouvelle Espagne et aux îles de l'Amérique, Paris, 1725, 4to. — Brown (Patr.), The Civil and Natural History of Jamaica, etc., London, 1756, fol. fig.

[2] Marsigli (L. F.), Brieve Ristretto del Saggio fisico intorno alla Storia del Mare, Venezia, 1711, 4to. fig. (French by Leclerc), Histoire physique de la Mer, Amsterdam, 1725, fol. fig. — Réaumur (R. Ant. de), Observations sur la formation du Corail et des autres productions appelées Plantes pierreuses. Mém. Acad. Sc. Paris, 1727. — Catesby (Mark). Natural History of Carolina, Florida, and the Bahama Islands, etc., London, 1731–1743, 2 vols. fol. fig. col.; Appendix, London, 1748, fol. — Plancus (Janus), De Conchis minùs notis in Littore Ariminensi, Venetiis, 1739, 4to. fig.; edit. altera Romæ. 1760, 4to. fig. — Jussieu (Bern. de), Examen de quelques productions marines qui ont été mises au nombre des Plantes, et qui sont l'ouvrage d'une sorte d'Insecte de mer, Mém. Ac. Sc. Par. 1742, p. 290. fig. — Baker (H.), Essays on the Natural History of the Polyps, London, 1743, 8vo. fig.

[3] Besler (M. R.), Rariora Musei Besleriani quæ olim Bas. et M. R. Besler collegerunt, etc. Commentatio illustrata à J. H. Loehner, Nürnberg. 1716, fol. — Seba (Alb.), Locupletissimi Rerum naturalium Thesauri accurata Descriptio et Iconibus artificiosissimis per universam Physices historiam (Lat. et Gall.), Amstelodami, 1734–1765, 4 vols. fol. fig.

Medusæ proper with the Siphonophoræ and the Hydroids.[1] Nevertheless, the share of attention bestowed upon the Acalephs is steadily increasing, and many valuable contributions to their history appear during this period; nay, several investigators begin to study with special care these and other soft-bodied animals, as well as the lower animals generally. The extraordinary disclosures of Trembley respecting the fresh-water Hydra,[2] and the discovery of the animal nature of the Corals by Peyssonnel,[3] had a great and lasting influence upon the progress of our knowledge of the lower animals; and even now their investigations are constantly alluded to as the starting points of a better era in the natural history of the Radiates. The paper of Réaumur upon Rhizostoma, and Plancus's delineation of the Marsupialis, were soon followed by Gronovius's[4] illustrations of several Medusæ; Baster's[5] descriptions and figures of many others; Bohadsch's[6] remarks upon Beroe, with a figure; Chanvallon's

[1] The history of the successive editions of the *Systema Naturæ* is instructive, on account of the progress Linnæus himself has made in fixing forever the nomenclature of Natural History. The first edition consisted of a single folio sheet, and has been republished by Ant. L. A. Fée in 1830, in Paris; the last edition published by Linnæus himself is the twelfth, printed in Stockholm in 1767, in 3 vols. 8vo.

[2] TREMBLEY (ABR.), Mémoires pour servir à l'histoire d'un genre de Polypes d'eau douce, à bras en forme de cornes, Leyde, 1744, 4to. fig.

[3] PEYSSONNEL (J. A. DE), Traité du Corail, etc., Phil. Tr. Roy. Soc. London, 1753, vol. 47, p. 445. The history of the views entertained at different periods respecting the nature of the Corals truly illustrates the progress of Natural History. At first considered as stones by Boccone (see note 4, p. 12) and Woodward (An Essay towards a Natural History of the Earth, London, 1695), they were regarded as plants by Marsigli (see note 2, p. 13), who was the first to observe, in 1706, what he called the *flowers of the Coral*. These supposed flowers, which are the individual polyps of the Coral stock, were at once considered as proving the vegetable character of the Coral, and even the greatest botanist of that time, Bernard de Jussieu, shared this view, until he had an opportunity of verifying for himself the accuracy of Peyssonnel's statements. Réaumur opposed Peyssonnel so pertinaciously that the extensive work of this accurate and ingenious observer never was published (see Flourens in Ann. des Sc. Nat. 2d ser. vol. 9, p. 334), and only an abstract of it appeared in the Transactions of the Royal Society of London. Had the whole been printed at once, naturalists would have known a century sooner, that the animals of the Stony Corals are homologous to the Actiniæ and Acalephs, for Peyssonnel does not hesitate to call them by the same name, *Orties*, Urticæ, though he also applies to them the name of Insects. The same volume of the Transactions of the Royal Society in which an abstract of Peyssonnel's work was published, also contains, p. 95, an interesting paper by DONATI, entitled "New Discoveries relating to the History of Coral."

[4] GRONOVIUS (L. TH.). His chief work is the Zoophylacium Gronovianum, exhibens Animalia, Quadrupeda, Amphibia, Pisces, Insecta, Vermes, Mollusca, Testacea et Zoöphyta quæ in Museo suo adservavit atque descripsit. Lugduni-Batavorum, 1763–1781, fol. fig.; but for the Acalephs consult his Observationes de Animalibus aliquot marinæ aquæ innatantibus, atque in littoribus Belgicis obviis, in Acta Helvetica, 1760, vol. 4.

[5] BASTER (JOB), Opuscula subseciva, observationes miscellaneas de Animalculis et Plantis quibusdam marinis eorumque ovariis et seminibus continentia. Harlem, 1759–1765, 2 vols. 4to. fig.

[6] BOHADSCH (J. B.), De quibusdam Animalibus

description of the Physalia[1] (which ought to be remembered in connection with the illustrations of Patrick Brown already quoted); Dana's[2] dissertation upon marine animals; and Slabber's delineations of several Medusæ.[3] Besides these, the more general works of Donati,[4] Hughes,[5] Hill,[6] Kalm,[7] Pontoppidan,[8] and Borlase,[9] also mention incidentally different kinds of Acalephs. The book of Borlase contains the first descriptions ever published of the Medusæ of the British coast accompanied with figures that may be recognized.

Notwithstanding this accumulation of observations, the real information respecting Medusæ thus far brought together is still scanty and disconnected. It consists chiefly of isolated facts without connecting links; and, though the modes of observing and describing are fast improving, we must pass on through another half century before we find naturalists applying to the study of Acalephs .the accurate methods to which Zoölogy owes its present condition. Pallas[10] and Forskål[11] are the first who give fuller descriptions of Medusæ and attempt to distinguish their parts

marinis eorumque proprietatibus vel nondum vel minus notis, etc., Dresdæ, 1761, 4to. fig.

[1] CHANVALLON (THIB. DE), Voyage à la Martinique, contenant diverses observations sur la Physique, l'Histoire naturelle, l'Agriculture, les mœurs et les usages de cette île, Paris, 1763, 4to.

[2] DANA (J. P. M.), Dissertation sur les différences que présentent certains animaux marins connus sous la dénomination d'Ortie marine. Misc. Taurin, III. p. 206. — Description d'une espèce de Méduse, in Rozier, Journal de Physique, Indroduct. I. 1771, p. 141.

[3] SLABBER (MART.), Naturkundige Verlustigingen, Haarlem, 1778, 4to.

[4] DONATI (VITAL.), Saggio della Storia naturale marina dell'Adriatico, Venezia, 1750, 4to. fig. French translation: Essai sur l'Histoire Naturelle de la mer Adriatique, La Haye, 1758, 4to. fig.

[5] HUGHES (GRIFFITH), The Natural History of Barbados, London, 1750, fol. fig. — A letter concerning a Zoöphyton somewhat resembling the Flower of Marigold, Phil. Trans. XLII. p. 590, fig.

[6] HILL (J.), A Natural History of Animals, containing Descriptions of the Birds, Beasts, Fishes, Insects, and of the several Classes of Animalcula visible only by the assistance of microscopes, London, 1752, fol. fig.

[7] KALM (PETER), En Resa til Norra America, Stockholm, 1753–1761, 3 vols. 8vo. English translation: Travels in North America, containing its Natural History, etc., transl. by J. R. Forster, Warr. and Lond. 1770, 1771, 3 vols. 8vo.

[8] PONTOPPIDAN (ERIC), Norviges Natural Historie, etc., Kiöbenhavn, 1751–1753, 2 vols. 4to. fig. English: The Natural History of Norway, London, 1755, fol.

[9] BORLASE (WILL.), The Natural History of Cornwall, Oxford, 1758, fol. fig.

[10] PALLAS (PETER SIMON), Miscellanea Zoologica, quibus novæ imprimis atque obscuræ Animalium species describuntur, etc., Hagæ-Com., 1766, 4to. fig. — Spicilegia Zoologica, Berolini, 1767–1780; 14 Fascic. 4to. fig.; German translation by E. G. Baldinger: Naturgeschichte merkwürdiger Thiere, etc., Berlin, 1769–1778, 10 vols. 4to. fig. — Elenchus Zoophytorum, sistens Generum adumbrationes generaliores et Specierum cognitarum succinctas descriptiones, cum selectis auctorum Synonymis, Hagæ-Com., 1766, 8vo.

[11] FORSKÅL (P.), Descriptiones Animalium, Avium, Amphibiorum, Piscium, Insectorum, Vermium, quæ in Itinere orientali observavit; edidit C. Niebuhr, Hafniæ, 1775, 4to. — Icones Rerum naturalium quas in Itinere orientali depingi curavit; ed. C. Niebuhr, Hafniæ, 1776, 4to.

with scientific precision; and their followers, O. F. Müller[1] and O. Fabricius,[2] contribute many valuable additions. Thus far, whenever illustrations had been added to the descriptions of animals, they were chiefly wood-cuts, or engravings printed in black. But in the year 1776, O. F. Müller began the publication of a series of truly magnificent colored plates, painted and engraved by his brother, which appeared in successive numbers under the title of Zoölogia Danica. This work forms an era in Natural History, and has set an example, to which we are indebted for all the costly and ever improving colored illustrations of this kind during the last eighty years. To this day the Zoölogia Danica is indispensable to the student of marine animals. It contains a considerable number of good figures of Acalephs, including true Medusæ, Beroids, and Hydroids. Henceforward, the number of Medusæ known is not only much larger than before, but they are described with much greater fulness and nicety. At the same time, the investigations of Spallanzani[3] upon the most delicate problems in the structure of animals excited universal attention by the extraordinary disclosures to which they led. Cook's voyages also stimulated inquiries into the animals of every part of the globe; and Banks, Solander, and Forster, who had made the voyage round the world with the great English captain, describe, with the coöperation of Ellis, the most remarkable natural productions brought home

[1] MÜLLER (O. FR.), Zoölogiæ Danicæ Prodromus, seu Animalium Daniæ et Norvegiæ indigenorum characteres, nomina, etc., Hafniæ, 1776, 8vo. — Zoologia Danica, seu Animalium Daniæ et Norvegiæ rariorum Descriptiones et Historia, Hafniæ et Lipsiæ, 1779–1781, 2 vols. 8vo., and Hafniæ, 1788–1806, 4 vols. fol. fig., with additions by Abilgaard, Holton, Vahl, and J. Rathke.

[2] FABRICIUS (O.), Fauna Grœnlandica, systematicè sistens Animalia Grœnlandiæ occidentalis, hactenus indagata, Hafniæ et Lipsiæ, 1780, 8vo. fig. This work is particularly important to the naturalists of New England, as it contains the first descriptions of many marine animals found on our own coasts.

[3] SPALLANZANI (LAZ.), Prodromo di un opera sopra le Riproduzioni animali, Modena, 1768, 4to. French translation by Bonnet: Programme ou Précis d'un Ouvrage sur les Reproductions animales, Genève, 1768, 8vo. English translation: An Essay on Animal Reproductions, etc., London, 1769, 8vo. Latin edition: Prolusio Operis de Animalibus microscopio visibilibus, Mutinæ, 1770, 4to. — Saggio di Osservazioni microscopiche, concernenti il Sistema della Generazione di Needham e Buffon, Modena, 1765, 4to. French translation by Regley: Nouvelles Recherches sur les Découvertes microscopiques et la Génération des Corps organisés, London et Paris, 1769, 2 vols. 8vo. fig. — Lettera sulla Fecondazione artifiziale, e sull' Elettricità delle Torpedini; Opusc. Scelt. 1783. — Risultati di Esperienze sopra la Riproduzione della Testa nelle Lumache terrestri; Mem. Soc. Ital. I. p. 581; II. p. 506, fig. — Sopra gli' Animali delle Infusioni, e sui nuovi Pensamenti, in proposito di Needham; Giorn. d'Ital. III. — Lettera relativa à diverse Produzioni marine; Opusc. Scelt. VII. — Opuscoli di Fisica animale e vegatibile, Modena, 1776, 2 vols. 8vo. fig.; Venezia, 1782, 3 vols. 8vo. French translation by Senebier: Opuscules de Physique animale et végétale, etc., Genève, 1777; Paris, 1787, 2 vols. 8vo. English Translation, London, 1784, 2 vols. 8vo. — Dissertazioni di Fisica animale e vegetabile, Modena, 1780, 2 vols. German translation: Abhandlungen über einige Gegenstände aus der animalischen und vegetabilischen Naturkunde, Leipzig, 1778, 2 vols. 8vo.

by these expeditions. Cavolini[1] investigates the minute animals of the Mediterranean, Pennant[2] those of the coast of England, Forskål and Löfling[3] those of the Red Sea and of New Spain, Swartz[4] those of the Antilles, Modeer[5] those of the Northern Ocean, Scopoli[6] and Olivi[7] those of the Adriatic, and Macri[8] those of the Bay of Naples. Everywhere, stimulated by the influence of their great teacher, we find the pupils of Linnæus foremost in this race for knowledge. The harvest of Acalephs is, however, still scanty; and the works of Pallas, Forskål, O. F. Müller, and O. Fabricius, are the only ones deserving now special attention, and this chiefly on account of the influence their accurate descriptions had upon the progress of that branch of Zoölogy. Pallas, in his Zoölogical Miscellanies, published in 1776, is the first who gives accurate figures of Hydroids, without suspecting, however, that they have the least relation to the Medusæ proper.

The use of the microscope having become more frequent, objects are not only examined with more care and accuracy than before, but also frequently magnified, so as to give a more satisfactory view of their parts. The treatise of Ellis[9] on Corallines is, in that respect, a master-work, to this day indispensable to the student of the Hydroids; and next to it must be ranked the work of Cavolini.

The last quarter of this century is marked by various compilations of the labors

[1] Cavolini (Fil.), Memorie per servire alla Storia dei Polipi marini, Napoli, 1785, 4to. fig. German translation by W. Sprengel: Abhandlungen über Pflanzenthiere des Mittelmeeres, Nürnberg, 1813, 4to. fig. — Nuove Ricerche sulle Gorgonie e sulle Madrepore, Napoli, 1785, 4to. fig. German translation by Zimmermann, Berlin, 1792, 8vo. — Memoria sulla Generazione dei Pesci e dei Granchi, Napoli, 1787, 4to. German translation by Zimmermann: Abhandlung über die Erzeugung der Fische und der Krebse, Berlin, 1792, 8vo. fig.

[2] Pennant (Thomas), British Zoölogy, Lond. 1761, 1 vol. fol.; 1768–1769, 3 vols. 8vo.; 103 additional plates, 1770; 1776–1777, 4 vols. 8vo.; 1812, 4 vols. 8vo.

[3] Löfling (Peter), Iter hispanicum; eller Resa til spanska Länderna uti Europa, och America, Stockholm, 1768, 8vo. fig. German translation by Al. B. Kölpin: Reise nach den spanischen Ländern, Berlin, 1776, 1 vol. 8vo. fig.

[4] Swartz (Olof), *Medusa unguiculata* och *Actinia pusilla* upptäckta och beskrifna, Vet. Acad. Handl. 1788, p. 198.

[5] Modeer (Adolph), Om Slägtet Sjokalf, Medusa, in Svenska Vetenskaps Academiens Nya Handlingar, Vol. XII. 1791.

[6] Scopoli (J. Ant.), Introductio ad Historiam naturalem, sistens genera Lapidum, Plantarum et Animalium, etc., in tribus divisa, subinde ad leges Naturæ, Pragæ, 1777, 8vo. — Anni historico-naturales, IV. Lipsiæ, 1769–1772, 5 vols. 8vo.

[7] Olivi (Gius.), Zoologia Adriatica, ossia Catalogo raggionato degli Animali del Golfo e delle Lagune di Venezia, Bassano, 1792, 4to. fig.

[8] Macri (Sav.), Nuove Osservazioni intorno la Storia naturale del Polmone marino degli Antichi, Napoli, 1779, 12mo.

[9] Ellis (J.), An Essay towards a Natural History of the Corallines and other Marine Productions of the like kind, commonly found on the coasts of Great Britain and Ireland, etc., London, 1755, 4to. fig. French translation: Essai sur l'Histoire Naturelle des Corallines, etc., LaHaye, 1758, 4to. fig. German translation: Versuch einer Naturgeschichte der Korall-Arten und anderer solcher Meerkörper. Nürnberg, 1764, 4to. fig.

of preceding years. Several works give such *résumés;* but they only serve to bring more glaringly to light the deficiency of the information upon which a natural system might be built. The fullest of these compilations is the thirteenth edition of the Systema Naturæ of Linnæus, published between the years 1783 and 1793 by J. Fr. Gmelin.[1] Another is the Encyclopédie Méthodique, published by an association of naturalists in Paris in 201 vols. 4to., between the years 1782 and 1832, with a view of presenting a complete cyclopædia of all that was known at the time in every branch of Natural History. The Acalephs were compiled by Bruguière. Nearly all the illustrations published by earlier observers are here reproduced, but nothing new is added. These publications have lost their merit now, and can only be used as books of easy reference to the scattered descriptions and figures of previous writers.

Besides the publication of these systematic cyclopædias, we have also to notice the scientific dictionaries of the time, which aimed at giving similar, though more condensed, accounts of the knowledge of their age,[2] but did not add much to the real progress of science. Not so with the proceedings and transactions of learned societies;[3] for in their volumes we find innumerable original papers in which the discoveries of the day are recorded, and among them, here and there, some notices bearing more or less directly upon the natural history of the Acalephs. The most important of them have already been quoted.

SECTION IV.

THE SYSTEMATIC WRITERS AND ANATOMISTS.

With the beginning of the nineteenth century opens another era in the history of Acalephs. Now, for the first time, are successful attempts made to combine systematically the investigations of the past, and every year adds new materials to

[1] GMELIN (J. FR.), Car. a Linné Systema Naturæ per Regna tria Naturæ, etc., editio decima tertia, aucta et reformata, Leipzig, 1788–1793, 7 vols. 8vo.

[2] VALMONT DE BOMARE, Dictionnaire raisonné universel d'histoire naturelle. Paris, 1765–1768, 5 vols. 8vo.; 2e édit. 1768, 1769, 12 vols. 8vo.; 3e édit. 1775, 6 vols. 8vo.; 4e édit. Lyon, 1791, 15 vols. 8vo.

[3] The most valuable of these transactions are those of the Royal Society of London, of the Academia Naturæ Curiosorum, and of the Academy of Sciences of Paris. The former are published under the title of Philosophical Transactions of the Royal Society, the latter as Mémoires de l'Académie des Sciences de Paris, and those of the Academia Naturæ Curiosorum appeared, first under the title Miscellanea, next as Ephemerides, and afterwards as Acta, and are now continued as Nova Acta Academiæ Cæsareo-Leopoldinæ Naturæ Curiosorum.

the edifice. Thus far all the Discophoræ, whether covered-eyed or naked-eyed, had been placed in one and the same genus, and even the Ctenophoræ were associated with them. Only a few species of Siphonophoræ were referred to other genera: but then these were not placed in close proximity with the Medusæ proper, and the Hydroids were unhesitatingly referred to the class of Polyps, or at least arranged among them. The whole number of genera distinguished among the animals now referred to the class of Acalephs amounted only to thirteen in 1801; namely, Beroe *Brown*, Medusa *L.*, Physalia *Lamrk.* (first called Arethusa by P. Brown, then Physalis by Osbeck and Salacia by Linnæus), Velella *Lamrk.*, and Porpita *Lamrk.* (first called Phyllodoce and Thalia by P. Brown), Gleba *Brug.*, Physophora *Forsk.*, Lucernaria *Müll.*, Hydra *L.*, Coryne *Gärtn.*, Tubularia *L.*, Sertularia *Lamrk.*, Millepora *L.*

Owing to the greater number of Medusæ now known, including species from distant parts of the world, and also to the discovery of numerous animals more or less closely allied to them, it has become necessary to institute comparisons between the animals of this class and the representatives of other classes, which were not even suggested before. This is therefore truly the age of Comparative Natural History; and a new science, Comparative Anatomy, arises with it, by the gigantic labors of the scientific hero of modern times.

Péron and LeSueur[1] open this period with investigations upon a far greater number of species of Acalephs than had been observed by all the investigators of former ages taken together. Engaged as naturalists in the expedition of Captain Baudin to the South Seas during the first four years of this century, they had the fullest opportunities of examining these animals alive; and LeSueur, with incomparable skill, reproduced their delicate appearance in a series of colored plates, so magnificent and of such costly execution, that to this day a small part of them only have been published. But these illustrations were deposited in the library of the Jardin des Plantes in Paris, and have been extensively used by French naturalists who have written upon Acalephs during the last thirty years. They are referred to, and partly copied by, de Blainville in his Manuel d'Actinologie.

[1] PÉRON (FR.) ET LESUEUR (C. A.), Voyage de découvertes aux Terres Australes, pendant les années 1800–1804, Paris, 1807–1816, 3 vols. 4to. fig. — Histoire générale et particulière de tous les Animaux qui composent la famille des Méduses, Ann. Mus. XIV. p. 218. — Tableau des Caractères génériques et spécifiques de toutes les espèces de Méduses connues jusqu'à ce jour. Ann. Mus. XIV. p. 325. — Sur les Méduses du genre Equorée, Ann. Mus. XV. p. 41. — LeSueur by himself published two papers relating to the Acalephs and allied animals: Mémoire sur quelques nouvelles espèces d'Animaux Mollusques and Radiaires recueillies dans la Méditerranée près de Nice, Journal de Physique, vol. 77, p. 119, and Mémoire sur l'organisation des Pyrosomes et sur la place qu'ils doivent occuper dans une classification naturelle, Journal de Physique, vol. 80, p. 413. He was the first to suggest that the Siphonophoræ are compound animals, — an opinion now almost universally admitted.

Lesson used them while preparing his Prodrome d'une Monographie des Méduses and his Histoire naturelle des Acalèphes; and Milne-Edwards has caused some to be engraved for the new illustrated edition of Cuvier's Règne Animal.[1] The publications of Bory de St. Vincent[2] and of Tilesius,[3] which next follow, are interesting as furnishing the first indications upon the Diphyes; while those of Scoresby,[4] Otto,[5] VanHasselt,[6] Eichwald,[7] DeHaan,[8] Guilding,[9] Piet,[10] Baird,[11] Woodward,[12] von Olfers,[13] Meyen,[14] Patterson,[15] Forbes, Goodsir,[16] and Hyndman,[17] add new species to our lists, and new facts respecting species already known. Bosc's[18] Natural History of the Worms also contains some valuable remarks. On account of his residence upon our southern coasts, the works of Bosc are interesting to American naturalists.

While Péron and LeSueur and their successors were thus steadily enlarging the range of our knowledge by special investigations, the systematic writers of this period began to perceive more and more clearly the general affinities of these animals;

[1] CUVIER (G.), Le Règne animal distribué d'après son organisation, pour servir de base à l'Histoire naturelle des animaux, et d'introduction à l'Anatomie comparée; édition accompagnée de planches gravées, par une réunion de disciples de Cuvier, publiée par Fortin, Masson & Co., Paris, 8vo. since 1836. The volume containing the Acalephs is edited by Milne-Edwards.

[2] BORY DE SAINT-VINCENT (J. B. G.), Voyage dans les quatre principales îles des mers d'Afrique, Paris, 1804, 3 vols. 8vo. avec atlas.

[3] TILESIUS (W. G.), Naturhistorische Früchte der ersten kaiserlich-russischen Weltumseglung, Petersburg, 1813, 4to.

[4] SCORESBY (W.), An Account of the Arctic Regions, Edinburgh, 1820, 2 vols. 8vo. fig.

[5] OTTO (AD. W.), Conspectus animalium quorundam maritimorum nondum editorum, Vratislaviæ, 1821, 4to. fig. — Beschreibung einiger neuer Mollusken und Zoophyten, N. Act. Nat. Cur. XI. 2, p. 273, fig.; Isis, 1824, VI. p. 626.

[6] VANHASSELT, Ueber Physalia, Brief an Prof. VanSwindern, Isis, 1823, p. 1113.

[7] EICHWALD (ED.), Observationes nonnullæ circa fabricam Physaliæ, Mém. Acad. Petersb. 1821, IX. p. 455.

[8] DEHAAN (W.), Verhandeling over de Rangschikking der Velellen, Porpiten und Physalien, Bijdrag Natuur. Wetens, 1827, II. p. 489.

[9] GUILDING (LANSD.), Mollusca Caribbæana, Zool. Journ. 1827, III. p. 403.

[10] PIET, Description de la grande Physale et d'une curieuse espèce de Médusaire, trouvées sur les côtes de Bretagne, Lyc. Armor. XII. p. 189.

[11] BAIRD (DR.), On the Luminousness of the Sea, Mag. Nat. Hist. 1830, III.

[12] WOODWARD (SAM.), On the Luminosity of the Sea, Mag. Nat. Hist. 1831, IV. p. 285.

[13] VON OLFERS, Ueber die grosse Seeblase, Physalia Arethusa, und die Gattung der Seeblasen im Allgemeinen. Ak. Wiss. Berlin, 1831.

[14] MEYEN (F. J.), Beiträge zur Zoologie; N. Act. Nat. Cur. XVI. suppl. I. 1834.

[15] PATTERSON (ROBERT), Description of the Cydippe pomiformis (Beroë ovata, Flem.), with Notice of an apparently undescribed Species of Bolina, also found on the Coast of Ireland, Proc. Roy. Irish Acad. 1839, p. 237.

[16] FORBES (EDW.), Contributions to British Actinology, An. and Mag. Nat. Hist. 1841, VII. p. 81. — FORBES (EDW.) and GOODSIR (J.), On the Corymorpha nutans, Ann. and Mag. Nat. Hist. 1840, V. p. 309.

[17] HYNDMAN (G. C.), On the Occurrence of the genus Diphya on the Coast of Ireland; Ann. and Mag. Nat. Hist. 1841, VII. p. 164.

[18] BOSC (L. A. G.), Histoire naturelle des Vers, Paris, 1802, 18mo. 3 vols. fig.

and the works of Cuvier,[1] Blumenbach,[2] Duméril,[3] Lamarck,[4] Oken,[5] Goldfuss,[6] and Schweiger,[7] suggest successive improvements in their classification. There remains, however, so much uncertainty respecting the general characteristics of the different groups of Radiates or Zoophytes, that naturalists disagree even as to the classes that should be referred to this type. Cuvier, for instance, unites the Intestinal worms and the Infusoria with the Radiates, while DeBlainville refers the first to the Articulata, and the second to his Microzoaires. Cuvier also at first unites the Actiniæ with the Acalephs, while he afterwards separates them.[8] Even the limits between the Radiates and the lower Mollusks are ill-defined, so that Sa-

[1] Cuvier (George), Tableau élémentaire de l'Histoire naturelle des animaux, Paris, 1798, 8vo. fig. — Le Règne animal distribué d'après son organisation, pour servir de base à l'Histoire naturelle des animaux et d'introduction à l'Anatomie comparée, Paris, 1817, 4 vols. 8vo. fig.

[2] Blumenbach (J. Fr.), Handbuch der Naturgeschichte, Götting. 1779, 8vo. fig.; Götting. 1825 (11th ed.), French transl. by Artaud, Manuel d'Histoire Naturelle, Paris, 1803, 2 vols. 8vo. fig.

[3] Duméril (A. M. C.), Zoologie analytique, ou Méthode naturelle de Classification des Animaux, Paris, 1806, 8vo.

[4] Lamarck (J. B. de), Histoire naturelle des animaux sans vertèbres, présentant les caractères généraux et particuliers de ces animaux, leur distribution, etc., Paris, 1815–1822, 7 vols. 8vo.; (Sec. édit. augmentée de notes par MM. Deshayes et Milne-Edwards), Paris, 1835–1843, 10 vols. 8vo. — His Cours de Zoologie is also important.

[5] Oken (Lor.), Lehrbuch der Naturgeschichte, Weimar, 1816, 2 vols. 8vo. — Allgemeine Naturgeschichte, Stuttgart, 1833–1842, 14 vols. 8vo. fig.

[6] Goldfuss (G. A.), Handbuch der Zoologie, Nürnberg, 1820, 2 vols. 8vo.

[7] Schweiger (A. Fr.), Handbuch der Naturgeschichte der skelettlosen ungegliederten Thiere, Leipz. 1820, 8vo. One of the most valuable textbooks of that period. It is full of original observations.

[8] At the time Cuvier characterized the Acalephæ as a distinct class among Radiata in the first edition of the Règne Animal, published in 1817, the great French naturalist included among them the Actiniæ, now generally referred to the class of Polypi. To this class he himself removed them in the second edition of that important work. It is a remarkable circumstance, that no advance was made towards a natural classification of the Acalephs from the days of Aristotle to the period when Savigny, Schweiger, Cuvier, and others attempted to improve our knowledge of the lower animals. In the first edition of the Règne Animal we find the same distinction introduced among the Acalephs, between the free and the fixed Acalephs, which Aristotle had adopted; whilst a number of animals which must be united with the Acalephs are still left among the Polyps, as they were centuries before. From the beginning, then, the class of the Acalephæ was far from being circumscribed within natural limits; and we shall presently see, that it has required the indefatigable investigations of some of the ablest observers for about a century, before the natural affinities of the animals belonging to this class were fully appreciated. It is one of the most instructive lessons for a student of nature to trace the gradual progress of the discoveries which have led to the views now prevailing respecting these animals, as they involve discussions upon all the fundamental principles of Zoölogy. Instead, therefore, of giving only the results of my own studies of the Acalephs, I will attempt, in this work, to trace also this successive growth of our present knowledge, with the special view of teaching the young naturalists of America how to proceed in their own researches.

vigny's[1] admirable researches upon compound Ascidians may be said to have contributed largely to the progress of the natural history of Acalephs. The same is true of the papers of Chamisso[2] and Cuvier[3] upon the Salpæ. The attempt of Latreille[4] to characterize the natural families of the animal kingdom did nothing towards improving the classification of the Acalephs; but Van der Hoeven gave a good account of what was then known about them.[5] In the special Faunæ of Risso[6] and Fleming,[7] there is much to be gleaned. The paper of Rang[8] deserves especially to be noticed, as it is very important for the study of the Beroids.

The interest excited by the success attending a combination of political objects with scientific explorations in the voyage of Captain Baudin soon led other powers to imitate the example of the French government, and the result has been a series of invaluable contributions to science. The most important of these scientific exploring expeditions are as follows: that of Admiral Krusenstern, with Langsdorf and Tilesius as naturalists;[9] the two voyages of Captain Kotzebue,[10] with Chamisso and Eschscholtz as naturalists; then the voyage of Captain Freycinet[11] in the Uranie

[1] SAVIGNY (JULES-CÉSAR), Mémoires sur les animaux sans vertèbres, Paris, 1816, 2 vols. 8vo. See also the great work upon Egypt published by order of Napoléon after the memorable campaign of 1798.

[2] CHAMISSO (ALBERTUS DE) ET EYSENHARDT (C. G.), De Animalibus quibusdam e classe Vermium Linnæana, in circumnavigatione terræ, auspicante comite N. ROMANZOFF, duce OTT. DE KOTZEBUE, ann. 1815–1818 peractâ, observatis. Act. N. Nat. Cur. 1819. 4to.

[3] CUVIER (G.), Mémoire sur les Thalides et les Biphores, Ann. du Mus. 1804, IV. p. 360. — Mémoire sur les Ascidies, Mém. du Mus. 1815, II. p. 10. Both these papers are reprinted in Mémoires pour servir à l'Histoire et à l'Anatomie des Mollusques, Paris, 1817, 4to. fig.

[4] LATREILLE (P. A.), Familles naturelles du Règne animal, exposées successivement et dans un ordre analytique, avec l'indication de leurs genres, Paris, 1825, 8vo.

[5] VAN DER HOEVEN (JOHAN.), Tabula Regni animalis, additis Classium Ordinumque characteribus, Lugd.-Bat., 1828, fol. — Handboek der Dierkunde, Delft, 1827, 8vo.; Rotterdam, 1828, 3d edit., 2 vols. 8vo. — English translation: Handbook of Zoölogy, by the Rev. W. Clark, Cambridge, 1856–1858, 2 vols. 8vo. fig. This is the best modern text-book of special Zoölogy.

[6] RISSO (A.), Histoire naturelle des principales productions de l'Europe méridionale, particulièrement de celles des environs de Nice et des Alpes maritimes, Paris, 1826, 5 vols. 8vo. fig.

[7] FLEMING (JOHN), A History of British Animals, exhibiting their Descriptive Characters, Edinburgh, 1828, 8vo. — The Philosophy of Zoölogy, London, 1822, 2 vols. 8vo.

[8] RANG (SANDER), Etablissement de la famille des Béroïdes dans l'ordre des Acalèphes libres, et Description de deux genres nouveaux qui lui appartiennent, Mém. Soc. Hist. n. Par. IV. p. 166, fig.; Férussac, Bull. 1829, 17, p. 141.

[9] See note 3, p. 20.

[10] KOTZEBUE (OTTO), Voyage pittoresque autour du monde, sur le brick le Rurick, en 1815–1818, Paris, 1821–1823, fol. — Neue Reise um die Welt in den Jahren 1823–1826, Weimar, 1830, 2 vols. 8vo. fig.

[11] FREYCINET (L. DE), Voyage autour du monde sur les corvettes l'Uranie et la Physicienne, pendant les années 1817–1820, Paris, 1824, 8 vols. 4to. and 4 vols. atl. fol.

and Physicienne, with Quoy and Gaimard[1] as naturalists; that of Captain Duperrey[2] in the Coquille, with Lesson and Garnot[3] as naturalists; the two voyages of Captain Dumont d'Urville,[4] the first in the Astrolabe with Quoy and Gaimard,[5] and the second in the Astrolabe and Zélée with Hombron and Jacquinot, as naturalists; that of Captain LaPlace[6] in the Favorite, with Eydoux and Baume as naturalists; that of Captain Vaillant[7] in the Bonite, with Eydoux and Souleyet as naturalists; and that of Captain Dupetit-Thouars[8] in the Venus. These publications are truly admirable in their execution, and that of the Astrolabe particularly important for the Acalephs. The more recent exploring expeditions fitted out by the United States and in England can fairly be placed by the side of them.[9] In this connection it is fitting to remember the great works of Humboldt, the scientific expedition to Egypt, those in Morea and Algiers, and the many more recent explorations in almost every part of the world.

[1] Quoy et Gaimard, Zoologie du Voyage de l'Uranie, sous les ordres du Capitaine Freycinet, de 1817 à 1820, Paris, 1824, 4to. atl. fol.

[2] Duperrey (L. J.), Voyage autour du monde sur la corvette la Coquille, pendant les années 1822–1825, Paris, 1828, 6 vols. 4to. and 4 vols. atl. fol.

[3] Lesson (R. P.) et Garnot (P.), Zoologie du Voyage autour du monde exécuté sur la Corvette la Coquille par L. Duperrey commandant de l'Expédition, pendant les années 1822–1825, Paris, 1829, 2 vols. 4to. atl. fol.

[4] Dumont-d'Urville (J.), Voyage autour du monde et à la recherche de la Pérouse, sur la corvette l'Astrolabe, pendant les années 1826–1829, Paris, 1830, et suiv., 6 vols. 8vo. Atl. fol. — Voyage au Pole Sud and dans l'Océanie sur les corvettes l'Astrolabe et la Zélée, pendant les années 1837–1840, Paris, 34 vols. 8vo. atl. fol.

[5] Quoy et Gaimard, Zoologie du Voyage de l'Astrolabe, sous les ordres du Capitaine Dumont d'Urville, pendant les années 1826–1829, Paris, 1830–1833, 5 vols. 8vo. atl. fol. — Observations Zoologiques faites à bord de l'Astrolabe en Mai 1826, dans le Détroit de Gibraltar, Ann. Sc. n. 1827, X. pp. 5, 172, 225, fig.

[6] LaPlace (C. P. Th.), Voyage autour du monde par les mers de l'Inde et de la Chine, sur la corvette la Favorite, pendant les années 1830–1832, Paris, 1833–1839, 5 vols. 8vo. Histoire naturelle, vol. 5, par Eydoux et Baume.

[7] Vaillant, Voyage autour du monde, sur la corvette la Bonite, pendant les années 1836 et 1837, Paris, 1838 et suiv. Zoologie par Eydoux et Souleyet, 2 vols. 8vo. et atl. fol.

[8] Dupetit-Thouars, Voyage autour du monde sur la frégate la Vénus pendant les années 1837–1839, Paris, 1840, et suiv. 10 vols. 8vo. atl. fol. Zoologie par Isid. Geoffrey St. Hilaire et Valenciennes, 1 vol. 8vo. et atl. fol.

[9] Belcher (E.), Narrative of a Voyage round the World in the Sulphur, 1836–1842, London, 1843, 2 vols. 8vo. — The Zoölogy of the Voyage of the Sulphur, by R. B. Hinds, London, 1845, 2 vols. 4to. — Narrative of the Voyage of the Samarang among the Islands of the Eastern Archipelago, 1843–1846, London, 1848, 2 vols. 8vo. — The Zoölogy by Adams and Reeve. — Fitzroy (Robert), Proceedings of the Beagle's Second Voyage to South America, 1831–1836, London. — The Zoölogy of the Voyage of the Beagle, edited and super. by Ch. Darwin, London, 1839–1843, 5 vols. 4to. — Wilkes (Ch.), Narrative of the United States Exploring Expedition during the Years 1838–1842, Philadelphia, 1845, 3 vols. 8vo. — The Zoölogy, Zoophytes, and Crustacea, by J. D. Dana.

In the year 1829, Eschscholtz,[1] who had made two voyages round the world with Captain Kotzebue, published his system of the Acalephs, the most important work yet published upon this class, as it embodies not only the results of all the investigations of his predecessors, but presents, with great fulness and precision, original investigations made by himself upon all the members of this class now referred to it, with the sole exception of the Hydroids. The figures, though mere outlines, are invaluable for their accuracy. In the following year DeBlainville published a general account of the Zoöphytes, in which the Acalephs occupy a large place; but it can hardly be said to mark a progress in our science, notwithstanding the many additions it contains in the details, for De Blainville[2] has been led in the classification to make changes which are unjustifiable, and to remove from among the Acalephs a large number of genera which undoubtedly belong to this class. The more recent publications of systematic importance are those of Mertens,[3] Brandt,[4] and Lesson;[5] and with the latter ends fairly the period of the purely descriptive history of Acalephs. There are, still, many papers published at a later

[1] ESCHSCHOLTZ (FR.), System der Acalephen, eine ausführliche Beschreibung aller medusenartigen Strahlthiere, Berlin, 1829, 4to. with fourteen plates. Eschscholtz made two voyages round the world, the first in 1815–1818 as physician on board the brig Rurick under the command of Captain Otto von Kotzebue, while Chamisso was naturalist to the expedition. He has contributed several papers to the report of this voyage. The results of the second voyage, in the years 1823–1826, on board the Predpriaetië sloop of war, under the command of the same distinguished seaman, are particularly interesting to American naturalists, as, during a prolonged stay upon the north-west coast of this continent, Eschscholtz visited California, and discovered a great many curious animals peculiar to our western Fauna, which are described for the first time in the "Zoologischer Atlas, enthaltend Abbildungen und Beschreibungen neuer Thierarten, während des Flottecapitains v. Kotzebue's 2ter Reise um die Welt, von Dr. Friedr. Eschscholtz, Berlin, 1829–1833, in 5 Hefte," the last of which was edited by Rathke, after the author's death. The name of Eschscholtz is familiar to every lover of flowers, in the elegant plant that now adorns our gardens and which bears his name, the Eschscholtzia of California. The scientific results of the first voyage of Kotzebue were in part published by *Chamisso and Eysenhardt* in N. Act. Nat. Cur. X. 1821.

[2] BLAINVILLE (H. D. DE). Article Zoophytes in Nouveau Dictionnaire d'histoire naturelle, Paris, 1830. Republished under the title of Manuel d'Actinologie, Paris, 1834, 2 vols. 8vo. fig.

[3] MERTENS (H.), Beobachtungen über die Beroëartigen Acalephen, Mém. Acad. Pétersb. 1833.

[4] BRANDT (J. F.), Ausführliche Beschreibung der von C. H. MERTENS beobachten Schirmquallen, etc., Petersb. 1838, 4to. fig. col., Mém. Acad. Pét. sér. 6, 11. Also Prodromus, etc. 1835.

[5] LESSON, Histoire naturelle des Zoophytes, Acalèphes, Paris, 1843, 1 vol. 8vo. fig. — Centurie Zoologique, Paris, 1830, 8vo. fig. — Tableau de la famille des Zoophytes Béroïdes, Ann. Sc. Nat. V. p. 254, 1836. Translated in Proc. Zool. Soc. III. p. 2. — Prodrome d'une Monographie des Méduses, in-4to. de 62 pages, Rochefort, juin, 1837. Edw. Forbes questions the existence of this work; but it was really published, in the shape of autographed sheets, of which, however, a very small number of copies were issued. I myself used it when preparing the Nomenclator Zoologicus. The copy I saw belongs to Duméril.

date, which, however, contain so little concerning the structure or embryonic development of the Acalephs, that they may fairly be enumerated here. Such are Peach's Observations on the Luminosity of the Sea;[1] Lütken's[2] classification of the Medusæ; Forbes and Goodsir's[3] description of new species; F. Müller's[4] Medusæ of Santa Catharina; Alders's[5] new British Hydroids, and Catalogue of the Zoöphytes of Northumberland; Gould's enumeration of those of Massachusetts;[6] Sars's, and Leuckart's Contributions to those of the Mediterranean;[7] Gosse's Rambles along the British shores,[8] etc.; the Dictionnaire des Sciences Naturelles,[9] the Dictionnaire Classique,[10] Ersch and Gruber's Encyclopädie,[11] the Isis of Oken, the Annales des Sciences Naturelles, the Archiv für Naturgeschichte, the Zeitschrift für wissenschaftliche Zoölogie, Müller's Archiv, the Annals and Magazine of Natural History; and the innumerable smaller periodical publications, and proceedings of learned societies of our time, should also be consulted. Enough is now known of the Acalephs to show, that, since they undergo the most extraordinary changes during their life, the history of no one species can be considered as satisfactory before it has been traced in all its conditions. Henceforth, mere descriptions of isolated forms can have but a very limited interest. The time when it could be thought sufficient merely to draw up a diagnosis, in order to characterize a species, is indeed gone for the Acalephs, and, I trust, for other classes of animals also. This great change in the requirements of our science was chiefly brought about by the investigations related in the next section.

[1] PEACH (CH. W.), Observations on the Luminosity of the Sea, with Descriptions of the several Objects which cause it, Ann. and Mag. Nat. Hist. 1850, VI. p. 425.

[2] LÜTKEN (C. F.), Ueber die systematische Gruppirung der Medusen, Vidensk. Meddels. 1849–1850, p. 15. I only know this paper from the abstract in Arch. f. Naturg. 1854, XX. p. 424.

[3] FORBES (EDW.) and GOODSIR (J.), On some remarkable marine Invertebrata, new to the British Seas, Trans. Roy. Soc. Edinb. 1851, XX. p. 307.

[4] MÜLLER (FR.), Zwei neue Quallen von Santa Catharina (Brasilien), Abh. Nat. Ges. Halle, 1859, V. p. 1.

[5] ALDER (JOS.), Notice of some new Genera and Species of British Hydroid Zoophytes, Ann. and Mag. Nat. Hist. 1856, XVIII. p. 353 and 439. — Catalogue of the Zoophytes of Northumberland and Durham, Trans. Tyneside Natur. Club; in abstract in Micr. Journ. V. p. 242.

[6] GOULD (A. A.), Report on the Invertebrata of Massachusetts, Boston, 1841, 8vo.

[7] SARS (M.), Bidrag til kundskaben om Middelhavets Littoral-Fauna, Reisebemärkninger fra Italien, Christiania, 1857, 8vo. Abstracts of it may be found in Arch. Naturg. 1858, II. p. 156 and 163. — LEUCKART (R.), Beiträge zur Kenntniss der Medusenfauna von Nizza, Arch. Naturg. 1856, I. p. 1.

[8] GOSSE (TH. H.), Naturalist's Rambles on the Devonshire Coast, London, 1853, 1 vol. 8vo. fig. — Tenby, a Sea-side Holiday, London, 1856, 1 vol. 8vo. fig.

[9] Dictionnaire des Sciences Naturelles, publié par les Professeurs du Jardin du Roi, Paris et Strasbourg, 1816–1829, 60 vols. 8vo. fig.

[10] Dictionnaire Classique d'Histoire naturelle, etc., Paris, 1824–1830, 17 vols. 8vo.

[11] ERSCH (J. S.) und GRUBER (J. G.), Allgemeine Encyclopädie der Wissenschaften, Leipzig, 1818 und folg. 4to.

The harvest to be gathered for the history of Acalephs from the works of anatomists of preceding periods would be so meagre that I have not even alluded to them thus far; though, with reference to some particular points of their structure, and especially those bearing upon their reproduction, it will be necessary hereafter to return to a consideration of the methods applied in their investigations by the great anatomists and physiologists of the eighteenth century, in order to trace the connection between the progress of our knowledge of the lower animals and the general progress of Zoölogy as a science. We owe to Cuvier the first anatomical description of a Medusa;[1] and next to this paper, those of Tilesius,[2] Eysenhardt,[3] Gäde,[4] Baer,[5] and Delle Chiaje,[6] deserve a special notice. Eschscholtz,[7] in his classical treatise on Acalephs, gives the first summary of the anatomy of these animals, and this is soon followed by Mertens's[8] investigations of the Beroids; Brandt's[9] descriptions of the Medusæ of Mertens, with numerous anatomical details; and the more special illustrations of Ehrenberg[10] on the organization of the Medusæ of the German Ocean; Milne-Edwards's[11] masterly observations on various Acalephs; Grant[12] on Beroe; R. Wagner[13] on the structure of Pelagia; Costa,[14] Hollard,[15] and Krohn[16]

[1] CUVIER (G.), Sur l'organisation de quelques Méduses, Bull. Soc. Philom. p. 69, Paris, 1800.

[2] TILESIUS (W. G.), Beiträge zur Naturgeschichte der Medusen, N. Act. Nat. Cur. XV. 2, p. 247, fig., contains magnificent figures.

[3] EYSENHARDT (C. W.), Zur Anatomie und Naturgeschichte der Quallen, N. Act. Nat. Cur. X. p. 375, fig., contains a very elaborate anatomy of the Rhizostoma Cuvieri.

[4] GADE (HENR. M.), Beiträge zur Anatomie und Physiologie der Medusen, Berl. 1816, 8vo.

[5] BAER (PROF. K. E. V.), Ueber Medusa aurita, Meckel's Arch. VIII. p. 369.

[6] DELLE CHIAJE (ST.), Memorie sulla Storia e Notomia degli Animali senza vertebre del Regno di Napoli, Nap. 1825–1830, 4 vols. 4to. fig. — Descrizione et Notomia degli Animali invertebrati della Sicilia citeriore, etc., Nap. 1841–1844, 6 vols. 4to.; 2 vols. fig.

[7] See note 1, p. 24.

[8] See note 3, p. 24.

[9] See note 4, p. 24.

[10] EHRENBERG (C. G.), Die Akalephen des rothen Meeres und der Organismus der Medusen der Ostsee, Ak. Wiss. Berlin, 1836, 4to. fig.

[11] MILNE-EDWARDS (H.), Observations sur la structure de la Méduse marsupiale ou Charybdée marsupiale de Péron et LeSueur, Ann. Sc. Nat. 1833, vol. 28, p. 248, fig. — Observations sur la structure et les fonctions de quelques Zoophytes, Mollusques et Crustacés des Côtes de France, Ann. Sc. Nat. 2de sér. 1841, vol. 16, p. 193, fig. — Ann. Sc. Nat. 3e sér. 1857, vol. 7, p. 285. — Recherches Anatomiques et Zoologiques faites pendant un voyage sur les côtes de la Sicile, Paris, 1844, 4to. fig. vol. 1, p. 57. The last paper gives full descriptions of the gastrovascular system.

[12] GRANT (R. E.), On the Nervous System of Beroe Pileus, Trans. Zool. Soc. I. p. 9, fig.

[13] WAGNER (R.), Ueber den Bau der Pelagia noctiluca und die Organisation der Medusen, Leipzig, 1841, fol. fig.; also in Icones Zootomicæ, etc., Leipzig, 1841, fol.

[14] COSTA (O. G.), Note sur l'appareil vasculaire de la Vélelle, Ann. Sc. Nat. 2de sér. 1841, vol. 16, p. 187, fig.

[15] HOLLARD (H.), Recherches sur l'organisation des Vélelles, Ann. Sc. Nat. 3e sér. 1845, vol. III.

[16] KROHN (A.), Ueber die Anwesenheit eigenthümlicher Luftkanäle bei Velella und Porpita, Arch. Naturg. 1848, vol. 1, p. 30.

on Velella; Philippi[1] on Physophora; Ecker and Leydig on Hydra;[2] Allman on Cordylophora;[3] Quatrefages on Physalia;[4] Huxley's Anatomy and Affinities of the Medusæ;[5] my own contributions to the natural history of the Acalephs of North America;[6] and the works and papers of Will,[7] Sars,[8] Forbes,[9] Leuckart,[10] Vogt,[11] Kölliker,[12] Gegenbauer,[13] and Schultze.[14] The papers relating more especially to the embryology of the Acalephs will be enumerated in the next section. General accounts of the structure of the Acalephs may be found in most text-books on Comparative Anatomy, especially in the more recent ones.[15]

[1] Philippi (R. A.), Ueber den Bau der Physophoren und eine neue Art derselben; Müller's Arch. 1843, p. 58, fig.

[2] Ecker (Al.), Zur Lehre vom Bau und Leben der kontractilen Substanz der niedersten Thiere, Basel, 1848, 4to. fig. — Leydig (F.), Einige Bemerkungen über den Bau der Hydren, Müller's Arch. 1854, p. 270.

[3] Allman (G. J.), On the Anatomy and Physiology of Cordylophora, Phil. Trans. Roy. Soc. 1853, vol. 143, p. 367.

[4] Quatrefages (A. de), Mémoire sur l'organisation des Physales, Ann. Sc. Nat. 4e sér. 1854, vol. 2.

[5] Huxley (Th. H.), On the Anatomy and Affinities of the Family of the Medusæ, Phil. Trans. Roy. Soc. 1849, p. 413. — On the Anatomy of Physalia, Proc. Linn. Soc. 1848. — Observations upon the Anatomy of the Diphydæ, and the Unity of Organization of the Diphydæ and Physophoridæ, Proc. Linn. Soc. 1849. — Report on the Structure of the Acalephs; Brit. Assoc. for Adv. Sc. 1851. — Ueber die Sexual Organe der Diphyden und Physophoriden; Müller's Arch. 1851. — The Oceanic Hydrozoa; a Description of the Calycophoridæ and Physophoridæ observed during the Voyage of H. M. S. Rattlesnake; Ray Society, London, 1859, fol. fig.

[6] Agassiz (L.), Contributions to the Natural History of the Acalephæ of North America, Parts I. and II.; Amer. Acad. Arts and Sc. vol. IV. 1850.

[7] Will (J. G. Fr.), Horæ tergestinæ oder Beschreibung und Anatomie der Akalephen, Leipzig, 1844, 4to. fig.

[8] Sars (M.), Fauna littoralis Norvegiæ, Christiania, 1846 and 1856, fol. fig.

[9] Forbes (Edw.), Monograph of the British Naked-eyed Medusæ; Ray Society, London, 1847, fol. fig.

[10] Leuckart (R.), Ueber den Bau der Physalien und Siphonophoren, Zeitsch. f. wiss. Zool. 1851, vol. 3. — Zoologische Untersuchungen, 1853, 4to. fig. — Zur nähern Kenntniss der Siphonophoren von Nizza, Arch. Naturg. 1854, I. p. 249. — Also Frey und Leuckart, Beiträge zur Kenntniss wirbelloser Thiere, Braunschweig, 1847, 4to. fig.

[11] Vogt (C.), Ueber die Siphonophoren, Zeitsch. f. wiss. Zool. 1852, vol. 3, p. 522. — Untersuchungen über Thierstaaten, Frankfurt, 1851, 8vo. fig. — Recherches sur les animaux inférieurs de la Méditerranée; Premier Mémoire, sur les Siphonophores de la mer de Nice, Genève, 1854, 4to. fig.

[12] Kölliker (A.), Die Schwimmpolypen oder Siphonophoren von Messina, Leipzig, 1853, fol. fig.

[13] Gegenbauer (C.), Beiträge zur nähern Kenntniss der Schwimmpolypen (Siphonophoren) Zeitsch. f. wiss. Zool. 1854, vol. 5, p. 285, and p. 442. Bemerkungen über die Randkörper der Medusen, Müller's Arch. 1856, p. 230. — Studien über Organisation und Systematik der Ctenophoren, Arch. Naturg. 1856, I. p. 163. — Versuch eines Systems der Medusen, mit Beschreibung neuer oder wenig gekannter Formen; Zeitsch. f. wiss. Zool. 1857, vol. 8, p. 202.

[14] Schultze (Max.), Ueber den Bau der Gallertscheibe bei den Medusen, Müller's Arch. 1856, p. 311.

[15] See notes to pages 26 and 27 of the first

SECTION V.

EMBRYOLOGICAL RESEARCHES UPON ACALEPHS.

The history of the successive steps which have led to a full knowledge of the reproduction and mode of development of the Medusæ exhibits some of the most interesting features in the annals of scientific discoveries, on account of the peculiarity of the facts brought to light in the course of the investigation not only, but also because the progress has been so very slow and gradual that it discloses, more clearly than most other subjects, the care, the patience, and the unrelenting perseverance, with which natural phenomena ought to be traced, in order to secure satisfactory results.

As I have already enumerated the numerous papers relating to the Embryology of Acalephs in another part of this work,[1] I shall limit myself here to a brief

volume of this work; to which may be added: COLDSTREAM (JOHN). Article Acalephæ in Todd's Cyclop. of Anat. and Phys. 1835, 8vo.; MILNE-EDWARDS Leçons sur la Physiologie et l'Anatomie comparée de l'homme et des animaux, Paris, 1857–1859, 4 vols. 8vo. — CARUS (V.), Icones Zootomicæ, mit Original-Beiträgen von Allman, Gegenbauer, Huxley, Kölliker, Müller, Schultze, Siebold, und Stein, Leipzig, 1857, fol.; and GEGENBAUER (C.), Grundzüge der vergleichenden Anatomie, Leipzig, 1859, 1 vol. 8vo.

[1] See vol. 1, p. 69. To the works there quoted may be added: HASSALL (A. H.), Catalogue of Irish Zoöphytes, Ann. and Mag. Nat. Hist. 1841, vol. 8. — STEENSTRUP (J. J. SM.), Untersuchungen über das Vorkommen des Hermaphroditismus in der Natur. aus dem Dänischen von Dr. C. F. Hornschuch. Greifswald. 1846, 4to. fig. — VAN BENEDEN (P. J.), Un mot sur le mode de reproduction des animaux inférieurs, Bulletins Acad. Roy. de Belgique, 1847. — REID (JOHN), Observations on the Development of the Medusæ, Ann. and Mag. Nat. Hist. 1848, vol. 1, p. 25. — GILES (EDW.) and CLARKE (W. B.). A few Remarks upon a Species of Zoöphyte discovered in the New Docks of Ipswich, Ann. and Mag. Nat. Hist. 1849. vol. 4, p. 26. — MÜLLER (J.), Archiv für Anat. und Phys. 1852, p. 32, (in the paper on the origin of shells in Holothuria.) — THOMPSON (W.), On the Analogy between the Processes of Reproduction in the Plant and in the Hydroid Zoöphyte, Ann. and Mag. Nat. Hist. 1851. XIV. p. 313. — BURMEISTER (H.). Zoonomische Briefe, Leipzig, 1856. 2 vols. 8vo. See vol. 1, p. 139. — PEACH (C. W.), Notice of a curious Metamorphosis in a Zoöphyte-like animal, Edinb. New Phil. Journ. 1856, vol. 4. — SARS (M.), Einige Worte über die Entwickelung der Medusen, Wiegmann's Archiv of Naturg. 1857, I. p. 117. — DALYELL (SIR JOHN G.), On the Propagation of Scottish Zoöphytes, Edinb. New Phil. Journ. 1834, vol. 17, and 1836, vol. 21. — GEGENBAUER (K.), Zur Lehre vom Generationswechsel und der Fortpflanzung bei Medusen und Polypen, Würzburg, 1854, 8vo. fig. — WRIGHT (J. J.), On the Reproduction of Cydippe pomiformis, Edinb. New Phil. Journ. 1856, vol. 4, p. 85. — Observations on British Zoöphytes, Edinb. New Phil. Journ. 1857–1859. — On Hydractinia echinata. 1857, Edinb. New Ph. Journ. — GOSSE (TH. H.), Naturalist's Rambles on the Devonshire Coast, Lon-

narrative of the successive steps which have furnished us with a connected account of the extraordinary modes of reproduction of this class of animals. The first facts relating to the history of the earlier stages of development of the most common Jelly-fish of the European seas, the Aurelia aurita, were observed by Sars, and related by him in a paper published in 1829,[1] and more fully illustrated in a subsequent work,[2] issued in 1835, which opens a new era in the natural history of the Acalephs. The fundamental discoveries made by Sars were afterwards generalized by Steenstrup, and presented to the world in a most unexpected connection with other genetic phenomena which had remained entirely unintelligible.

The first paper of Sars contains only descriptions of animals not noticed before;[3] but among them are those found in the sequel to represent the transitory stages in the growth of the common Medusa. These are here described as Scyphistoma and Strobila; the first being considered as a distinct genus of Polyps, the second as

don, 1853, 8vo. fig. — KROHN (A.), Ueber die Natur des kuppelförmigen Anhanges am Leibe von Phillirhoë bucephalum, Arch. Naturg. 1853, I. p. 278. — MCCRADY (J.), Description of Oceania nutricula, and the Embryological History of a singular Medusan Larva found in the cavity of its Bell; Proc. Elliott Society, Charleston, S. C., 1857. — Gymnopthalmata of Charleston Harbor, Proc. Elliott Society, Charleston, S. C., 1858. — On the Development of two Species of Ctenophoræ found in Charleston Harbor, Proc. Elliott Society, Charleston, S. C., 1859. — ALLMAN (G. J.), On the Structure of the Reproductive Organs of certain Hydroid Polyps, Proc. Roy. Soc. Edinb. 1858. — Additional Observations on the Morphology of the Reproductive Organs in the Hydroid Polyps, Proc. Roy. Soc. Edinb. 1858. — SEMPER (C.), Ueber die Entwickelung der Eucharis multicornis, Zeitsch. f. wiss. Zool. 1858, vol. 9, p. 234, fig.

[1] The first paper of SARS appeared in 1829, under the title of Bidrag til Söedyrenes Naturhistorie af M. Sars, Cand. Theol. Förste-Haefte, med sex illuminerede Steentryktafler, 8vo. Bergen, 1829. At that time Sars was still "Candidatus Theologiæ." An abridged translation of this paper, with a reproduction of the plates, was published in Oken's Isis for 1833, p. 221. I myself have never seen the original, and I find that most writers have quoted the investigations related in this paper as bearing the date of 1833; but this is erroneous. The paper contained in the Isis of 1833 was not forwarded to Oken by Sars, but is simply a translation of the paper of 1829, with a few introductory remarks by Thienemann.

[2] SARS (M.), Beskrivelser og Jagttagelser over nogle mærkelige eller nye i Havet ved den Bergenske Kyst levende Dyr af Polypernes, Acalephernes, Radiaternes, Annelidernes og Molluskernes Classer, etc., Bergen, 1835, 4to. with 15 plates. I am indebted for a copy of this rare work to my friend Professor Eschschricht of Copenhagen. As it may not be easily accessible to naturalists in this country, I would mention that abstracts of its contents may be found in the Isis of Oken for 1837, p. 354, in the Annales d'Anatomie, etc., II. p. 81, and in Wiegmann's Archiv fur Naturgeschichte, 1836, 2d vol. p. 197. What relates to Acalephs may be found p. 197–200.

[3] I avoid intentionally, whenever I can, the use of the expression *new*, as applied to animals not known before to naturalists; for, besides the impropriety of applying the word new to what has only been unnoticed before, I find that students of Palæontology are much puzzled in ascertaining whether that expression, when applied to fossils, means a newly discovered species, or one belonging to the more recent geological formations.

a peculiar genus of Acalephs, and both as distinct from all the other genera of Polyps and Medusæ known at that time. The genus Scyphistoma is considered as intermediate between Hydra and Coryne; *Scyphistoma filicorne*, the only species described, is characterized as having twenty-four to thirty-two tentacles, the mouth as being retractile and protractile, and the body as annulate. This last indication shows, that the Scyphistoma first observed by Sars was on the point of passing to the Strobila condition. The genus Strobila is thus described: Animalia nunc simplicia et libera, nunc plura invicem conjuncta, alterum scilicit super alterum positum, ita ut seriem forment, cujus extremitas infima pedunculo brevi est affixa, singulum animal disci formam referens, supra paullulum convexum, subtus concavum, margo disci in radios plures divisa. Os subtus maxime prominens tetragonum. One species, *Strobila octoradiata*: Margo disci in radios octo dichotomos divisa. When free, these discs are said to move like small Medusæ. The eight small ocelli between the lobes of the eight rays were correctly observed, and compared to those of the Medusa (Aurelia) aurita and Medusa (Cyanea) capillata. Thienemann, who furnished the abstract for the Isis, suggests that Sars should ascertain whether this is not the embryonic state of some Medusa. Sars himself considered Strobila as establishing a transition between the fixed Zoöphytes and the Medusæ, while Ehrenberg[1] mistook it for a Lucernaria in the process of transverse division.

In his later work, published in 1835, Sars gives a more detailed account of the Strobila, and shows that the animal he had described as a distinct genus under the name of Scyphistoma is simply an earlier stage in the development of the Strobila, and that the free discs of the Strobila are themselves closely allied to the animals described by Eschscholtz as Ephyra, a genus referred by the latter to the Acalephæ cryptocarpæ. This is illustrated by figures, on his Pl. 3d. These observations establish beyond the possibility of a doubt the fact, that extraordinary changes take place in animals that were at first considered to be Polyps, and the growth of which ends in the production of animals belonging unquestionably to the class of Medusæ. In a later note, Sars declares[2] that he has satisfied himself that the Ephyra-like Medusa arising from his Strobila is a younger state of the common Medusa (Aurelia) aurita, without, however, furnishing the evidence of this assertion, which is still questioned by Wiegmann.[3]

In 1841, Sars takes the whole matter up again, and in a masterly paper[4] demon-

[1] Ehrenberg (C. G.), Die Akalephen des rothen Meeres und der Organismus der Medusen der Ostsee, Berlin, 1836, p. 52.

[2] Wiegmann's Archiv für Naturgeschichte, 1837, vol. 1, p. 406.

[3] Wiegmann's Archiv für Naturgeschichte, 1837, vol. 2, p. 276.

[4] Sars (M.), Ueber die Entwickelung der Medusa aurita und der Cyanea capillata, Wiegmann's Archiv für Naturgeschichte, 1841, vol. 1, p. 9–34,

strates beyond the possibility of a doubt, that the Scyphistomas are the offspring of Medusæ; that they are transformed into Strobilæ, which produce Ephyroid Medusæ; and that the latter end their life as Medusa aurita and Cyanea capillata. All these facts are illustrated by beautiful figures. He begins by showing that the free disks of his Strobila are the young Medusa (Aurelia) aurita. He next instances facts showing the similarity of the development of Cyanea capillata with that of Aurelia aurita; and then describes his attempts to raise the eggs of the Medusæ, in which he succeeded so far as to show that Scyphistomas are developed from eggs laid by both these Medusæ, and thus closes the cycle of the investigation undertaken with the view of ascertaining the normal connection of all these animal forms. There can no longer be any doubt that they are genetically linked together, even though the transformation has not been watched through all its stages in one and the same specimen. The difficulty of keeping them alive for a sufficient time in confinement makes it impossible to obtain that kind of evidence. But as far as the closest similarity of the forms watched in confinement with those observed in their natural element is sufficient to trace their mutual dependence, the evidence is satisfactory and conclusive.[1]

The investigations of Sars had scarcely begun to be noticed in Germany when Siebold proceeded to trace the earliest stages of the formation of these animals.[2] His object was partly to revise the observations of Ehrenberg upon the structure of the Aurelia aurita, and partly to study the development of its eggs. To him we are indebted for the first accurate observations respecting the segmentation of the egg, and the formation of the embryo. Siebold clearly perceived the connection of the facts he had observed with those seen by Sars, yet a direct transition of the young from the state to which he had traced it to that observed by Sars was not seen by him.

The successive discoveries of Sars, combined with the investigations of von Siebold, had already led to a full knowledge of the characteristic features of the mode of development of the Medusæ, when Steenstrup took up this subject; and yet this ingenious observer gave a new impulse to the investigation of the Aca-

pl. 1–4. — A French translation, by Dr. Young, appeared in the Annales des Sciences naturelles, 2d series, 1841, vol. 16, p. 321.

[1] There are, however, two assertions in this paper with which I cannot coincide: 1st, the reversal of the young embryo when it becomes attached. Notwithstanding the objections of Sars, Siebold was right in what he said of the formation of the mouth, though he gave it up afterward. See note in Wiegm. Arch. 1841, I. p. 20. 2d, The base of the Strobila, after the Ephyræ are freed, does not die, as Sars states. Dalyell is correct when he affirms that they survive, and that tentacles reappear.

[2] SIEBOLD (C. TH. VON), Beiträge zur Naturgeschichte der wirbellosen Thiere; Neueste Schriften der naturforschenden Gesellschaft in Danzig, vol. 3d, No. 2, Danzig, 1839.

lephs, by the unexpected views under which he presented the facts recorded by his predecessors, so much so that a new era may be dated from the publication of his little work, for the history of the Acalephs not only, but also for the invertebrate animals in general. The whole aim of Steenstrup's investigations is fully expressed in the title of his work, "On the alternation of generations."[1] He expresses himself upon that point very clearly and in very few words, in his preface: "The substance of this paper is the fundamental idea expressed by alternation of generations. It is a remarkable, and, thus far, unexplained phenomenon of nature, that an animal brings forth a brood neither similar, nor growing to be similar, to the parent, but differing from it, and producing by itself another brood, that returns to the form and relations of the mother animal, in such a manner that a mother animal does not rear the like of itself, but reappears only in its descendants of the second or third or a following generation; and this appears always, in different animals, in a definite generation, and with definite intermediate generations."

Next to Sars and Steenstrup, Sir John Dalyell has been most successful in tracing the phenomena here alluded to. This author, whom Ed. Forbes, with his quick appreciation of every kind of merit in others, justly calls the Spallanzani of Scotland, has done more for the elucidation of the early history of the Medusæ than any other writer, although, from want of method in his descriptions and owing to his disregard of the modern systematic forms of presenting such subjects, his observations are only intelligible upon very careful perusal, and not available for a connected study of the gradual growth and successive phases of their development. For instance, it has not occurred to Sir John Dalyell, that what he calls "Hydra tuba" may be the offspring of several distinct genera of Medusæ, and so he con-

[1] STEENSTRUP (JOH. JAPETUS SM.), Ueber den Generationswechsel, oder die Fortpflanzung und Entwickelung durch abwechselnde Generationen, übersetzt von C. H. Lorenzen, Copenhagen, 1842, 8vo. fig. English translation by George Busk, published by the Ray Society: On the Alternation of Generations, London, 1845, 8vo. fig. Although the question of alternate generations is for the first time distinctly raised by Steenstrup, and presented by him as a phenomenon occurring not only among Radiates, but also among Mollusks and Articulates, it would be doing injustice to Sars not to remember, that, as far as the Medusæ are concerned, he had already correctly appreciated the character of the development of Aurelia aurita, which he does not consider as a simple metamorphosis of a larva, but as the metamorphosis of a new generation derived from the progeny of a Medusa. He goes even so far as to consider this mode of reproduction as a case parallel to that of Salpa, first observed by Chamisso, and to vindicate the accuracy of the investigations of the genial poet. Thus the groundwork upon which the theory of alternate generations could be reared is already laid out by Sars, when he says (Wiegmann's Archiv, 1841, vol. 1, p. 28), "It is, therefore, not the larva, or the individual hatched from the egg, that develops into a perfect Acaleph, but the brood arising from this larva by transverse division."

founded the history of at least two different genera; for I have no doubt, that, while the Hydra tuba, represented by him in his great work on "Rare and Remarkable Animals of Scotland," Vol. I., Pl. XIII., is the offspring of Aurelia aurita, the forms which he represents under the same name, Pl. XIV., are the offspring of Chrysaora, and those of Pl. XIX. are perhaps derived from Cyanea capillata.

In 1834, John Graham Dalyell[1] (afterwards Sir John) describes, under the name of Hydra tuba, an animal which is identical with Sars's Scyphistoma, already mentioned and figured by the latter in his paper of 1829; but Dalyell mentions many particulars, which seem to have for a long time remained unknown to other naturalists. He says that this animal is very voracious, and that it multiplies by budding, the buds remaining united to the base of the parent by a ligament, until this is ruptured as the embryo withdraws to establish itself independently. A single specimen had eighty-three descendants in thirteen months. Sars did not observe the budding before the year 1836,[2] and he did not see the buds separate and grow independently, as Dalyell did, and as I have done myself. In a subsequent paper,[3] Dalyell describes his further experiments with Hydra tuba up to 1836. He kept a colony of these animals alive, with their descendants, during six years, and numbers attained maturity. They fed rapaciously, grew and bred successive generations at all seasons of the year. In February and March he observed a pendulous flexible prolongation, of an inverted conical form, on the face or disk of some of these Hydras (the Strobila of Sars), developing gradually into twenty or thirty successive strata, broadening outwards, which, when more mature, were liberated, and swam at large in the water (the Ephyroid Medusa of Sars). He also considers them as Medusariæ, and gives good figures of one of them, figs. 2 and 3, p. 94. Later authors have failed to do justice to Sir John Dalyell. Speaking of his observations of the year 1836, Wiegmann, for instance, says,[4] that they contain so much that is enigmatical, that they require to be repeated and explained by other naturalists. Surely his own ignorance of the facts observed by Dalyell, the accuracy of which has been fully borne out, did not justify such a rebuke.

[1] On the Propagation of Scottish Zoöphytes, Edinb. New Philos. Journ. 1834, vol. 17, page 411, and Report British Association for Adv. of Science, 1834, p. 598. An abstract appeared in Froriep's Notizen. The name of Dalyell is misspelled in the Edinburgh New Philosophical Journal, and stands as Dalzell; under which name the author became known in Germany, and is quoted again and again in Wiegmann's Arch. for 1834, vol. 1, p. 303 and 305, and for 1837, vol. 2, p. 192.

[2] Wiegmann's Archiv, 1841, vol. 1, p. 24.

[3] Further Illustrations of the Propagation of Scottish Zoöphytes, Edinburgh New Philosophical Journal, 1836, vol. 21, p. 88; fully translated into German in Froriep's Notizen, vol. 50, No. 6, and in abstract in Wiegmann's Archiv, 1837, vol. 2, p. 278. The Isis of 1838 contains also abstracts of Dalyell's papers.

[4] Archiv, für Naturgeschichte 1837, 2d vol. p. 278.

Sars, again, speaks of them as partly confirmatory of his own, when, of course, the earlier observation was the original one, and the later ones should be considered as confirmations. The budding of the polypoid state of Strobila had been known to Dalyell for years before it had even been noticed by Sars. Dalyell already knew, in 1836, what Sars was still ignorant of in 1841, and, what seems hardly to be generally known even now, though it is certainly true, that the base of the Strobila resumes the form of the original Scyphistoma after the Strobila has dissolved itself into free Ephyræ.

But all these so-called "Hydra tuba" are not one and the same animal. They are the early stages of development of the different kinds of covered-eyed Medusæ which occur on the coast of Scotland, and the development of which presents similar phases. However, while Dalyell confounds in this manner the progeny of all the Steganophthalms of the vicinity of Edinburgh, his very mistake shows the more plainly how similar are the earlier stages of development of these different species of Medusæ.

It is much to be regretted, that the facts so carefully and patiently traced by Sir John Dalyell, for so many successive years, should not have earlier attracted the general attention of the investigators of Acalephs; for his work contains satisfactory information upon many points, which were afterwards discussed as if no observations had yet been made respecting them. Not less is it to be regretted, that Sir John Dalyell was not more fully acquainted with the investigations of Sars and of von Siebold. Had he known their import, his own results would have been much sooner incorporated into the history of these animals, while they would also have acquired more precision and directness in his own mind. As it happened, the highly important labors of Dalyell have remained almost unnoticed until recently, and have failed to exercise the influence they might have had upon the progress of science.

Various facts bearing upon the phenomena of alternate generations had been observed among Hydroids by Ehrenberg,[1] Loven,[2] Nordmann,[3] VanBeneden,[4] and

[1] Ehrenberg (C. G.), Die Korallenthiere des rothen Meeres physiologisch untersucht und systematisch verzeichnet, Berlin, 1834, 4to.

[2] Loven (S. L.), Beitrag zur Kenntniss der Gattung Campanularia und Syncoryne, Wiegmann's Arch. 1837, vol. 1, p. 249.

[3] Nordmann (Al. v.), Sur les changements que l'âge apporte dans la manière d'être des Campanulaires; Comptes-Rendus de l'Acad. des Sc. Paris, 1839, vol. 9, p. 701. This account is too short to be at all satisfactory.

[4] VanBeneden (P. F.), Mémoire sur les Campanulaires de la côte d'Ostende, considérées sous le rapport physiologique, embryogénique et zoologique; Ann. Sc. Nat. 2e sér. 1843, vol. 20, p. 350, et Mém. Ac. Brux. 1843, vol. 17, 4to. fig. — Mémoire sur l'embryogénie des Tubulaires, etc. Mém. Acad. Brux. 1844, 4to. fig.

Quatrefages,[1] without leading to conclusive results, when Dujardin turned his attention to the subject, and published two most important papers[2] describing the formation of genuine Medusæ from Hydroids; and thus establishing beyond question a genetic relation between animals of another family which had thus far been considered as belonging to different classes. Dujardin's investigations had a great influence in establishing the correctness of the views of Sars and Steenstrup, and in extending the range of our knowledge of the alternate generations; for, not only did he trace the development of several Medusæ from Hydroid Polyps, but he even saw the eggs of the free Medusæ derived from Hydroids reproduce their Hydroids. His second paper is accompanied by many beautiful figures, which add greatly to the clearness of his descriptions, and have forced the facts more directly upon the attention of naturalists.

Henceforward the study of the Acalephs is pursued in a new light and with broader views. The investigation of their affinities, their structure, and their mode of development, forms a part of their history; and their classification is modified accordingly, and gradually brought nearer and nearer to nature.

[1] QUATREFAGES (A. DE), Mémoire sur la Synhydre parasite (*Synhydra parasites*), nouveau genre de Polype voisin des Hydres; Ann. Sc. Nat. 2de sér. 1843, vol. 20, p. 230.

[2] DUJARDIN (FÉL.), Observations sur un nouveau genre de Médusaires (*Cladonema*) provenant de la métamorphose des Syncorynes; Ann. Sc. Nat. 2de sér. 1843, vol. 20, p. 370. — Mémoire sur le développement des Médusaires et des Polypes Hydraires; Ann. Sc. Nat. 3e sér. 1845, vol. 4, p. 257.

CHAPTER SECOND.

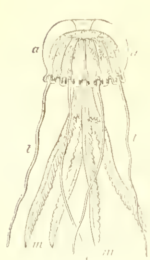
ACALEPHS AS A CLASS.

SECTION I.

MODE OF DETERMINING THE NATURAL LIMITS OF THE CLASS.

AFTER what has been said, in the first volume of this work, respecting systems in Zoölogy, it is hardly necessary to repeat here, that no arbitrary arrangement of animals can ever constitute a natural classification. Were it not so, every naturalist might present an arrangement suited to his individual views, and for which he would have as much authority as any one else. The absurdity of such a view, when clearly stated, is at once obvious. And yet most classifications have no better foundation for their details than a vague feeling of appropriateness in the minds of their authors. The class of Acalephs, however, has presented particular difficulties to systematic writers; and it is not too much to say, that there are no two naturalists, conversant with the animals belonging to this type, who agree in their arrangement of them. Nay, the limits of this class are by no means clearly determined; for, while some unite under that name only the free moving gelatinous Radiata (*Fig.* 1), others would associate with them a number of pedunculated individuals and fixed communities of animals somewhat allied to Polyps (*Fig.* 2), and actually united with Polyps by some naturalists. Again, some refer to the class of Polyps all the compound

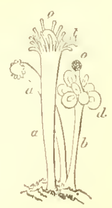
Fig. 1.



PELAGIA CYANELLA, Pér. and LeS.

a a Umbrella. — *m m* Mouth tentacles, or arms; the prolongation of the angles of the mouth. — *t t* Margiual tentacles

Fig. 2.



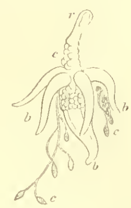
HYDRACTINIA POLYCLINA, Ag.

a a Sterile individuals. — *b* Fertile individual, producing male Medusæ. — *d* Clusters of male Medusæ. — *o o* Proboscis, with the mouth at the apex. — *t* Elongated tentacles of the sterile individuals; in the fertile one *b*, they are simple knobs upon the proboscis *o*.

communities of free-moving gelatinous animals, the Siphonophoræ (*Fig.* 3), which others consider as genuine Acalephs, while some do not hesitate to unite all Acalephs and Polyps in one single division. On the other hand, we have lately seen a part of the Acalephs, the Ctenophoræ (*Figs.* 4, 5, 6, and 7), removed from that class, and referred to the type of Mollusks.

Such conflicting views could not be entertained by so many and such eminent naturalists, did not almost insuperable difficulties obstruct our attempts to trace the truth. I know only one way to overcome these obstacles, and to attain greater precision on this subject. It is to test the affinities of all these animals by the standard of what is known of their mode of development, in the manner done before with full success for other classes; taking at the same time into account the homologies of their parts, as far as they can be ascertained. Embryology has, indeed, become the key-note to the knowledge of the closer affinities among animals. Granting, for instance, that anatomy alone could have settled the question of the true affinities of the Barnacles with Crustaceans, I hardly believe, that, but for our knowledge of their embryology, naturalists would ever have dared to consider them merely as a group of the natural division of Entomostraca, which they really are. But for our knowledge of the mode of development of toads and frogs, their close

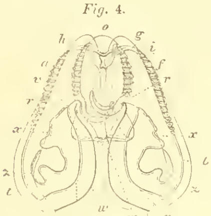
Fig. 3.



YOUNG PHYSOPHORA,
(*Copied from Gegenbauer.*)

e Buds of swimming bells.—*b b* So-called tentacles; lower *b* so called Polyp. — *c c* Feelers with lasso cells. — *r* Air sac.

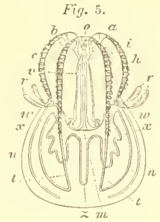
Fig. 4.



BOLINA ALATA, Ag.
(Seen from the broad side.)

a and *f* Long rows of locomotive fringes. — *g* and *h* Short rows of locomotive fringes. — *o* Central black speck (eye-speck?). — *i* to *m* Triangular digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity. — *v* Chymiferous tube of the tentacular apparatus. — *m* Tentacular apparatus on the side of the mouth. — *r r* Ear-like lobe, or auricles, in the prolongation of the short rows of locomotive fringes. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same tubes turning upwards. — *x x* Bend of the same tubes. — *z z* Extremity of the same tubes meeting with those of the opposite side. — *w* Recurrent tube anastomozing with those of the auricles.

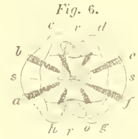
Fig. 5.



BOLINA ALATA, Ag.
(Seen from the narrow side.)

a b Long rows of locomotive fringes. — *c h* Short rows of locomotive fringes. — *o* Central black speck (eye speck?). — *i* Upper end of the digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity of the body. — *m* to *i* Digestive cavity. — *r r* Auricles. — *m* Mouth. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same turning upwards. — *x x* Bend of the same tubes. — *z* Anastomosis of the two longitudinal tubes *t t*. — *w w* Recurrent tube, anastomozing with those of the auricles. — A comparison of this figure with *Fig.* 4 gives a distinct idea of the relative position of the digestive cavity *m* to *i*, and the chymiferous tubes of the tentacular apparatus *v*.

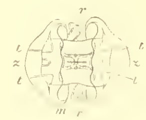
Fig. 6.



BOLINA ALATA, Ag.
(Seen from above.)

o Central black speck (eye speck?). — *a b e f* Long rows of locomotive fringes. — *c d g h* Short rows of locomotive fringes. — *r r* Auricles. — *s s* Circumscribed area of the upper end of the body.

Fig. 7.



BOLINA ALATA, Ag.
(Seen from below.)

m Mouth. — *r r* Auricles. — *t t t t* Prolongation of the vertical chymiferous tubes. — *z z* Anastomosis of these tubes.

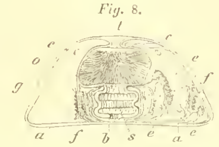
affinity to Salamanders and to Ichthyoid-Batrachians could never have been determined with the same precision; but for our knowledge of the development of the Comatulæ, that family would for ever have remained associated with the Star-fishes; and it seems to me that the inference is unavoidable, that the various modes of development of the Acalephs, as far as their embryology has already been traced, must afford the surest clue to the natural affinities of these animals, and, perhaps, furnish a standard also by which we may determine to what group certain polyp-like Radiata, alternately placed among Polyps and among Acalephs, truly belong. Should their special homologies coincide with the indications furnished by their embryology, all doubts on this point would seem to be removed; for, if the conclusions arrived at in those types of the animal kingdom which are now best known have any analogy with the phenomena observed in other types, we should be able to trace special homologies between all the representatives of the class of Acalephs, in the same manner as between all Insects, or between all Mammals.

In this way, it would scarcely seem difficult to determine whether those animals which have been at different times referred to the class of Acalephs and to that of Polyps truly belong to the one or the other, if the Polyps and Acalephs indeed constitute two classes, or if not, to demonstrate satisfactorily that they should form but one class. Again, all the representatives of the different classes of one branch are found to agree in their general homologies, as far as they have been thoroughly studied, — the Fishes with the Reptiles, Birds, and Mammals; the Insects with the Crustaceans and Worms; and the Acephala with the Gasteropods and Cephalopods. On the other hand, should there be any animals, thus far referred to the class of Acalephs or to that of Polyps, which do not agree in their general homologies with the true Polyps and the true Acalephs and Echinoderms, we should not hesitate to remove them from the type of Radiates. Thus we may also settle the question, whether the Ctenophoræ are true Radiates or Mollusks, as Quoy and Vogt have maintained.

In order to avoid any hasty conclusions, let us examine successively all the leading representatives of every group that may have been associated with either the Acalephs or the Polyps, both with reference to their homologies and their mode of development. Beginning with the Medusæ proper (Pl. III., IV., V., VI., VII., VIII., IX., XII., XIII., and XIV.), we find them to be animals which move freely, presenting an hemispheric gelatinous disk, in the centre of which a digestive sac is hollowed out. From the margin hang numerous filaments, and the central opening is surrounded by four larger appendages. From the central cavity arise many tubes radiating towards the periphery, where they anastomoze. The essential feature of this structure consists in the central cavity hollowed out of a continuous mass, which is traversed along its lower surface by radiating tubes. It requires but little familiarity with the Medusæ to know that the marginal fringes vary greatly in number, as well as in structure; some being hollow, while others are solid. These appendages are not even present in all Medusæ; for neither the Rhizostomata nor the Cassiopeiæ nor the Cepheæ have them. The central opening presents also marked differences in its outward termination. In some it has a simple rim, while in others, four or more prominent angles may extend outward and assume the shape of very complicated appendages. But in no Medusa is the margin of the central opening inverted into the digestive cavity.

Not so with the Actiniæ (*Fig.* 8) and the other Actinoid Polyps. Here the walls of the body, whether soft, or hardened by calcareous deposits, enclose a wide cavity, which is divided by radiating partitions into a number of chambers, communicating freely with the so-called tentacles or marginal fringes. The central opening does not communicate directly with the main cavity of the body, but leads into a distinct digestive sac, suspended in the main cavity. It is as if the upper part of the hollow cylindrical body had been turned into the cavity below, its edge hanging free and open in that cavity, though capable of closing by contraction. We have here, then, two distinct types; but they are homologous in all their parts. The outer wall of the Actiniæ corresponds to the gelatinous disk of the Medusæ, only that the centre of its outer surface is so constructed as to enable these animals to attach themselves by it, while in the Medusæ it is uniformly rounded off, and affords no point of attachment. The marginal fringes of the Actiniæ correspond to the marginal fringes of the Medusæ, only that in the Medusæ they communicate directly with the marginal circular tube, and through this with the radiating tubes, while in Actiniæ they open directly into the radiating chambers. The radiating tubes of the Medusæ correspond, it is true, to the radiating chambers of the Actiniæ; but in Actiniæ these chambers open freely for their whole length into the centre of the main cavity of the body, while in the Medusæ the radiating tubes are closed cylinders, opening only at their inner end into the main cavity. The central opening leads, in both, into the main cavity of the body; but in Medusæ the margin of that opening is turned outward, and may be prolonged into large appendages, between the inner surfaces of which a cavity is formed leading into the main cavity, while in the Actiniæ the outer margin of the central opening is turned inward and extends to a considerable length into the main cavity, so that the inner surface of the sac so formed corresponds to the outer surface of the wall of the main cavity; and it is

Fig. 8.



ACTINIA MARGINATA, LeSueur. (Contracted and the tentacles drawn in.)

a a Base of the animal. — *b* Opening of the digestive sac leading into the main cavity of the body. — *c c* Opening leading from one radiating partition into the other. This opening is homologous to the circular chymiferous tube of the naked-eyed Medusæ. — *e e e* Radiating partitions. — *f f* Bunches of eggs hanging from the inner margin of the radiating partitions. — *g* One of the largest radiating partitions, to which the digestive sac is attached. — *o* Tentacles. — *s* Digestive sac.

this body wall, and not the mouth, which is surrounded by radiating appendages outside of the central opening.

This comparison is in itself sufficient to show, that, while every part in a Medusa is homologous to every part in an Actinia, these homologies are only general homologies; that is, indications that these two animals belong to the same branch of the animal kingdom, but that special homologies cannot be traced between them. The body of the Actinia has a flat disk at the lower end, which, though contiguous with the outer wall, differs from it so much as to constitute a base of attachment entirely wanting in the Medusa. The upper part of the lateral walls of the Actinia is thinned in a manner which forms a sort of circular neck below the fringes, facilitating the inversion of the whole margin towards the centre in a manner impossible to the Medusa. The central opening of the Actinia is not circumscribed by the margin of the upper part of the walls of the body, but that margin is turned inward; while in the Medusa it hangs free, outward. The radiating hollow spaces are limited in Actinia by radiating partitions, the inner margin of which is free, and suspended vertically in the main cavity; while in the Medusa, what may be compared to the partitions of the Actinia is a continuous gelatinous mass, between which simple tubes are left, communicating only through narrow openings with the central cavity, or in other words, the homologous parts of the Actinia and Medusa exhibit a structure special to each.

We find the same special homologies in all the Actinoid Polyps. They all have a cylindrical body with a central cavity, divided into chambers by radiating partitions, marginal fringes communicating with these chambers, and a digestive cavity hanging free into that cavity below the central opening; while in all Medusæ we find the same continuous gelatinous body with a simple central cavity and radiating tubes, and a margin of the central opening turned outward. Now, if the classes of each branch of the animal kingdom, as has been shown in the first volume of this work, are natural divisions exhibiting the same plan of structure, but built respectively in different ways and with different means, we have, in Actinia and in Medusa, the types of two distinct classes; and it only remains for us to examine what are the natural limits of these classes, and what different kinds of animals belong to each. I hold, however, that the preceding remarks are in themselves sufficient to show that it is an exaggeration of their affinities to unite, as Leuckart has done, and as most German naturalists now do, the Polyps and Acalephs in one and the same great division under the name of Cælenterata.[1]

[1] Leuckart (R.), Ueber die Morphologie, und die Verwandtschafts-Verhältnisse der wirbellosen Thiere, Braunschweig, 1848, 8vo. p. 13. Full of original investigations and suggestions.

SECTION II.

THE DIFFERENT ANIMALS REFERRED TO THE TYPE OF RADIATA.

I shall presently show that all the true Polyps and all the true Acalephs may naturally be grouped with the two characteristic representatives of their respective classes, alluded to in the preceding section; and that, in connection with the Echinoderms, they constitute one of the four great types of the animal kingdom, characterized by a peculiar plan of their structure, founded upon the idea of radiation; and that the anatomical differences exhibited by the Echinoderms do not justify us in considering them as a distinct type.[1] The latter are, in reality, only another class of Radiata, as a comparison of any of the flat Echinoids, such as the Echinarrachnius, with an ordinary Medusa, say the Aurelia, readily shows; Echinus being, as it were, a Medusa, the soft disk of which is charged with limestone particles. But before proceeding to demonstrate these propositions, it is proper to take a glance singly at all the different beings which, at different times, have been associated with or removed from the Radiata.

Whether considered as a distinct type, or simply as a class of the Radiata, the Echinoderms, as a natural group, are now very generally circumscribed within the same limits by all naturalists. The question, long agitated among zoölogists, whether the Sipunculoids should be associated with the true Echinoderms or referred to the class of Worms, has finally been settled in favor of their complete removal, by the investigations of the late lamented J. Müller.[2] We may henceforth consider as Echinoderms all the radiated animals provided with an ambulacral system, and need not for the present enter into a farther consideration of their structure and general affinities, but leave them out of consideration until we attempt to trace the general homologies, which, in connection with their mode of development, bind these animals indissolubly with the Acalephs and Polyps as a separate class of the type of Radiata.

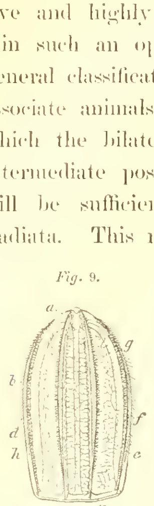
The natural limits of the class of Acalephs cannot be considered as settled,

[1] The separation of the Echinoderms from the other Radiates, as a distinct type, was first proposed by Leuckart in the work quoted on the preceding page. This distinction has been adopted by Kölliker, and by Gegenbauer in his recent excellent text-book of Comparative Anatomy. To me, however, such a division of the Radiates into two types seems unjustifiable, since the consideration of the complication of their structure is surely a feature subordinate to the idea of their plan of structure; and the mode of execution of a plan should not be confounded with the plan itself.

[2] Ueber den Bau der Echinodermen, Ak. d. Wiss. Berlin, 1854.

since Quoy[1] and Vogt[2] would remove the Beroids not only from that class, but even from the type of Radiata, and refer them to the lower Mollusks in the vicinity of the Ascidians. It seems hardly credible, that the author of an extensive and highly valuable monograph upon the swimming Ascidians[3] should entertain such an opinion. Every idea of typical plans of structure, as a guide in the general classification of the animal kingdom, must be given up by those who would associate animals that are so distinctly radiated as the Ctenophoræ with others in which the bilateral type is so evident as in the Tunicata, and place them in an intermediate position between the latter and the Bryozoa. A general comparison will be sufficient to show that the Ctenophoræ or Beroid Medusæ are truly Radiata. This may best be seen in our Idyia (*Fig.* 9), where the central mouth, surrounded by a circular tube, leads into a vast digestive cavity, above which arise two horizontal tubes, each dividing into four branches. These branches follow the surface of the cylindrical, slightly compressed walls of the animal, and unite again with the circular tube encircling the mouth. On the outer surface of the body extend eight vertical rows of flappers, whose upper ends converge to a central knob at the summit of the animal. The rows of flappers, the hollow tubes, the central mouth, the rosette at the summit, every essential feature in the structure of these animals, is as strictly radiated as in any other Radiata in which indications of a bilateral arrangement are subordinate to the general plan of radiation.

Fig. 9.



Idyia roseola, Ag.

Anal opening. — *b* Lateral radiating tube. — *c* Circular tube. — *d e f h* Vertical rows of locomotive fringes. — *g* The locomotive fringes seen in profile.

These subordinate features in the genus Idyia consist of two additional radiating tubes along the sides of the animal, in the flattening of the digestive cavity which exists also in all the Polyps, and in the eccentric position of the double anus. This eccentricity of the terminal end of the alimentary canal occurs, however, in the majority of Echinoderms, as well as in the Ctenophoræ, only that in Echinoderms the anus is simple. But the Ctenophoræ are not only radiated; they, in fact, are radiated after the fashion of the other Acalephs, and ought to remain associated with the common Medusæ, as they have been ever since Cuvier distinguished these animals as a class.

The special homologies of the Ctenophoræ and true Medusæ are most striking. A comparison with Aurelia will at once show this. From the main cavity arise,

[1] Quoy et Gaimard, Voyage de l'Astrolabe, Zoologie, vol. 4, p. 36.

[2] Vogt (C.), Zoologische Briefe, Frankfurt a. M., 1851, vol. 1, p. 254.

[3] Vogt (C.), Recherches sur les animaux inférieurs de la Méditerranée; 2d. Mémoire, sur les Tuniciers nageants de la mer de Nice, Mém. de l'Institut national genevois, Genève, 1854, vol. 2.

in opposite directions, two main stems of the chymiferous tubes. Each of these divides into two forks, which in their turn are subdivided again, so that each stem ends in four branches opening into four vertical tubes, extending without farther ramifications to the lower margin of the animal; and all this with only such differences in the number of branches as occur between different genera among genuine Medusæ. We have even in Idyia, in the two simple tubes that follow the flattened sides, a close resemblance to the arrangement prevailing in Aurelia, where straight, simple tubes alternate with those that are subdivided.

These facts may be sufficient to show that the Ctenophoræ cannot be separated from the ordinary bell-shaped Medusæ; yet when we come to examine the characteristics of the orders in the class of Acalephs, we shall trace those homologies farther, and also show how the structure of all the Ctenophoræ, even of those differing most from the type of Idyia, such as Cestum, Lesueuria, Bolina, and Pleurobrachia, is strictly homologous to that of Idyia in all their peculiarities.

Among the Discophoræ there exists also a great diversity; and I shall compare closely all their different types, when examining the natural limits of that order. Suffice it to say here, that the Rhizostomes, which have been represented as widely differing from the others in the structure of their mouth, differ only in so far that the edges of the four pendent branches of the central peduncle — which are free for their whole length in Aurelia, Chrysaora, Pelagia, and Cyanea, and form four channels leading to a central opening, the so-called mouth, that opens into the main cavity — are soldered together for their whole length in Rhizostoma, Cephea, and Cassiopeia, leaving only here and there small openings between their folds, through which a less bulky food passes in the same way as in the common Medusæ, along the channels thus formed, into the main cavity of the body. The homology is perfect, the only difference being that the edges of these four appendages coalesce, instead of remaining open. (See Pl. XIII. and XIV.)

Before the mode of reproduction of the so called naked-eyed Medusæ was known as it now is, no question could be raised as to their affinity; and they were simply referred to the order of Discophoræ. But since many of them have been ascertained to arise from buds formed upon the stem, or between the tentacles, of the crown of the so-called Hydroid Polyps, the question now is, whether their association with the ordinary Discophoræ in one and the same order is true to nature or not; and further, what should be the position in a natural system of the Hydroids themselves, which, before these discoveries, were unhesitatingly associated with the ordinary Polyps. Does this show that genuine Polyps produce genuine Medusæ, to be considered as distinct animals; or that the Hydroids, with their respective Medusæ, are only alternate modes of existence of the same being? Or does it follow from these facts, that the classes of Polyps and Medusæ must be united into one? That there is a considerable difference between the Medusæ arising as buds from Hydroids and the other Discophoræ appears plainly from the fact, that Eschscholtz has already separated them into two groups, calling the former Discophoræ Cryptocarpæ, and the latter Discophoræ Phanerocarpæ; while Forbes, grouping them in a similar manner, calls the former Gymnophthalmata and the latter Steganophthalmata, and Gegenbauer, Craspedota and Acraspeda. This distinction, it is true, is mainly founded upon differences in the structure of the ovaries and spermaries, of the eye-specks of the margin of the disc, and of the radiating tubes, which are much fewer in the naked-eyed Medusæ, and generally simple; but now the striking peculiarity of their mode of reproduction may be added to separate them with more precision.

It is important here to remark, that the so-called Hydro-Medusæ have generative organs only in their Medusa state, and that the Hydroids themselves show no sign of sexuality; for I shall show hereafter that what has been considered as sexual organs in some Hydroids are themselves Medusæ, differing simply from the ordinary naked-eyed Medusæ in not separating from the Hydroid stem upon which they bud. The Hydroids appear, then, as a kind of larval condition of the Hydro-Medusæ; and, in my opinion, can no more be considered as genuine Polyps, than the wormlike larvæ of Insects can be considered as genuine Worms. For, just as by a series of transformations the worm-like young of the Insect pass into the state of perfect Insects, so also are the Hydroids a state of the naked-eyed Medusæ preceding the maturity of the latter, and standing in a definite relation to them, even though that relation be not exactly the same as that which exists between the Insect larva and the perfect Insect. The Hydroids are no more a distinct group of animals than the larvæ of Insects, and while they bear a certain resemblance to Polyps, they can no more be united with the Polyps than the larvæ of Insects with the Worms, except in as far as they belong to the same branch; for the Worms, as a class, stand in the same relation to the Crustacea and Insects as the Polyps to the Acalephs and Echinoderms. The structural peculiarities that essentially distinguish the Insects from the Worms appear already in their larvæ, which are provided with tracheæ as well as the perfect Insects. And so also is the structure of the Hydroids a Medusa structure (*Fig.* 10), and not a Polyp structure. The margin of the mouth spreads outward, and is not inverted to form a digestive cavity distinct from the main cavity of the body. Moreover, the main cavity of the body in the Hydroid has no radiating partitions, as that of the Polyps has; and this is true of all Hydroids without exception. Those from which the Medusæ

Fig. 10.

Campanularia, expanded.

a Axis of the body. — *b* Calyx. — *c* and *d* Digestive cavity. — *o* Mouth. — *t t t* Tentacles.

buds are not freed have no more the special structure of the Polyps described above, than those which produce free Medusæ.

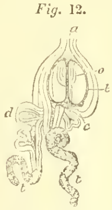
Whether we consider their special structure or their genetic relation to certain Medusæ, the Hydroids must be associated in close connection with the Medusæ proper; while their peculiar mode of reproduction, and the greater simplicity of their structure when compared to that of the covered-eyed Medusæ, show that they form a distinct group in that class. This will be still more evident, should I succeed in showing that all Hydroids produce, in the same way, Medusæ buds; even though these Medusæ do not in all of them separate from the mother stem to lead an independent life. The family of Tubulariæ is most interesting in that respect, because, while they all agree in their Hydroid state, there are some, among them the genus Hybocodon (*Fig.* 11), for instance, in which the buds (*Fig.* 11 *d d*, and *Fig.* 12), though at first not differing from those of other kinds, become free and lead an independent life as distinct, sexual, naked-eyed Medusæ (*Figs.* 13, 14). In others, such as Tubularia proper, Thamnocnidia, and Parypha, the

Fig. 11.

HYBOCODON PROLIFER, Ag.

a Stem of a single Hydra. — *o* Its mouth surrounded with tentacles. — *t t* Its marginal tentacles. — *d d d* The most advanced of its Medusæ buds.

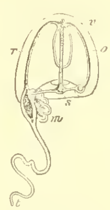
Fig. 12.



Medusa bud of HYBOCODON PROLIFER, Ag.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *c* Circular chymiferous tube. — *b* Radiating chymiferous tube. — *d t* Proliferous Medusa with its single tentacle. — *t* Single tentacle of the primary Medusa. — Near *c* Another small proliferous Medusa-bud, and several others upon the main radiating tube of the proliferous Medusa *d t*, between the letters *d* and *t*; exhibiting a striking analogy to Siphonophoræ.

Fig. 13.

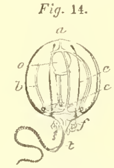


Free Medusa of HYBOCODON PROLIFER, Ag.

The largest vertical tube being seen in profile. At first sight this Medusa resembles much the Steenstruppia of Forbes; yet it differs generically.

v Proboscis. — *r o* Radiating tubes. — *s* Circular tube. — *t* Tentacle. — *m* Buds of Medusæ, proliferous from the base of the single tentacle.

Fig. 14.



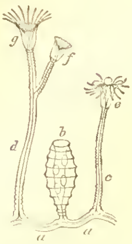
Free Medusa of HYBOCODON PROLIFER, Ag.

Facing the largest chymiferous tube, from the lower end of which hangs the single tentacle, with many small proliferous Medusæ buds.

a Point of attachment before its separation from the Hydra stock. — *b c* Radiating or vertical chymiferous tubes, *c* pointing to the circular tube. — *t* Tentacle. — *f* Bunch of proliferous Medusæ buds. — *e* Rows of epithelial cells forming distinct bands at the surface. — *o* Proboscis.

Medusæ buds produce new Hydroids without freeing themselves; and yet these Medusæ buds show all the characteristic features of genuine naked-eyed Medusæ. In Tubularia proper, for instance (Vol. 4, Pl. XXIV. and XXVI., figs. 3 and 4), they have four radiating tubes with a pendent proboscis and a circular tube, but hardly a trace of tentacles; while in other genera these characters are variously combined. Thaumocnidia (Vol. 4, Pl. XXII.) has four distinct tentacles and a large proboscis, but neither radiating nor circular tubes. Parypha (Vol. 4, Pl. XXIII.) also has tentacles, but of a very different form, and a large proboscis, but no chymiferous tubes.

Fig. 15.

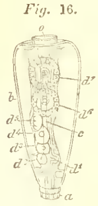


Trochopyxis, Ag.
New genus of Campanulariæ.

a a Common basis of the community. — *b* Fertile Hydra. — *c d* Stems of sterile Hydræ. — *e g* Sterile Hydræ expanded. — *f* Secondary sterile Hydra bud.

In the family of Campanulariæ, the Hydroids seem to differ greatly from the Tubulariæ, the stem being horny, and the bell-shaped animal surrounded by a horny bell; but a microscopic examination of the surface of the stem, and even of the bell, of all Hydroids, shows that the only difference in the outer layer of the animal consists in the thickness of that hyaline layer which in Campanularia and Sertularia becomes so firm as to assume permanent forms and to be visible to the naked eye as a sort of horny sheath enclosing all the soft parts, while in Tubularia it is soft and flexible. This once understood, the difference between a Campanularia (*Fig.* 15) and a Tubularia head is only such as we should expect between members of different families, — they differ in form only. Yet there is another distinction to be made among them. The individuals of the same community, united upon the same stem but arising from different axes, exhibit marked differences among themselves: the larger number, which have all the same form, remain for ever sterile (*Fig.* 15, *c d*), while others, of a different form, produce buds along their internal proboscis (*Fig.* 16 d^1, d^2, d^3, d^4, d^5, d^6, d^7), which in due time free themselves and swim off as distinct Medusæ (*Fig.* 17). This is, for instance, the case with Thaumantias and Tiaropsis, which are only the free Medusæ of different genera of Campanularians. The same is the case, again, with the Sertularians (*Fig.* 18), which produce other kinds of free Medusæ.

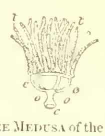
Fig. 16.



Fertile Hydra of Campanularia.

a Base of attachment. — *b* Calyx. — *c* Digestive tube. — *o* Mouth. — d^1 d^2 d^3 d^4 d^5 d^6 d^7 Medusæ buds successively older. I have frequently seen these buds freeing themselves and assuming the form of *Fig.* 17.

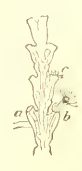
Fig. 17.



Free Medusa of the Campanularia represented in *Fig.* 16. It is represented here with the margin of the disc and the tentacles raised, while the proboscis is pendent. Its adult state is described in the Contributions to the Nat. Hist. of the Acalephs, under the name of Thaumantias.

c Mouth and proboscis. — *o o* Radiating chymiferous tubes. — *e e* Eyes. — *t t* Tentacles.

Fig. 18.



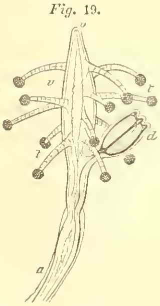
Dynamena Fabricii, Ag.
One of the most common Sertularian Hydroids of our coast.

a b c Single individuals; that occupying the cell *b* is entirely, and that in cell *c* partly, expanded.

With these facts before us, there can be no doubt left in the mind of any unprejudiced observer, that, even though the Hydroids from which arise many of the naked-eyed Medusæ thus far described have not yet been ascertained, and though many Hydroids are known the Medusæ of which have not yet been identified, enough is clearly understood of the relations of Hydroids and naked-eyed Medusæ to show that there is a genetic connection between them all, and such an identity in the essential structure of the Hydroids on one side and the naked-eyed Medusæ on the other, that the view which represents the Hydroids as true Polyps must be for ever banished from our science. This would be none the less true even should it appear that the genuine Polyps form part of a larger division, embracing also the Hydroids with the naked-eyed Medusæ; for such a comprehensive division would still have to be subdivided into secondary groups, no one of which could include at the same time true Polyps and Hydroids, without conflicting with their natural affinities.

A few more words upon the Sertularians and Campanularians and their free Medusæ will set this matter at rest. A sterile head of Campanularia (*Fig.* 10, and 15 *c d*), which is so strictly homologous to Sertularia or Dynamena (*Fig.* 18) that a comparison between the two is superfluous, shows a bell-shaped body, in every respect identical with that of a Tubularia or Hybocodon (*Fig.* 11). It has a row of feelers around its margin like the latter, only the feelers are more active, and capable of being drawn in more completely. The floor stretched across the wider part of the bell is open in the centre, where we find the oral aperture. The only difference in these parts between Campanularia and Tubularia is, that the centre of this floor rises, in Tubularia, in the shape of a proboscis, while in Campanularia it may only be raised to a small extent, but is at the same time capable

Fig. 19.

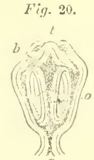


Coryne mirabilis, Ag.

Hydra with a Medusa bud. The buds when freed become Sarsiæ. See fig. 21.

a Stem of the Hydra. — *v* Its club-shaped body. — *o* Its mouth. — *t t* Tentacles scattered over the body. — *d* Medusa bud.

Fig. 20.

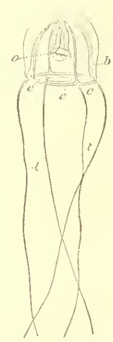


Medusa bud of Coryne mirabilis, Ag.

The bud represented here separately, with its base of attachment *a* cut through, is younger than that represented in its natural connection in fig. 19 *d*. The free Medusa is represented *Fig.* 21, and described as *Sarsia mirabilis* in the Contributions to the Nat. Hist. of the Acalephs.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *b* Radiating chymiferous tubes. — *t* Tentacles.

Fig. 21.



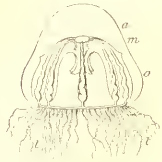
The free Medusa, Sarsia, of Coryne mirabilis, Ag.

o Proboscis. — *b* Vertical chymiferous tube. — *c* Circular tube. — *e e* Diaphragm. — *t t* Tentacles.

of greater expansion and contraction. There is in that respect no greater difference between Campanularia and Tubularia as Hydroids, than between Sarsia (*Figs.* 19 *d*, 20, and 21) or Hybocodon (*Figs.* 12, 13, and 14) as naked-eyed Medusæ and

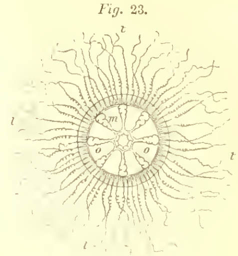
Thaumantias (*Fig.* 17) or Melicertum (*Figs.* 22, and 23), which are respectively the free Medusæ of a Coryne (*Fig.* 19), a Tubularian (*Fig.* 11), a Campanularian (*Figs.* 10 and 16), and a Sertularian (*Fig.* 18). And if we compare the Coryne with the Tubularia, the only essential difference we notice is, that while in Tubularia the feelers are arranged in a whorl around the base of the proboscis, in Coryna they are scattered all over the proboscis.

Fig. 22.



Medusa campanula, Fabr.
(A species of Melicertum *Oken*, seen in profile.)
The free Medusa of a very common Sertularian Hydroid of the North American coast.
t Tentacles. — *o* Ovaries, along the vertical chymiferous tubes. — *m* Mouth. — *a* Disc.

Fig. 23.



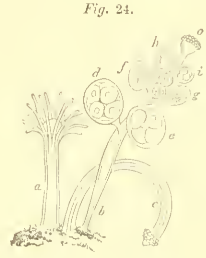
Medusa campanula, Fabr.
(A species of Melicertum *Oken*, seen from above.)
The free Medusa of a very common Sertularian Hydroid of the Atlantic coast of North America.
m Mouth. — *o o* Ovaries along the vertical chymiferous tubes. — *t t t* Tentacles.

There is only one more group of animals that has been associated with the Medusæ. I mean the *Acalèphes hydrostatiques* of Cuvier, called *Siphonophoræ* by Eschscholtz and the more recent writers. From the time they became first known through the descriptions of Forskål and the splendid illustrations of LeSueur, they have always been considered as allied to the Medusæ, until recently Kölliker has associated them with the Polyps under the name of swimming Polyps, *Polypi Nechalei.* An opinion expressed without hesitation by so eminent an investigator as Kölliker requires the most careful examination. To arrive at a satisfactory result on this critical point, it is necessary, in the first place, to consider the fact, that the so called swimming Polyps, the Siphonophoræ of most authors, are compound animals, — that is to say, communities of individuals organically connected in a manner similar to the community that exists between the numerous individuals of a Coral stock or of a Hydroid stock. But this is not all. The individuals so connected in these communities have no more the same appearance than those of the communities formed by certain Hydroids; and that we may be the better prepared to appreciate the extraordinary extent to which different individuals of the same community may differ in a stock of so called swimming Polyps, it may be well to consider beforehand the extent of the differences we observe between the individuals of similar stocks among genuine Polyps, as well as among Hydroids.

In a Polyp community the rule is, that all the individuals of the same stock resemble one another in every respect, differing slightly in size, and, it may be, as in the confluent species, in the number of mouths, circumscribed by a continuous series of tentacles, as for instance in Mæandrina, Diploria, Gyrophyllia, Manicina, etc. In some of the Madrepores, however, and especially in those which produce numerous distinct branches, there is a greater difference, each branch terminating with a larger Polyp, which is perfectly symmetrical; while the individuals which stand upon the sides of the branches are not only smaller but at the same time one-sided, the broader and more prominent side being turned outward, and the tentacles on that side being also larger than those turned toward the common axis.

Among the Hydroids, as among the Polyps, we find those in which the communities are formed by identical individuals differing, perhaps slightly, in size. This is the case in the families to which the genera Tubularia (Vol. IV., Pl. XXIV.) and Coryne (Pl. XVII., XVIII., and XIX.) belong. But there are others, in which we find, either constantly or at least at certain seasons, two kinds of individuals, differing not only in size, but also in form, and still farther in the presence or absence of tentacles, one kind being always sterile, while the other produces Medusæ buds that may be freed. This is the case with the Campanularians (*Figs.* 10, 15, 16, and 17) and the Sertularians (*Figs.* 18, 22, and 23). In the Plumularians, the differences are still more marked; for besides the fertile individuals there are several kinds of sterile individuals, grouped together in various clusters, the smaller ones being attached around the large ones. Finally, there is a genus—Hydractinia (*Figs.* 24 and 25)—which, among the Hydroids, exhibits the greatest range of difference thus far observed between the individuals of the same species. For in this genus we have, in the first place, two kinds of communities: one (*Fig.* 25) in which the fertile individuals produce only male Medusæ, and another (*Fig.* 24) in which the fertile individuals produce only female Medusæ. Again, the fertile individuals in both kinds of communities have tentacles (*Figs.* 24 *o* and 25 *b*, *o*) entirely different from those of the sterile individuals. The sterile individuals (*Figs.* 24 *a* and 25 *a*) differ also greatly among themselves, some being slender and almost thread-like; others slender, but with a distinct proboscis and a whorl of tentacles; others short, widening greatly upward, and assuming almost the form of a trumpet-mouth. All these individuals differ not only in their form and complication, but also in their color, so that we have in this genus about as great a diversity of individuals in one community, as is observed in the most complicated Siphonophoræ. The only difference between the two groups consists in this: that while all

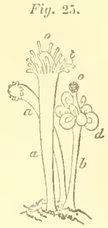
Fig. 24.



HYDRACTINIA POLYCLINA, Ag.

a Sterile individual. — *b* Fertile individual producing female Medusæ. — *d e* Female Medusæ containing advanced eggs. — *f g h i* Cluster of female Medusæ with less advanced eggs. — *o* Peduncle of the mouth with short globular teutacles. — *c* Individuals with globular tentacles, upon which no Medusæ have as yet appeared, or from which they have already dropped.

Fig. 25.



HYDRACTINIA POLYCLINA, Ag.

a a Sterile individuals. — *b* Fertile individual, producing male Medusæ. — *d* Clusters of male Medusæ. — *o o* Proboscis, with the mouth at the apex. — *t* Elongated tentacles of the sterile individuals; in the fertile one *b*, they are simple kuobs upon the proboscis *o*.

compound communities of Hydroids are attached to the ground, those of Siphonophoræ are free; but this is not a character exclusively peculiar to them, for among the Polyps we have also free communities belonging to the same order as others that are immovably attached to the ground. Such are the genera Renilla, Pennatula, Virgularia, Veretillum, etc., which are inseparable from the genera Gorgonia, Alcyonium, Xenia, Tubipora, etc., or at least belong to one and the same order. In these locomotive Halcyonoids the individual Polyps are identical among themselves, but grouped together in the most diversified ways, varying in that respect quite as much among themselves as the fixed Halcyonoids. In Pennatula and Virgularia they form regular rows upon the two sides of a feather-like stem, in Veretillum they are scattered around a cylindrical stem, in Renilla they are arranged in symmetrical lines upon the surface of a kidney-shaped disk. And yet these communities move and act as one individual. I have frequently seen Renilla, which is our only genus of free Halcyonoid Polyps, move slowly about in the sand, its stem buried in a vertical position with the disk spread horizontally.

Now, if I have succeeded in showing that, by their structure, the so-called Hydroid Polyps are not Polyps, but Acalephs, and if I should also succeed in showing that the different kinds of individuals forming the communities of Siphonophoræ have the same structure as the Hydroids, and present everywhere, in all their parts, special homologies with the Hydroid Polyps and naked-eyed Medusæ, without even exhibiting one of the peculiar characteristics which distinguish the true Polyps from the Hydroids, I should then have proved that the Siphonophoræ are really Hydroid Acalephs, and not Polyps, as Kölliker believes them to be. The evidence thus adduced would be an additional reason for keeping the true Polyps, the so-called Anthozoa, by themselves, in a distinct class.

Fig. 26.

PHYSALIA ARETHUSA, Til.

a Blunt end of the air sac, supporting the whole community, at which the youngest buds may be found. — *b* Open end of the air sac. — *c* Crest of the air sac. — *m* Bunches of single individuals. — *n* Tentacle contracted. — *t t* Tentacles of the largest kind extended.

Let us therefore compare more in detail the different kinds of Siphonophoræ with the different kinds of Hydroids and naked-eyed Medusæ. Beginning with Physalia (*Fig.* 26), it is not difficult to perceive that the various kinds of appendages which hang from the floating air-bag of that animal may be compared to the heterogeneous individuals of an inverted Hydractinia. Fancy the channelled layer which forms the attached base of Hydractinia to be swollen into a large oblong bag, and the comparison may be carried even into the details; for the essential difference between these two genera does not so much consist in a difference of the individuals forming these communities, as in the form of the basis to which the individuals are attached. In Physalia that basis is a sac, inverted upon itself, the inner bag of which, opening externally, is filled with air; the intervening cavity, communicating with the open bases of the pendent individuals, contains a greater or less quantity of fluid. Now, suppose the air-bag to be turned inside out, there would be formed a large and simple hose, containing liquid that may be pressed into the individuals attached to it, or to which the individuals may add by pouring their fluid contents into the bag. In Hydractinia, the narrow anastomozing tubes, in the basis of attachment of the polymorphous individuals of the community, may be compared to this hose of the Physalia, only that they are branching. But as a number of individuals arise from each of these stems, we may just as well consider their basis as a single tube; and then the only difference between Hydractinia and Physalia would be the narrowness of the tube of the former, and the great width of that of the latter. But reduce the diameter of the one or swell the cavity of the other, and all difference disappears, especially if we suppose them both floating or both attached. It may be that the crest of the Physalia, with its many chambers, carries the homology with the anastomozing tubes of the Hydractinia still farther.

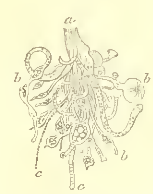
As to the various kinds of individuals forming these communities, we find first in Physalia the numerous so-called suckers, or Polyps (*Figs.* 27 *b b* and 28 *b b*), corresponding to the larger trumpet-like individuals of the Hydractinia community (Pl. XVI. *Fig.* 1 *a*, 1 *d*). These suckers, very numerous, and also much diversified among themselves, are genuine Hydroids. I have seen them feeding greedily upon small fishes, and gorging themselves to such a degree that the silvery scales of their prey could be distinctly seen through their distended walls. But these so-called "Polyps" have nothing of the polyp structure about them, neither radiating partitions dividing their internal cavity, nor tentacles opening directly into radiating chambers, nor an inverted sac hanging in that cavity; on the contrary, the edge of their oral opening is turned outward as in all Hydroids. They are, in fact, Hydroids of the simpler kind, but not so simple as some of the individuals of the Hydractinia communities; for though they have no whorl of tentacles around their mouth, they have at least one very long and very complicated tentacle. Of these tentacles there are two kinds,—larger ones connected

Fig. 27.

Bunch of single Hydræ and clusters of Medusæ of PHYSALIA ARETHUSA, Til.

b b The Hydræ, with their tentacles *c c*. — *d d* The bunches of Medusæ.

Fig. 28.



Bunch of Hydræ of PHYSALIA ARETHUSA, Til.

In various states of contraction and expansion.

a The hollow base of attachment of the whole bunch, communicating freely with the chymiferous cavity of the air sac. — *b b b* Single Hydræ. — *c c* Tentacles with the larger so-called Polyps, and smaller ones connected with the smaller individuals (*Fig.* 28 *c c*). These two kinds of individuals seem to be always distinct, and some of them never even gape at their outer end. The individuals of these two kinds form large clusters, small communities as it were, connected with the larger community. There is a third kind of individuals, smaller than either (*Fig.* 27 *d d*), which are fertile, and upon the neck of which arise numerous Medusæ buds, presenting all the characters of the naked-eyed Medusæ; that is, having, like them, four radiating tubes and a circular tube (*Fig.* 29 *d d*). These Medusæ form clusters so similar to the bunches of Medusæ that hang from the genuine Tubularia, that they might easily be mistaken one for the other (*Fig.* 30). (Compare Pl. XXIV. fig. 1 with *Fig.* 29.) Here, then, is a Siphonophorous community, in every respect similar to a Hydroid community, consisting of various kinds of Hydroids, from some of which are produced Medusæ buds, as in ordinary Hydroids. The fact that in Physalia these Medusæ buds do not separate from the community but wither upon the stock from which they arise, is not peculiar to this group of animals; since we have already seen, that, in the family of Tubulariæ, we have those that produce free Medusæ, the genus Hybocodon and others, the genera Tubularia (*Fig.* 30), Thamnocnidia, and Parypha, the Medusæ of which do not separate from their parent stock. These facts are in themselves sufficient to show that the Physalia community does not consist of aggregated Polyps, but of aggregated Hydroids; and that in a natural classification they cannot be referred to any other order than the Hydroids, though in that order they constitute a distinct family.

Fig. 29.

Bunch of Medusæ of Physalia Arethusa, Til.

In various stages of development.

a Common hollow base of attachment of the whole bunch, communicating with the chymiferous cavity of the air sac. — *b* So-called Polyp, or sucker. — *d d d d* The Medusæ buds.

Fig. 30.

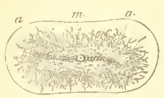
Bunch of Medusæ of Tubularia Couthouyi, Ag.

a Common axis. — *d d d* Mature Medusæ, already withering.

The idea of considering the Medusæ buds of these communities as the sexual organs of the Hydroids is not admissible; for we have seen that these buds may become independent and free, and that in due time they acquire themselves distinct sexual organs, some individuals being provided with ovaries the eggs of which undergo all the changes through which ordinary eggs pass until new individuals are formed in them, while other individuals are provided with spermaries which at the time of spawning are filled with spermatic particles. Now, unless sexual organs can themselves have distinct sexual parts of both sexes, all these so-called sexual organs of the Hydroids must be considered as naked-eyed Medusæ, which are not freed from their parent stock as is the case with others.

Velella and Porpita consist of compound communities like Physalia, only that here the diversity of the Hydroids attached to a common base is not so great, there being, in fact, only two kinds of individuals: the sterile ones, among which that occupying the centre of the community is larger than the others, like the top animal of the Madrepores, and around it, clustered together, a large number of smaller ones; and outside, the large fertile individuals (*Fig.* 32) from which Medusæ buds arise that become free, and are very similar to the common Oceania among the naked-eyed Medusæ. This, at least, is the case in Velella (*Figs.* 31 and 32), as I shall show hereafter more fully. Meanwhile the wood-cut below (*Fig.* 33) represents an Oceania-like Medusa that freed itself, with many others, from the larger fertile individuals of the common Velella of the Gulf of Mexico, represented in *Fig.* 31. The individuals forming the communities known as Velella and Porpita have no more the structure of Polyps than those of the Physalia. They are genuine Hydroids.

Fig. 31.

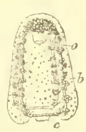


Velella mutica, Bosc.
m So-called mouth — *a a* So-called tentacles.

Fig. 32.

Single so-called tentacle of Velella mutica, Bosc, Bearing Medusæ buds *d d*. — *a* Base of attachment.— *b* Blunt end of the tentacle.

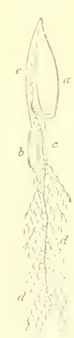
Fig. 33.



Free Medusa of Velella mutica, Bosc.
o Proboscis. — *b* Radiating chymiferous tube. — *c* Circular tube.

If from these we pass to the Diphyidæ, we notice a long string of heterogeneous individuals suspended from one or two larger elongated, bell-shaped individuals, commonly called the swimming-bells, and generally considered as organs destined to move the whole community (*Figs.* 34 and 35). But I believe that this view is not correct, but that, on the contrary, these so-called swimming-bells are themselves distinct individuals of one kind connected with smaller individuals of other kinds, forming together a community composed of very heterogeneous elements. The invaluable investigations of Gegenbauer upon the development of Diphyes seem to me to leave no doubt upon this point; for he has observed the whole development of the egg of one of these animals, showing that the process of segmentation of the egg terminates in the formation of one of these so-called swimming-bells. Now, the product of the egg, whatever it may be, cannot be a mere organ. It is unquestionably a young animal; and that animal, as represented by Gegenbauer, is a genuine naked-eyed Medusa. It has the four characteristic radiating tubes, a circular

Fig. 34.



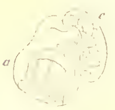
Diphyes Sieboldii, Köll.
(*Copied from Kolliker.*)
a b Anterior and posterior swimming-bells. — *e* Base of the axis of the community. — *c* Main axis of the community, with young buds. — *d d* Fully developed buds, with their feelers.

Fig. 35.

Galeolaria filiformis, Leuck.
Diphyes quadrivalvis, Gegenb.
(*Copied from Gegenbauer.*)
a b Anterior and posterior swimming-bells. — *c* String of twin individuals. — *d* Feelers with lasso cells. — *e* Cæcal termination or base of the connecting tube or axis.

tube, and even the inverted rim of the margin of the bell so constant in naked-eyed Medusæ (*Fig.* 36); and though no mouth is described, I can hardly suppose that it is wanting. The radiating tubes imply the circulation of a fluid, and that fluid is in all naked-eyed Medusæ derived from the surrounding medium, and introduced either through a proboscis or through a cruciate opening in the centre leading into the radiating tubes. The fact that in Staurophora[1] I have found an immense mouth where none was suspected, leads me to suppose that this young Diphyes and the so-called swimming-bells of the Siphonophoræ generally, must have such an oral opening, which has probably not been remarked only because such an opening would not be looked for in what was supposed to be a mere organ. Yet, considering the strict homology between the open Polyps, so called, and the closed sacs mixed with them in Physalia, and like them provided with tentacles, it may be that the swimming-bells are not open externally, and only communicate with the main axis.

Fig. 36.



Embryo of DIPHYES SIEBOLDII, Köll.
(*Copied from Gegenbauer.*)
c Remnant of the embryonal body. — *a* Swimming-bell developed from the embryonal body.

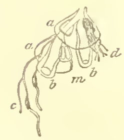
Be this as it may, the swimming-bells of the Diphyidæ cannot be compared to the swimming-bag of the Physalia, which, as we have seen, is the common base of all the Hydroids of that community; nor is it homologous to the so-called swimming apparatus of the Physophoridæ. The only part in these different communities really identical in all Siphonophoræ is the canal marked *c* in *Figs.* 34 and 35, along which hang the heterogeneous individuals of the community in Diphyidæ, Physophoridæ, and Physalidæ; in the same manner as the many individuals of the common Hydroids are attached to their hollow axis. In Diphyes proper there exist, generally, two so-called swimming-bells of nearly the same size, though occasionally but one is observed, and in others the lower one appears sometimes so much smaller than the upper one, that, taking these facts in connection with the facts observed by Gegenbauer respecting the origin of the first swimming-bell from an egg, it is natural to infer that the second swimming-bell arises from the main tube of the first, and gradually enlarges to the same size; in the same manner as in the proliferous naked-eyed Medusæ (*Figs.* 12, 13, and 14), in which one of the four radiating tubes becomes the basis of attachment of numerous lateral bells. It is farther to be observed, that the pendent string of Diphyes, with its numerous individuals, is only a continuation of that same tube which connects the two swimming-bells, and that the individuals attached to it arise also as buds from it. But here we perceive a variety of parts which require our special attention.

The individuals described as Polyps, or suckers, in Diphyes, are as it were

[1] AGASSIZ (L.), Contributions to the Natural History of the Acalephs, Part. I. p. 300.

protected by a flattened, scale-like, gelatinous body (*Fig.* 37 *a a*), and between the scale and the Polyp hangs a complicated tentacle, *c d*. These individuals I consider to be identical with the Hydroids of the Physalia, the so-called Polyp representing the proboscis, as we observe it in Coryne and Clava, only that each is provided with a single tentacle and surrounded by a protecting scale. Now, if I am not greatly mistaken, that protecting scale must be considered as a sort of bell, analogous to that of Campanularia, but gelatinous, and split open on one side; and the so-called sexual organs (*Fig.* 37 *m*) of these so-called Polyps are genuine Medusæ buds, with a proboscis, four radiating tubes, and a circular tube, with a diaphragm around the rim, exactly as in naked-eyed Medusæ, producing eggs or spermatic cells upon the proboscis, according to the male or female character of the different individuals, exactly in the same manner as in Sarsia or Hippocrene.

Fig. 37.



Two twin individuals of the pendent string of the community of DIPHYES SIEBOLDII, Köll.
a a The so-called scales. — *b b* The so-called Polyps. — *m* The so-called sexual capsule. — *c* External feeler, with lasso cells. — *d* Feeler contracted.

We have, then, in a Diphyes community, three kinds of individuals.[1] First, one or two, or sometimes three, Medusoid individuals at the base of the stock; secondly, a large number of more Hydroid-like individuals hanging connected with the pendent string, but differing from the common Hydroids in having an open, gelatinous, somewhat Medusoid bell, commonly called scale; and, thirdly, arising from the base of the proboscis of these Hydroids, genuine Medusæ buds that are either male or female, and which can no more be considered as the sexual organs of these so-called Polyps, than those of the types already considered, since they are themselves provided either with an ovary or a spermary.

The Diphyes community presents another peculiarity, highly important with reference to a correct appreciation of the Medusoid character of the genuine Hydroids. In most of these, we find that every individual consists chiefly of a bell-shaped or trumpet-shaped or club-shaped sac, with tentacles around the central opening, or upon its sides or around its base, comparable, indeed, in every respect, to the proboscis of the naked-eyed Medusæ as it exists in Sarsia. But though the body of the individual Hydroids appears more or less bell-shaped, as in Tubularia and still more in Campanularia, yet that bell is not hyaline and gelatinous like the bell of the Medusæ proper, while the so-called scale of the Diphyes is so, thus forming a sort of transition to the so-called swimming-bells, in which the radiating and circular tubes are fully developed, as in ordinary Medusæ, but at the expense of the proboscis, which is wanting. This would at once explain why the

[1] For illustrations of this and the following families I would refer to the papers of Gegenbauer, Huxley, Kölliker, Leuckart, and Vogt, quoted page 27, notes 5, 10, 11, 12, and 13.

Hydroids proper have no radiating tubes, while their Medusæ buds have them fully developed. I suppose the case to be this: That a perfect Medusa has two distinct structural elements, the disk or bell with its radiating tubes, and the proboscis with the mouth, and that in Hydroid communities the different individuals present one or the other of these two elements, singly developed or more or less combined; while their Medusæ buds have always the characteristic features of perfect Medusæ, and are always sexual, whereas the Hydroids are never so, whether the proboscidal or the bell element be the more prominent. If this be true, then the characteristic feature of a Diphyes community consists in the more Medusoid character of some of its Hydroids, while the more numerous individuals resemble the common Hydroids more, and, like those, produce the sexual Medusæ buds. We have already seen, in the family of Tubulariæ (p. 45), analogous combinations of characters; some of the fertile buds of these Hydroids being more Medusoid in their structure than others.

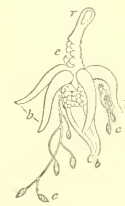
The peculiarities of the genus Abyla (Calpe) seem to confirm this view. We have here also, as in most Diphyes, two so-called swimming-bells, only that the first is much smaller and less Medusa-like than the second, and that the so-called Polyps of the pendent string are not protected by simple scales, but by a cap resembling the first swimming-bell, with this additional peculiarity, that the tentacles are more or less removed from the base of the Polyps.

The genus Praya is very closely allied to the genus Diphyes, but its two swimming-bells are placed side by side, and the pendent string consists of Hydroids with a distinct helm-shaped bell, from which arise the Medusæ buds. This string of twin individuals, one of which is a Hydroid with a helm-shaped bell and another a genuine Medusa, has been described as a string of single individuals, the Medusa buds being considered as their sexual organ, but with as little propriety as in the genuine Diphyidæ, for these buds again are themselves sexual. The so-called single individuals of all Diphyidæ are not single beings, but twins, one of which is Hydroid, and the other Medusoid, in its structure; and these twins drop together and swim about freely as independent individuals.

In the genus Vogtia, the so-called swimming-bells have a quadrangular shape, somewhat like a contracted Staurophora, and though no radiating tubes have been described in them, I doubt not that they will be found when sought for. Below the pyramid of these Medusoid Hydræ, there are a few simple, sucker-like Hydroids, and from the lower part of the axis arise the sexual Medusæ buds, with enormous proboscides, covered either with eggs or spermatic cells, projecting far out of the Medusa bell, as is sometimes the case with those Sarsias that are not detached from their stem. (Pl. XVII. *Figs.* 13, 14, 15, and 16.) In the genera Hippopodius and Elephantopus, which are certainly distinct, though frequently considered as synonyms. the swimming-bells are boat-shaped, and their radiating tubes winding, as in Galeolaria among the Diphyidæ. In the genus Athorybia, the swimming-bells have the shape of arched ribs; and, though no radiating tubes have been described in them, I doubt not that they will be found, unless there exist here, as in Tubularia, various combinations of the more Hydroid or more Medusoid features. In the genus Apolemia, the swimming-bells resemble those of Physophora, and the Hydroids are arranged in clusters, hanging at intervals. along the main axis.

The genus Physophora, with its double row of bottle-shaped swimming-bells, approaches more nearly Hippopodius and Vogtia than Agalmopsis and Forskålia; for the sucker-like Hydræ are few (*Fig.* 38), at the base of the axis, as in Vogtia, and the Medusæ buds form small bunches. In Agalmopsis, on the contrary, there is below the double row of heart-shaped swimming-bells a long string of large Hydroids, provided with protecting scales and furnished with tentacles, and their sexual Medusæ buds form small bunches, suspended at considerable intervals between them. In Forskålia, finally, the more or less quadrangular swimming-bells, arranged in several rows, form a long cone, from which hang two kinds of Hydroids, one protected by, and the other without, scales; and it is from the cluster of the latter that arise the male and female Medusæ buds.

Fig. 38.



YOUNG PHYSOPHORA,
(*Copied from Gegenbauer.*)
e Buds of swimming bells.—*b b* So-called tentacles; lower *b* so called Polyp. — *c c* Feelers with lasso cells. — *r* Air sac.

It is plain, from this rapid survey of the Siphonophoræ, that, with the exception of Physalia, Vellella, and Porpita, which consist of Hydroids only, they all agree in having a set of more or less numerous Medusæ-like Hydroids at the base of their common axis; and that from the prolongation of this axis arise other Hydroids, either altogether resembling the common Hydroids, without a bell, or protected by a scale-like open bell, in a measure intermediate between Medusæ and Hydroids; and that, finally, all produce Medusæ buds. These Medusæ buds mostly wither upon the community, though in some they free themselves in the shape of twin individuals composed of a Hydroid and a Medusa, which have been described as distinct genera, under the names of Eudoxia, Aglaisma, etc.

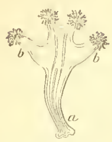
It follows from all this, that while the Siphonophoræ must be united with the Hydroids proper in one order, on account of the identity of their structure and of the similarity in the degree of complication of that structure, the types of this order in which the community consists of more Medusa-like Hydræ, such as the Physophoridæ and Diphyidæ, must constitute a sub-order by themselves; Physalia, another sub-order, on account of the peculiarity of structure of the common base of the community; Velella and Porpita, another, for similar reasons; and the true

Hydroids, a fourth: unless we separate at once the Sertularians with their horny stem and bell as a sub-order, distinct from the Tubularians, with their soft Hydroids, which seems to be the more appropriate course. Diphyidæ and Physophoridæ may require to be subdivided in the same way.

Now that the investigations of Olfers, Leuckart, Quatrefages, and Huxley, have made us as fully acquainted with the structure of Physalia as we are with that of the other Siphonophoræ, it is hardly worth while to recall the opinion of DeBlainville upon these animals, as it is evident from his description, that he could never have entertained such views about them, had he ever had an opportunity of studying them for himself. DeBlainville considered Physalia as a single animal, which he referred to the type of Mollusks in connection with the Heteropod Gasteropods, considering the crest of the bladder of Physalia as its foot, similar to that of these Gasteropods, and the pendent appendages as gill-like organs similar to those of the Dorsibranchiate, while he describes the opening of the bladder as their mouth. But I myself have had repeated opportunities for examining Physalia alive, and this examination has left no doubt on my mind that it constitutes a compound community of a great variety of individuals, presenting all the characters of true Hydroids.

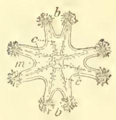
It is important here to remark, that this great discrepancy in the opinions expressed respecting the affinities of these animals was in a measure owing, either to an insufficient acquaintance with their true structure, as was no doubt the case with Blainville when he referred Physalia to the type of Mollusks, and with Vogt when he referred the Ctenophoræ to the same type, or to a want of familiarity with the other objects associated with them, as is no doubt the case with the German authors, who, from a want of opportunity of examining Corals alive, have so generally united the Hydroids and Siphonophoræ with the Polyps. It is a remarkable circumstance, that the naturalists who have known the Polyps best, as Milne-Edwards and Dana, never thought of associating the Siphonophoræ with them, though they were equally acquainted with both, and though we owe to Milne-Edwards in particular, some of the most minute investigations extant upon the Siphonophoræ. As to the Hydroids, though they are associated by Milne-Edwards with the Polyps, he considers them as forming by themselves a natural division in that class, coequal with the Halcyonoids and Actinoids; while Dana goes one step farther in the right direction, by uniting the Halcyonoids and Actinoids in one natural division, to which he opposes the Hydroids as another division of equal value. But even this position Dana has lately abandoned, and he now unites the Hydroids with the true Acalephs; so that it may be truly said, that, in proportion as our knowledge of the Siphonophoræ, the Hydroids, and the Polyps, has gradually advanced, naturalists have perceived more and more distinctly the

Fig. 39.



LUCERNARIA,
Seen in profile.
a Peduncle. — *b b* Tentacular bunches.

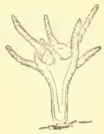
Fig. 40.



LUCERNARIA,
Seen from above.
m Mouth. — *c c* Ovaries. — *b b* Tentacular bunches.

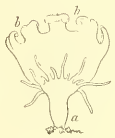
fundamental differences which distinguish the Polyps from the Acalephs, and at the same time incline more and more towards uniting the Hydroids as well as the Siphonophoræ with the genuine Acalephs. Incidentally, I would also remark that I entertain no doubt respecting the Hydroid affinities of Lucernaria (*Figs.* 39 and 40). Moreover, their resemblance to the young Medusæ is very great (*Figs.* 41, 42, and 43), especially during the incipient stage of their Strobila state of development.

Fig. 41.



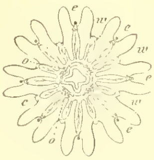
Scyphostoma of
AURELIA FLAVIDULA, Pér. & LeS.
In this stage of growth, Aurelia is simply a Hydroid.

Fig. 42.



Strobila of
AURELIA FLAVIDULA, Pér. & LeS.
a Scyphostoma reproduced at the base of a Strobila *b b*, all the disks of which have dropped off but the last.

Fig. 43.



Ephyra of
AURELIA FLAVIDULA, Pér. & LeS.
c Mouth. — *e e* Eyes. — *o o* Ovaries. — *w w* Tentacular spaces.

The types referred to the class of Polyps are not less diversified than those referred to the class of Acalephs; nor do the different writers upon that subject agree more closely in the views which they entertain respecting their affinities. The type which has always been considered as forming the bulk of the class of Polyps is that of the Corals. The Actiniæ have been by turns associated with them, and separated from them. As we have already seen, the Hydroids have also, for a long time, been united with them by all naturalists, until doubts arose respecting the correctness of this combination, in consequence of the discovery of alternate generations among them. Besides these we find, farther, the Bryozoa united with the Polyps even to this day by many naturalists; though the researches of Milne-Edwards and Audouin,[1] published more than twenty years ago,

[1] EDWARDS (H. MILNE) et AUDOUIN (J. V.), Recherches sur les animaux sans vertèbres faites aux îles Chausey, Ann. Sc. Nat. II. p. 20. — Milne-Edwards alone published more extensive accounts of those observations: Recherches Anatomiques, Physiologiques, et Zoologiques sur les Polypes; Ann. Sc. Nat. 2de sér. 1838, IV. p. 321; 1840, VI. p. 5; 1841, VIII. p. 321; and 1842, IX. p. 193. The opinion that the Bryozoa are not Polyps, but a low type of Mollusks, had already been expressed by K. E. v. Baer, in 1827, in his Beiträge zur Kenntniss der niedern Thiere, Nova Acta Academiæ Naturæ Curiosorum, Vol. XIII.

might have satisfied any unprejudiced investigator that they are not Polyps, nay, not even Radiata, but a kind of low Mollusks.[1]

What are commonly called Corals are communities of individuals possessing a solid frame, but of the most heterogeneous structure, and having no common character except the solidity of their frame. The moment we take into account the anatomical structure of the beings forming such communities, we must distinguish several kinds of Coral stocks. First, those which are uniformly calcareous, formed by genuine Polyps allied to the Actiniæ. In fact these Coral stocks differ from the Actiniæ only by the presence of solid deposits in the walls of their body. Such are the Astræans and Madrepores, all of which have, like the Actiniæ, numerous simple tentacles, and a digestive cavity hanging below the mouth, as well as radiating partitions projecting into the main cavity of the body, and to which the ovaries and spermaries are suspended. Secondly, on account of the similarity in the organization of their individuals, we would unite, as another group of Corals, the various solid stocks formed by Halcyonoid Polyps. Some of them are calcareous, like the Actinoids, the Red Coral, for instance; others are horny, the Gorgoniæ; and others consist of calcareous tubes, such as Tubipora. The Corals of these Halcyonoid Polyps are, it is true, far more diversified than those of the Actinoids, though there seems to be much less difference between the animals themselves than among the latter. They all have eight fringed tentacles, and agree fully in this respect, as well as in their general structure, with those Halcyonoids which have no solid frame at all, as the genera Halcyonium and Renilla, or only a simple horny rod in their axis, as Virgularia and Pennatula.

On account of the special homologies of the Actinoids and Halcyonoids, there can be no doubt that these two types of Polyps belong to one and the same natural group, as Dana has first shown. They all have vertical radiating partitions dividing the main cavity of the body into chambers, which communicate freely with the cavity of the tentacles; in all, the ovaries and spermaries are found hanging freely from the free inner edge of these partitions, and in all there is a distinct digestive sac suspended in the upper part of the main cavity of the body. They are, in one word, strictly homologous to the Actiniæ, the structure of which we have considered more fully above.

Among the Stony Corals generally referred to the Actinoid Polyps there is one

[1] Siebold in his Text-book of Comparative Anatomy, and Kölliker in his Schwimmpolypen, referred to above, (p. 27, note 12,) still unite the Bryozoa with the Polyps. Kölliker is particularly explicit on that point, and believes that the expression by which Mollusks and Radiates may be clearly distinguished has not yet been found. But, surely, *bilateral* animals with an *alimentary canal* open at both extremities and *bent in a plane dividing the body into equal halves* can no longer be associated with Polyps, which are built upon a plan characterized by *radiation around a vertical axis*.

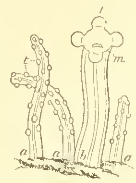
type, belonging to the order of Tabulata of Milne Edwards (*Figs.* 44, 45, and 46), formed by animals entirely different from the true Actinoids, and closely allied, as I shall show hereafter, to the genus Hydractinia, constituting a third type of

Fig. 44.

MILLEPORA ALCICORNIS, Lmk.

A branch of the Coral of that name, natural size. The little projections along the edge are meant for the extended Polyps. They are extremely shy and delicate, and never show themselves again after a branch has once been taken out of the water.

Fig. 45.

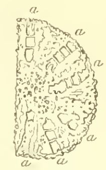


MILLEPORA ALCICORNIS, Lmk.

Magnified view of the extended Polyps or Hydroids of the same Coral stock.

a a Smaller Hydroids. — *b* Larger Hydroid, *m* its mouth, *t* its tentacles.

Fig. 46.



MILLEPORA ALCICORNIS, Lmk.

Transverse section of a branch of the Coral stock, magnified.

a a Pits of the Hydroids, with their successive floors. It is very difficult to obtain sections of the pits occupied by the smaller Hydroids.

Coral stocks, which, on account of its Hydroid affinities, must be united with the class of Acalephs. Moreover, these Corals differ greatly from those of the Actinoid Polyps. The pits into which the animals retreat have a horizontal floor extending from wall to wall, and these floors are built successively one above the other, as the animal rises, the radiating partitions never extending vertically through successive floors. Not so with the Actinoid Polyps, in which the radiating partitions extend from the top to the bottom of the pit, while the horizontal floors, if they exist, extend only from one radiating partition to the other.

Among Bryozoa we find a fourth type of Corals. These Bryozoa are constructed on a totally different plan, and exhibit a perfect bilateral symmetry; for even the whorl of feelers which surrounds the mouth is not circular, but, like a horseshoe, presents two symmetrical halves. From the mouth arises an alimentary canal, extending in the longitudinal axis of the body, which bends itself in the same plane, and, extending again forward, opens below the mouth. There is here no sign of the characteristic partitions and chambers of the true Polyps, nor of the radiating and circular tubes of the true Acalephs: so that we need not even take into consideration their bilateral structure, in order to satisfy ourselves that their true position cannot be either with the Polyps or with the Acalephs; while their relation to the Ascidians and Brachiopods, and especially to the latter, is so close as to place it beyond question now, that their true affinities are with the Mollusks, and not with the Radiates.

I shall hereafter have an opportunity of showing that the comparative simplicity of these animals is no evidence of any relation to the Polyps. The primary question to be decided, in considering the true relations of animals, is not one of complication of structure,[1] which determines the orders in a class, but one of plan, which stands even above the consideration upon which classes are founded, and determines the four great branches into which the whole animal kingdom is divided. As to the Coral stocks formed by Bryozoa, they vary greatly, being calcareous in some, as in Eschara; horny in others, as for instance in Acha-marchis; and in others again, as in Halcyonidium or Holodactylus, altogether gelatinous. Moreover, these Bryozoan Coral stocks never exhibit in the cells occupied by the animals, those radiating lamellæ so characteristic of the Coral stocks of the Actinoids. On the contrary, these cells, into which the animals may withdraw and conceal themselves entirely, are perfectly smooth, and the opening through which the animal is protruded presents uniformly a transverse, oblong, or crescent-shaped aperture, similar to the gaping opening between the valves of a Lingula, or the half-open shells of any other Brachiopod, with which they are much more closely allied than would at first appear. These cells are external, and do not form a part of the body-wall of the animal, as do the radiating pits of the Actinoids. The so-called arms of the Brachiopods are truly homologous to the marginal fringes of the Bryozoa, between the branches of which the mouth is placed in both. It is therefore evident, that, notwithstanding the high authority of some of our best anatomists, the Bryozoa must be removed altogether, not only from the Polyps, but also from the type of Radiata, and referred to that of the Mollusks. The presence of a Coral stock in most of them can no longer have the slightest weight in determining their affinities; since we have already seen that there is a kind of Coral stock, the Millepora, formed by certain Hydroids of the same type as Sertularia and Campanularia, or, rather, closely allied to Hydractinia, which truly belong to the Acalephs; and since, among the genuine Polyps themselves, we find Corals so diversified as those of the Astræans and Madrepores, of Gorgonias and the Red Coral, and of Tubipora. Under these circumstances, it must be self-evident that the name of Corals can no longer be applied to designate a natural group of animals, but only certain modes of association of animals belonging to very different

[1] I have already insisted upon this point in the first volume of this work (p. 143), and in the chapter on Embryological Systems (p. 220). Baer was the first to establish a clear distinction between the degree of perfection in the structure of animals and the plan upon which that structure is built, a distinction which Cuvier had not reached when he allowed the Intestinal Worms to remain among the Radiata on account of the simplicity of their structure. The same confusion remains in the minds of those who consider the Worms as a distinct branch of the animal kingdom, and associate with them the Rotifera and even the Bryozoa. With reference to the Bryozoa and Polyps it is essential to remember, that, though the body in both may be called a sac, in Polyps this sac is a *radiating* sac, while in Bryozoa it is a *bilateral* sac; i. e., the one is built upon one plan and the other upon another plan. In Polyps the fundamental idea is *radiation*, in Bryozoa *bilateral symmetry*.

types. The discovery that the Millepora is a genuine Hydroid, and not at all allied to the Actinoids, makes a farther revision of all these Stony Corals, the animals of which have not yet been sufficiently investigated, particularly desirable. This is especially the case with Pocillopora (Pl. XV. Fig. 14^b), which, from the structure of the Coral stock itself, I am now satisfied, must also be referred to the Hydroids with Millepora.[1] I believe the same also to be the case with Seriatopora (Pl. XV. Figs. 15 and 15^b).

There is a fifth type of Coral stocks, still more remote in its structure from the Polyps, which, as long as all Corals were considered to be Polyps, was, with the rest, referred to that class. I allude to the so-called Corallines and the Nullipores. When referring them to the Polyps, Lamarck assumed that there existed animals of a very soft nature upon their surface; which, however, could not retreat into distinct cells, and therefore left no mark of their existence upon the dried Coral stock. But since these Corallines have been more carefully examined, no trace of such animals has been observed; and, to say the least, their animal nature has become very questionable. For my own part, I entertain no doubt, that, as the investigations of Decaisne[2] first showed, they are neither more nor less than genuine Algæ with a tissue largely loaded with calcareous particles, and may fairly be designated under the name of Limestone Algæ. They are true plants of the lowest type, forming, in consequence of the large amount of lime they contain, Coral stocks of no small importance in the economy of the Coral reefs. It is by their agency, since they are capable of sustaining their life even when not permanently under water, that the crest of the Coral reef is raised above the level of low-water mark; and the growth of some of their representatives is so extensive that the exposed part of a large number of the islands of the Florida reef is almost entirely composed of the fragments of these calcareous sea-weeds. I have seen large slabs of rock, used in the construction of the foundations of Fort Jefferson, upon the Tortugas Islands, composed entirely of the joints of these calcareous sea-weeds, which were so distinct as to be recognized with ease.

[1] As the structure of the Coral stock of the Tabulata of Milne-Edwards presents in all the same general features, it is highly probable that the whole order will have to be referred to the class of Acalephs. I am farther inclined to believe, that the Rugosa will share the same fate. Their typical structure seems to be a combination of the characteristics of Lucernaria and the Strobila state of the higher Discophoræ. A section of Strombodes recalls at once the appearance of a Strobila.

[2] Decaisne (J.), Essais sur une classification des Algues et des Polypes calcifères, Ann. Sc. Nat. 2de sér. 1842, XVII. p. 297. — Mémoire sur les Corallines ou Polypiers calcifères, Ann. Sc. Nat. 2de sér. 1842, XVIII. p. 96. See also Lindley, Vegetable Kingdom, London, 1853, 1 vol. 8vo. p. 23. — Kützing, Phycologia Generalis. — Harvey, a Manual of the British Marine Algæ, London, 1848, p. 103. Schweiger already refers the Corallines to the Algæ.

It is evident that these Corallines ought to be eliminated from the class of Polyps, since their vegetable nature is proved.

There are a few more animals which have been referred to the class of Polyps, such as the Lucernaria, the Eleutheria, and the fresh-water Hydra,[1] about the affinities of which I shall have more to say hereafter, when considering in detail the Hydroids and their alternate generations. I leave them aside for the present, as, on account of their small number of representatives, their position in the natural system can in no way affect the natural limits of the classes of Acalephs and Polyps. I shall also take occasion to present some considerations upon the affinities of the Rugosa,[2] a type entirely unknown at the present day, but the representatives of which are found, in large numbers, in the oldest stratified rocks forming part of the crust of our globe. So long is it since the Tunicata were removed from among the Zoöphytes, that there is hardly a naturalist living who may remember the time when they were confounded with Polyps. I need not, therefore, insist here upon their affinities with the Mollusks.

SECTION III.

THE CLASSES OF RADIATA.

We have thus far considered the various types of animals, chiefly with the view of ascertaining which among them are true Radiata and which are not; and it appears plainly, even from this rapid sketch, that while the Ctenophoræ, the Medusæ proper, the Siphonophoræ, the Hydroids, the Halcyonoids, and the Actinoids, are truly radiated animals, this is not the case with the Bryozoa, which properly belong to the type of Mollusks, nor with the Corallines, which are genuine Plants.

[1] Milne-Edwards refers the genus Hydra to the same class, to which he refers also the Anthozoa, the Tabulata, and the Rugosa, which he calls Zoantharia, separating, however, the genus Hydra, as a distinct sub-class; Leuckart, on the contrary, places it among the Hydroids proper. Many important papers have lately been published upon the structure of this type, but with conflicting results. While this page was in the printers' hands I received No. 31 of the Quarterly Journal of Microscopical Science for April, 1860, in which I find Prof. Allman's description of a new genus of Lucernarioid Hydroids, called Carduella, showing, more distinctly perhaps than Lucernaria proper, the Acalephian character of this family, on one hand, and also its affinity to the Rugosa, as well as to the embryonic forms of the higher Discophoræ.

[2] If, as I believe, not only the Tabulata, but also the Rugosa, belong to the Acalephs, the existence of this class upon our globe, instead of beginning in the Jurassic period, dates from the earliest geological ages characterized by the presence of organized beings. Thus far the oldest Acaleph known, was a Medusa from Solenhofen.

The question, however, now arises, whether all these radiated animals form a type distinct from the Echinoderms, as Leuckart would have it; or constitute two classes of the type of Radiata, coequal with the Echinoderms, as Cuvier represented them; or three classes, as Owen and Ehrenberg admit; or any other number of classes.

In uniting the Acalephs and Polyps into one primary division distinct from the Echinoderms, Leuckart has overlooked the general homologies which unite the Echinoderms with the Acalephs and the Polyps, and has paid no attention to the Acalephian character of the embryo of a large number of Echinoderms. There is no feature more striking in all these animals, in the Polyps and Acalephs on the one side and the Echinoderms on the other, than the radiated arrangement of their parts. A comparison of Echinarachnius with Polyclonia and Æquorea, and of the latter with Actinia, can leave no doubt upon this question; and since all Polyps can easily be reduced to the type of Actinia, as well as all Acalephs to that of Æquorea and all Echinoderms to that of Echinarachnius or of Asterias, it must be admitted that the plan of structure is the same in all these animals. They are built upon the idea of radiation; that is to say, all their organs are arranged around a centre, at which the mouth is placed, and diverge towards the periphery, to converge again at an opposite pole. But this is not the whole: all the organs of this structure are homologous. The chambers between the radiating partitions of the Actinia correspond to the radiating tubes of Æquorea, and these, again, to the ambulacral system of the Echinoderms; and the marginal tentacles of the Actiniæ correspond to the marginal tentacles of the Acalephs, and appear as ambulacral tubes in the Echinoderms, under the various forms of seeming gills around the mouth of Echinoids, or of seeming gills in the rosette of Clypeaster, or of branching tentacles and ambulacral suckers in the Holothurians. The identity of all these parts I shall have an opportunity of showing hereafter.

The central cavity, in open communication with the radiating chambers in Polyps, is closed in Acalephs, and communicates only through narrow openings with the radiating tubes; while in Echinoderms there arises a distinct alimentary canal, which is, however, still in direct communication with the ambulacral system through a network of anastomoses, about which I shall also have more to say hereafter. The ocelli at the base of the tentacles, which in Polyps are mere pigment cells, appear like modified tentacles in the higher Medusæ, while they are still connected with real tentacles in the lower ones; in Echinoderms they appear again, in the same relation with the ambulacral system and the terminal odd ambulacral sucker, as they are with the tentacles in Acalephs. The sexual organs are upon the sides of the radiating cavities; that is, upon the edge of the partitions in the Polyps, upon the sides of the radiating tubes in the Acalephs, and alternating with the ambulacra in Echinoderms, — everywhere in a homologous position and relation.

Leaving aside, for the present, some farther complication in the structure of Echinoderms, which we shall consider more fully in the latter part of this monograph, it can, finally, be said, that the Echinoderms are Acalephoid animals, the body-wall of which is loaded with limestone. Lamarck had truly perceived this close affinity between the Acalephs and Echinoderms when he united them into one great division under the name of Radiaires to the exclusion of the Polyps, calling the Acalephs "Radiaires Mollasses," and the Echinoderms "Radiaires Echinodermes." In thus closely combining these two types into one class, however, he committed an error similar to that of Leuckart, who united the Polyps with the Acalephs in one larger group, from which he excludes the Echinoderms. But the reference already made to the homology of their structure is in itself sufficient to show that Polyps, Acalephs, and Echinoderms are constructed upon the same plan, and ought therefore to be united in one and the same primary division, for which the name of Radiata, proposed by Cuvier, seems to be the most appropriate. This once settled, the question of the subdivision of the Radiata into classes becomes comparatively easy.

I take it for granted, that the distinction I have attempted to make[1] between the *plan of structure* in animals and the *mode of execution* of the plan is, if not admitted by other naturalists, at least fully understood by them; and upon this basis I now propose to discuss the limitation of the classes of Radiata. Admitting the *plan* of structure to be the criterion by which the primary groups of animals are distinguished, we have seen that Echinoderms cannot be separated from the other Radiates, since they differ only in structural complications, but not in the plan of their structure. Admitting, next, that the *mode of execution* of a given plan of structure constitutes the essential difference between classes, we have now to consider in what way the idea of radiation (upon which the plan of structure of the Radiates is founded) is carried out in different types of this branch of the animal kingdom, and with what means their body is built up; and this will furnish us with a key to find the natural limits of their classes.

The leading characteristics which distinguish the Polyps, the Acalephs, and the Echinoderms, are so obvious that it is only necessary here to allude to their most prominent features, in order to show that they are essentially different in their anatomical structure, though built upon the same plan. In Polyps, the body has the form of a sac, from the inner surface of which project radiating partitions, leaving an open space in the centre, however, which is the main cavity of the body. This central cavity is in free communication with the radiating chambers enclosed between the radiating partitions, for the whole height of the body. In

[1] See Vol. I of this work, pp. 137 and 145.

the upper part of the radiating cavity formed by the body-walls arise laterally more or less numerous hollow tentacles, which are also in direct and free communication with the radiating chambers. In fact, the tentacles are simply lateral diverticles of the upper part of the chambers. The centre of the upper part of the sac is widely open, but that opening, generally called the mouth, is not the open edge of the sac; it is the result of the inversion of the upper central part of the body-wall, the outer surface of which, in consequence of this bending inward, becomes internal, and forms what is commonly called the stomach. An accurate idea of this structure may be formed by comparing the sac of a Polyp to a bottle, the neck of which should be turned outside in, and expanded into another sac concentric to the body. This pendent sac, or stomach, is open at the bottom, and this opening leads into the main cavity of the body. The lower opening of the digestive cavity is, therefore, properly speaking, the outer opening of the body-wall, and strictly homologous to the mouth of the Acalephs. The habit of Actiniæ, of turning this so-called stomach inside out, affords an excellent opportunity to trace this homology, when it becomes plain that the opening commonly called mouth in Polyps in no way corresponds to the mouth of the Acalephs. It is equally plain, from such a comparison, that the so-called stomach of the Polyps is not any more homologous to the so-called stomach of the Acalephs. This stomach of the Acalephs can only be homologized with the open space in the centre of the main cavity of the Polyps, with which the radiating chambers stand in the same relation and communication as the radiating tubes of the Acalephs to their so-called stomach. The fluid circulating through the so-called gastero-vascular system of the Acalephs is chyme, and nothing but chyme mixed with water, as I have shown in my contributions to the Natural History of the Acalephs of North America, Part I. page 263.

These facts are in themselves sufficient to distinguish the Polyps under all circumstances, not only from the higher Acalephs, but also from the Hydroids, in which the structure is as essentially Acalephian as in the Medusæ proper. For many years past I have insisted upon these differences, and I truly wonder that there are still naturalists who do not see how completely distinct the structural type of the Polyps is from that of the Acalephs. In my lectures on Comparative Embryology,[1] delivered in the winter of 1848 and 1849, I have already shown, not only how the Hydroids differ from the Polyps, but also how the Hydroids agree

[1] Twelve Lectures on Comparative Embryology, delivered before the Lowell Institute, in Boston, in December and January, 1848–1849, Boston, 1849, 8vo. fig. pp. 42 and 43. See also my paper "On the Structure and Homologies of Radiated Animals, with Reference to the Systematic Position of the Hydroid Polyps," Proc. Amer. Ass. of Sc. Cambridge, 1849, p. 389.

in their structure with the true Medusæ. This agreement is complete; and there is no room left for a distinction between Hydroids and Medusæ, any more than for a reunion of Polyps and Hydroids.

The essential structural peculiarity of the Acalephs, as a class, consists in the presence of a central cavity, hollowed in the mass of the body, without radiating partitions, but with an external central opening, the edge of which is turned outward and more or less prolonged, in the shape of oral appendages or fringes. Tentacular appendages may also exist outside of this central opening, or so-called mouth, or may be wanting; but when they do exist, their cavity, if they are hollow, communicates only indirectly, through radiating tubes, with the main cavity of the body, the radiating tubes themselves uniting with a circular tube that follows the outline of the periphery. This is certainly an essentially different structure from that of the Polyps. Again, while the Polyps are always sexual animals, and frequently hermaphrodites in their adult age, the Hydroids are uniformly destitute of sexual organs, but produce, by budding, an alternate generation, the individuals of which, like ordinary Medusæ, are always, when adult, either male or female. When considering in detail the structure and mode of reproduction of the Acalephs, I shall have occasion fully and conclusively to show that the parts generally considered as generative organs in the Hydroids are truly individual animals, in every way homologous to true Medusæ, and themselves provided with the sexual organs that are wanting in the Hydroids. For the present I must limit myself to the assertion that it is so.

As to the homology between Polyps and Acalephs, it must be apparent, from what precedes, that the comparisons which have been instituted between them are not accurate. If the central opening between the tentacles of the Polyps is not homologous to the so-called mouth of the Acalephs, but simply an aperture arising from such an inversion of the body-wall that the opening at the bottom of the digestive cavity is in reality the external opening of the body, it is plain that the name *mouth* has been applied to very different parts in these animals. It must further appear, that, from the position of this opening and its relation to the whole structure of the animal, the name *mouth* can hardly be applied to it. Indeed, the more we study the lower animals, the more are we impressed with the imperfection of the nomenclature used to designate their parts. To me it now seems quite inappropriate to designate the opening through which the food is introduced into the body by the same name in all animals. Since the study of homologies has become a safe guide in the appreciation of the true nature of the parts of an animal, I can no longer see why we should use the name *mouth* to designate a simple opening in the centre of a radiated structure, when that name was originally applied to a cavity circumscribed by a bony frame, with a muscular apparatus provided with nerves and blood-vessels, and the seat of a special organ of sense. In fact, the Vertebrates alone have a real mouth; and the opening leading to the digestive cavity in other animals is in no way homologous to their mouth, and ought to be called by another name, and by a different name in each type, according to the general homologies of its structure. The so-called mouth of the Articulates is as different from that of the Vertebrates, as it is from that of the Mollusks and that of the Radiates. And if the name *mouth* is to be retained for all, it must be with the distinct understanding that the mouth is essentially different, both in its relations and in its structure, in Radiates, in Mollusks, in Articulates, and in Vertebrates. I do not consider innovations in the nomenclature as favorable to the progress of science, as long as it is possible to convey clear and distinct ideas by the use of ordinary language; but I believe, nevertheless, that a new name, applied to an object long known under another appellation, impresses more forcibly the difference it is intended to express, than a mere qualification of a generally received name. I would, therefore, propose to designate henceforth the mouth of the Radiates by the name of *Actinostome*, that of the Articulates by the name of *Arthrostome*, and that of the Mollusks by the name of *Malaeostome*, in allusion to the typical structure of these animals. I shall introduce similar changes in the nomenclature of other parts as often as, in the progress of my exposition, I may have an opportunity of showing, not only the necessity of the change, but also, by a fuller illustration of the homologies of these parts, the propriety of adopting the new name proposed.

The class of Echinoderms is characterized by as different a mode of execution of the plan of structure, involved in the idea of radiation, as the Acalephs and Polyps are; but the plan itself is the same in all. The peculiarity lies in the construction only. The body-wall in Echinoderms forms a radiating cavity, in which are suspended different systems of organs, distinct from the walls themselves, but in various ways connected with them. The ambulacral system, which is homologous to the radiating tubes of the Acalephs and to the radiating chambers of the Polyps, stands in the closest relation to the walls of the body. It traverses them in the form of tubes, radiating from one pole of the body to the other, and emitting, in most of them, external suckers, arranged in rows upon the surface. The alimentary canal, connected with the walls of the body only at the central opening, and, in some, also at the opposite end, extends as a distinct tube or sac, free in the main cavity, and is not circumscribed by the perisome or *spherosome*[1] itself, as in Acalephs. The reproductive apparatus consists also of distinct organs,

[1] I call *spherosome* the body-wall of a radiated animal. I prefer the name of spherosome to that of perisome because that of perisome has already been applied with different meanings.

arranged radiatingly between the ambulacral rows, with which they alternate. This arrangement is strictly homologous to that of the sexual organs of the Polyps and Acalephs; for in Polyps the ovaries and spermaries hang from the edges of the radiating partitions, and in Acalephs they are placed upon the sides of the radiating tubes, or, what amounts to the same, they alternate with the radiating chambers in Polyps and with the radiating tubes in Acalephs, as they alternate with the ambulacral system in Echinoderms. That in Echinoderms the ambulacral system is more or less complicated, assuming now the appearance of gill-like tentacles around the oral aperture in Holothuriæ and Echini, and now that of simple tubes with external suckers, as in most members of this class, does in no way alter the primary organic relations of these parts. The homological identity of the ambulacra of the Echinoderms with the radiating tubes of the Acalephs is most easily ascertained by comparing that system in those Holothuriæ which have no external ambulacral appendages with the disposition of the radiating tubes in the Ctenophoræ. In Synapta, for instance, and in allied genera, the ambulacral system consists of tubes as simple as the radiating tubes of the naked-eyed Medusæ; while in some Beroid Medusæ, such as Bolina, Alcinoë, and Mnemia, the radiating tubes are really more complicated than the ambulacral tubes of Synapta. This apparatus is so strictly homologous in both families, that the Ctenophoræ may fairly be said to possess an ambulacral system identical in its general disposition with that of the lower Holothuriæ. Even the form of some of the Ctenophoræ, such as Beroe proper, Idyia, etc., recalls that of the Holothuriæ.

At the peripheric ends of the ambulacral system of a large number of Echinoderms there are ocelli, which deserve a special notice in this connection. Above each of these ocelli there is frequently an odd ambulacral tube, particularly prominent in some Star-fishes. This odd ambulacral tube bears the same relation to its ocellus as the hollow tentacle of a Sarsia bears to the ocellus at its base; and both have an homologous connection with their respective aquiferous systems. In Sarsia, each hollow tentacle with its ocellus communicates in the same manner with the corresponding radiating tube, as the odd ambulacral tube of a Star-fish with the whole ambulacral system of its ray. When I represent the ambulacral system of the Echinoderms as homologous to the radiating tubes of the Acalephs and to the radiating chambers of the Polyps, I do not overlook the difference there is between them in structure and in functions. But these differences consist in a more or less complicated structure and more or less specialized functions, as we frequently observe even between members of one and the same class and not in a typical modification. Similar differences exist among Echinoderms taken as a class, and even among different families of the same order of that class. In some Star-fishes the digestive cavity is a blind sac, while in others it is open at both ends. So also, in the class of Acalephs, the digestive cavity in most Medusæ is simply hollowed out of the central part of their spherosome, while in Ctenophoræ that cavity has its walls, not only distinct from the spherosome, but in its upper part these walls recede from the mass of the body, and leave an open space between the two, into which the products of digestion are poured. There is, besides, in these animals, a double opening in the upper part of the spherosome, through which the fæcal matters are discharged. Nothing of the kind exists in any other Acaleph. Notwithstanding this, the Ctenophoræ are strictly homologous in all their parts to the other Acalephs. On the other hand, this peculiarity of the digestive cavity of the Ctenophoræ recalls the disposition already noticed in some Star-fishes, and establishes a sort of transition between the extreme modifications in the latter; for, while the digestive sac of some Star-fishes is a closed sac rising into the main cavity of the body without an open communication with it, in other Star-fishes it rises to the upper wall of the body, through which it passes, to open externally, and in Ctenophoræ it opens into the cavity of the body, the walls of which are in their turn pierced with two distinct openings, to afford a passage for the fæces. These two openings cannot be considered as anal openings, since they do not directly communicate with the digestive cavity; nor is the aboral end of the digestive sac to be compared to an anus, for it discharges its contents directly into the main cavity of the body. We have here, throughout, combinations which are entirely foreign to the plan of structure of the other branches of the animal kingdom, and which fully justify what I have already said above respecting the impropriety of calling the parts of these animals by the same names as those of other types. But while the Radiates are thus shown to differ in every respect from the Mollusks, Articulates, and Vertebrates, they at the same time become more and more intimately linked together, in proportion as we are better acquainted with the typical features of their organization.

As to the so-called external skeleton of Echinoderms, it in no way constitutes a peculiarity of this class, in contradistinction to the Acalephs and Polyps; for in Holothuriæ the amount of calcareous deposits is comparatively small and does not affect the flexibility of the spherosome, while the rigidity of the Echini is not greater than that of the Corals compared to Actiniæ. In both it is only a consolidation of the spherosome, resulting from the accumulation of limestone in its tissue; but the actinostome, as well as the diverticles of the aquiferous system, the tentacles and ambulacral suckers, remains soft and movable. To judge correctly of these relations, it is indispensable to observe these animals alive, with all their soft parts fully expanded. In that condition Star-fishes and Sea-urchins have a very different aspect from that which they exhibit when dried up or preserved in alcohol. By comparisons made in this way we are enabled to establish the closest homology between all Radiates, from the Echinoderms down to the Polyps, without losing the connection between their organic systems; nay, even the form and special disposition of certain organs in the two most remote classes of Radiates are intimately linked together by peculiarities characteristic of some of the Acalephs. For instance, the system of radiating tubes in the lower part of the disc of the genuine Medusæ, and still more strikingly in the Rhizostomes and Cassiopeiæ, presents the most striking resemblance to the distribution of the ambulacral tubes in the lower wall of the spherosome in Clypeaster, Scutella, and Echinarachnius; so much so that the difference between the two types is reduced to the difference there is between a soft wall and a solid wall, and that of an ambulacral system with and without external suckers. But since there are Holothuriæ — the Synapta and allied genera — in which these external suckers are wanting, the whole difference amounts only to a different degree of complication in one and the same system, similar to the various degrees of complication observed throughout the animal kingdom in the differentiation of the organs. The comparisons I have been able to make between Cassiopeia and Echinarachnius and Clypeaster are conclusive upon this point, as will be shown in the sequel.

After tracing so close a correspondence and so many connecting links in the structure of the Echinoderms, Acalephs, and Polyps, I may be permitted to ask what there is left to support the idea of a typical difference between the Echinodermata and Cœlenterata, now so generally and so strongly insisted upon by German naturalists. The truth is that the Cœlenterata do not constitute a primary division in the animal kingdom, but must be united with the Echinoderms as members of one and the same type, including three, and only three, natural classes, equally distinct one from the other, — the Polyps, Acalephs, and Echinoderms.[1]

I need hardly remind anatomists of the importance, for their own special studies, attaching to every improvement in the classification of animals; for it is only when their natural affinities are satisfactorily known, that it is possible to give a comprehensive account of their structure.

[1] If this be so, then the name of *Cœlenterata* as designating a distinct type, as well as that of *Anthozoa* as designating the Polyps in contradistinction to the Hydroidea, and that of *Hydromedusina* as including the naked-eyed Medusæ with their polypoid congeners, must be dropped from the system of Zoölogy, and the older names Radiata, Polypi, Acalephæ, and Echinodermata, restored.

SECTION IV.

MORPHOLOGY AND NOMENCLATURE.

Thus far, my aim has been to present an outline of the views entertained by different naturalists upon the various relations among the animals referred to the type of Radiata, taking that group in the widest sense in which it has ever been considered. I have accompanied this survey with incidental critical remarks, and with a few considerations upon the mode of ascertaining the natural limits of a class, and have arrived at the conclusion, that the type of Radiates embraces only three natural classes. This conclusion is founded upon the evidence adduced, that the animals heretofore referred to Radiates, and not belonging to the one or the other of these three classes, are not genuine Radiates, and must therefore be excluded from that type.

I have attempted to show, farther, that the proposed division of Radiates into Cœlenterata and Echinodermata, as distinct primary types, is a mistake arising from an incorrect appreciation of what constitutes respectively a type or branch, and a class, in the animal kingdom. If the views I hold on this subject are true, the Echinoderms, being built upon the same plan as the Polyps and Acalephs, belong to the same type as the so-called Cœlenterata, and constitute only one class of that type. The peculiarities insisted upon as a ground for considering Echinoderms as a distinct type are not differences in the plan of structure, but merely differences in the mode of execution of one and the same plan.

I hold, farther, that the Cœlenterata, as circumscribed by Leuckart, embrace two distinct classes, the essential characters of which are of the same kind as those that separate the Echinoderms from either of them; so that, considering classes to be founded on different ways of carrying out the same structural plan, the type of Radiata should be divided into three classes, — the Polyps, the Acalephs, and the Echinoderms. It is true that the range of structural differences in these classes, within their respective limits, is not always exactly parallel; but it is a fact, too much overlooked by naturalists, that there are very few groups in nature of the same essential value, presenting identical degrees of difference, or even approximating each other in their number of genera and species.

In the regular sequence of my exposition I should now present a sketch of the natural features of the class of Acalephs; but before I make the attempt, a few words upon their morphology and nomenclature are indispensable. This is important, in order that I may be able to present the characteristics of the class with more confidence, and with a clear understanding respecting the true value of the differences noticed between the animals now referred to it, and also that I may point out the various names under which the different parts of these animals have been designated by different authors in their descriptions.

It is much to be regretted that no uniform nomenclature has yet been adopted in describing these animals. Indeed, there are scarcely two authors, among those who have contributed most to build up our knowledge of the Acalephs, who describe their parts under the same name, and this ever-recurring discrepancy is a serious obstacle to an easy perusal of their works. This difficulty has arisen from two causes. First, from a difference of opinion among investigators respecting the real nature of the parts described, and secondly, from a laudable desire to avoid expressing premature opinions upon these structures. Thus, special names were given to any parts in the body of Acalephs that seemed to present characteristic differences, even though these parts might be homological. This conflicting nomenclature has not only made it very difficult to understand the full meaning of the descriptions of Acalephs published by different writers, but has also led to the impression, that the differences among the different families of this class are far greater than is really the case. Such Acalephs, for instance, as have a certain external resemblance to Polyps, as the Hydroids, have been described with the terminology generally applied to Polyps; while the Medusæ proper have been designated by a nomenclature of their own; and the Siphonophoræ in another way still: the latter, indeed, being described in one way by those naturalists who consider them as single animals, and in another way by those who look upon them as communities of combined individuals.

To avoid this complication of nomenclature hereafter, I deem it indispensable to consider not only their relations among themselves, but also their relations to the members of the other classes of the same type. Now, surely, if Acalephs are Radiates, they should bear such a structural relation to the Polyps and Echinoderms, assuming that they belong to the same type, as the Acephala, Gasteropoda, and Cephalopoda, considered as Mollusks, bear to each other; or the Worms, Crustaceans, and Insects considered as Articulates; or the Fishes, Reptiles, Birds, and Mammals considered as Vertebrates. This is so well understood in our days with reference to the Vertebrates and Articulates, and in a measure also with reference to the Mollusks, that no naturalist could consider it as a progress in his science were a new name introduced to designate the webbed hand of a bat or the flapper of a Cetacean, or the rudimentary extremity of the Lizards with imperfect feet, or any other such serial gradation in the development of their different systems of organs. On the contrary, modern naturalists constantly endeavor to simplify the nomenclature of Zoölogy by tracing the homologies of the most diversified parts of the same system. Surely, the head of a fish is not to be called by another name than that of Birds or Mammals, because it is not separated from the chest by a long neck; nor are we to have as many different names as there are different combinations of structure in the parts of the face. The olfactory organ, or the nose, must be called nose or olfactory organ, whether it be as prominent as the proboscis of the elephant, or as blunt as the snout of a fish. The ear must be called ear, be it ever so prolonged externally, or entirely concealed below the surface of the head. All this can be readily done among Vertebrates and among Articulates, because the structure of all these animals is sufficiently well known to force a uniform nomenclature upon the attention of any one who studies them.

The correspondence of the rings of an Articulate, be it a Worm or a Crustacean or an Insect, is evident, whether it be altogether deprived of locomotive appendages, or provided with legs only, or with wings as well as legs; and it will be at once understood, by any one who extends these comparisons sufficiently, that the parts now generally called legs and wings among Insects, though bearing the same names for the present, are not homologous with legs and wings in Vertebrates. The parts of the mouth of a sucking or a chewing Insect, on the contrary, will with the same readiness be recognized as homologous with their so-called legs. Unfortunately, this is not the case with the Radiates. We find almost as many different opinions respecting the parts of Echinoderms, Acalephs, and Polyps, as there are writers on the subject. Even with reference to Echinoderms alone, there are authors who have denied the homology of the solid parts of the Sea-urchins with those of the Star-fishes, and described the solid frame of the one as external, and that of the other as internal.

It is not my intention here to consider the general homologies of the Radiates in detail, as I shall take up the subject again at the end of this monograph. But for the purpose of introducing a more uniform nomenclature among these animals, or, at least, paving the way to it, I will attempt such a general comparison between them as may facilitate a reference of the parts of one class to the parts of another.

The plan upon which the Radiates are built is so peculiar, and so distinct from that of the Mollusks, Articulates, and Vertebrates, that the essential elements of their structure are entirely different. A common Star-fish or a common Sea-urchin is as readily divided into five segments, as a common Medusa into four, or an individual animal of a Gorgonia into eight, or that of an Actinoid Polyp into a larger number, according to different families. Such segments bear to the body as a whole, a relation similar to that observed in the ring of an Insect as one of the essential elements of its structure, or a vertebra with its muscular band

and corresponding pair of nerves and vessels in either Fish, Reptile, Bird, or Mammal, as a segment of the body of a Vertebrate.

Now, it requires no formidable stretch of the imagination to reduce any single Polyp, or any Acaleph or any Echinoderm, to a spheroidal form. Indeed, the sphere is the essential form of all Radiates, — not the mathematical sphere, but the organic sphere, loaded in different directions, according to the peculiarities of the subordinate groups of this type. It has its nearest approach to the sphere in the Echinus; it becomes a cylinder in the Holothuria; it is stellate in the Star-fish; it is bell shaped in the Acaleph; it is trumpet shaped in the Polyp; and in all it has an oral opening in the centre of structure, which may not be the centre of figure.

Keeping in mind this starting point, if we consider the natural position of the animal in its element, we find in Polyps the so-called mouth turned upward in the centre of the broadest expansion of one side of that organic and flexible sphere, while the opposite end, more or less tapering, becomes a base of attachment. Hydroids retain the same attitude, and bear the same general relation to the surrounding medium. Not so with the Medusæ, in which the sphere is freed from all attachment and the oral aperture turned downward, the whole body being more or less hemispheric or bell shaped. In Echinoderms we have not only the Crinoids, recalling, in their relations to the surrounding mediums, the Polyps and Hydroids, but also the Sea-urchins and Star-fishes, in which the mouth is turned downward as in Medusæ, and the Holothurians, in which it is directed forward. In order, therefore, to have a normal position for all Radiates, we must compare them with one another, not in their natural attitudes, but in such a position as would exhibit, in all, the centre of their structure in the same relation to the surrounding medium.

The necessity of thus distinguishing the natural attitude and the normal position of animals is particularly obvious in the study of Radiates. But the distinction is quite as important in other branches of the animal kingdom. Everywhere the possibility of acquiring an insight into the typical structure of any natural group depends primarily upon the position in which its representatives are compared. Had not Rathke taken these relations into consideration, we should not know the antagonism which prevails between the Articulates and Mollusks in their embryonic development. Without keeping them in mind, we shall never be able to homologize the Bryozoa and Tunicata with the other Acephala. Without knowing that an animal may move in a position entirely at variance with the normal position of the other representatives of its class, a description of its characteristic features may appear in direct contradiction to its habits, or mislead us with reference to its natural relation to the surrounding medium. In proportion as we are better acquainted with an animal, the difficulties arising from this discrepancy between natural attitudes and normal positions grow less and less. No one could be misled by a description of a Turbot or a Flounder, representing their structure according to their normal position, even though, in their natural attitude, they lie upon one side; nor would any philosophical observer describe the back of these fishes as lateral on account of their natural attitude. And yet it seems hardly to have occurred to some naturalists, that they make frequently a similar mistake when they describe the lower animals, in almost every group, in a different way; taking everywhere the natural attitude, and not the normal position, as their guide.

It is fitting, that, after alluding to the different attitudes in which the Radiates are found in their natural element, we should attempt to determine what is their normal position. Considering the plan of their structure, we have already seen that there exists in all of them an axis and centre of radiation, around which all their parts are symmetrically arranged in a radiating and concentric order, even though that axis or centre of structure be not the centre of figure or form. At one end of this axis we invariably find the so-called mouth or *actinostome*, while the opposite end of the alimentary canal may have an excentric position. We find, moreover, that in their natural attitude, the actinostome is in all of them turned either upward or downward, with the sole exception of the Holothuriæ, in which it is directed forward. This exception is, moreover, of little importance, since the structural relations of the Holothuriæ to the other Echinoderms leave no doubt as to what is their normal position; and whatever rule we recognize as binding for the other Echinoderms must be followed for the Holothuriæ also.

Once agreed upon this point, there can be no farther doubt, that, in the Radiates, the normal position of the main axis of the body is the vertical, since all, with the single exception of the Holothuriæ, stand in their natural element with that axis in a vertical position. We shall, therefore, not hesitate hereafter to describe the Holothuriæ as if they also were in the habit of standing upright.

It is not quite so easy to determine what should be considered as the upper, and what as the lower, end of the axis. If we look to the Polyps as a guide, we should certainly take the region of the actinostome as the upper end; but if we allow the relations of the higher Radiates to influence us, we should naturally consider the same region as the lower end of the body. It would be incorrect, unquestionably, to assume that the natural attitude of the Holothuriæ is to decide the question, and to describe all the radiated animals with the actinostome forward, as it is evident that the similarity in the natural attitude of the Holothuriæ and Worms is only an analogy, and not a leading feature applicable to the whole type of Radiates. The main axis of the body of these animals is truly vertical; and in this essential relation of their whole structure to the surrounding medium, we have an additional characteristic of this branch, distinguishing it from the three other branches of the animal kingdom. The significance of this upright position of the lowest type of animals with a radiating structure is most striking in view of the upright position of man, at the head of the animal creation.

The same reasons which induce me to discard the indications of the Holothuriæ in determining the normal position of the Radiates, apply to the Medusæ, Star-fishes, and Sea-urchins, when considering which end of the vertical axis should be regarded as the upper and which as the lower. The centre of radiation, as developed in the actinostome, is evidently the prominent feature of the whole organization of this type; it is the climax of the concentration of their structure; upon that side the most sensitive parts of the body are combined; around it the nervous ring with its ganglions is placed, in those representatives of the type in which the differentiation of the tissues goes so far as to lead to the development of a nervous system. It seems natural, therefore, to consider the oral end of the vertical axis as its upper end. But why that end should be turned upwards in the lower Radiates only, I am unable to say: I can only surmise that this position is connected with the immovability of the Polyps, the Hydroids, and the pedunculated Crinoids, and that the advantage they have in that respect over the Medusæ, the Star-fishes, and the Sea-urchins, is a compensation for their inability to move about freely.

Supposing, however, that the actinostome should be considered as the upper end of the vertical axis, it would not be advisable to use the expressions of *upper* and *lower* end or side of the body, in describing the one or the other end of the vertical axis of the Radiates; for, evidently, there would be something unnatural in constantly contrasting the normal position and the natural attitude of the different representatives of this type. I would therefore prefer to apply the name of *actinal* to the side or pole at which the so-called mouth or actinostome is placed, and that of *abactinal* to the opposite side or pole. In this way the description of a Sea-urchin, compared to that of an Actinia, will not involve a seeming contradiction with the attitudes in which these animals are constantly observed in their natural element.

This once fully understood, and assuming that the body of a Radiate, whatever be its real figure and its natural attitudes, may be reduced to a spheroidal form by homological transformations, it is self-evident that the essential segments composing this living sphere will bear to one another identical relations, and as parts of a sphere be homologous to one another, as far as they retain symmetrical relations to the main axis. For these homological segments of the body of Radiates I would propose the name of *Spheromeres*, and, in allusion to the well-known structure of these animals, describe the body of a Holothuria, for instance, or that of an Echinus and a common Star-fish, as consisting of five converging spheromeres, as the body of a Caterpillar or a Butterfly consists of thirteen rings movable upon a longitudinal axis. In most Crinoids we have also five spheromeres, but occasionally four or six, and in some Asterioids even a larger number. In Acalephs the body is generally built of four or eight or twelve spheromeres; but here and there the numbers vary, as we find also that the number of rings varies in the lower Worms. In the Halcyonoid Polyps the number of spheromeres is constantly eight, they being the highest Polyps. In the Actinoids we find, in the lowest families, a large and varying number of spheromeres, sometimes increasing regularly with age; whilst in the highest Actinoids — the Madrepores proper — the individual Polyps are made up of twelve spheromeres, six of which are more prominently developed than the six others. A similar difference between alternating spheromeres is observable among the higher Acalephs. Here unequal spheromeres may combine in such a manner as to produce the appearance of bilateral symmetry; and though this feature is not only common among Radiates, but even prominent in some of the higher representatives in each class of this type, it is yet subordinate to the plan of their structure: for, upon close analysis, it is found, that, even in those Radiates in which bilateral symmetry is most marked, it is in reality the result of a symmetrical arrangement of radiating elements around a vertical axis, and not of elements symmetrically placed upon the two sides of a longitudinal axis.

Thus it appears that the body of all Radiates, be they Polyps, Acalephs, or Echinoderms, is composed of identical elements, which may be called spheromeres; and that these parts are arranged symmetrically around a vertical axis, in the same manner as the wedge-shaped segments of an orange are arranged within its bark. There is no propriety, therefore, in considering the body of Acalephs as something peculiar, and different from that of a Polyp or an Echinoderm, and it is unnecessary to give it a distinct name, as Huxley does, who calls it Hydrosoma, else this name must be extended to all Radiates; for the body of the Actinia is as much a Hydrosoma as that of any Acaleph, and so also is that of Pluteus and allied forms (young Ophiurioids and Echinoids), that of Bipinnaria and Brachiolaria (young Asterioids), and that of Auricularia (young Holothuria). We need, however, distinct names to designate the different stages of development of these animals; which, once sanctioned by use, may become as significant as the names applied to the larval conditions of the Insects.

I should not object to the name of Hydrosoma for the young Acalephs, had we not already, for every stage of their growth, names which are very generally adopted, and which render new ones superfluous. For the earliest state of the embryo Hydroids we have the name of *Planula*, for the Medusæ buds of the Hydroids that of *Pyrulum*, and for the young free Medusæ of the Campanularians that of *Tintinnabulum*, all proposed by Dalyell; for the young of the Discophoræ we may choose between the name of *Hydra*, also proposed by Dalyell, and that of *Scyphistoma*,[1] used by Sars; and for the next stage of their development we have the name of *Strobila*, introduced by Sars and generally adopted. The young free Medusa may best be called *Ephyra*, as that name was first applied to it when it was considered as a distinct genus. If we retain the name Hydra for the sterile animals of the Hydroid type, and that of Scyphostoma for the young Medusa, the name of *Medusa* would be most appropriate for all the adult Medusoids. Our terminology would then be fixed in the following manner: *Planula* would designate the embryonic state of the young Acaleph just hatched from the egg, and moving about by the aid of vibratile cilia; such planulæ are born not only from the eggs of Hydroids, but also from those of Discophoræ, and the young Polyps exhibit the same appearance. The name *Scyphostoma* would apply to the young, from the time it is attached and the tentacles begin to make their appearance. In the Hydroids and Polyps this condition becomes permanent, as the worm-like state of the larvæ of the higher Articulates becomes permanent in the Worms; it is therefore appropriate to retain the name *Hydra* to designate the adult Scyphostoma, which undergoes no further development, and that same name may equally well be used to designate the single individuals in a Hydroid community, as we apply the name Polyps to designate either single Polyps, or single individuals in a Polyp community. The name *Strobila* is so generally used to designate the stage of Scyphostoma in which the vertical axis becomes divided by transverse constrictions, and that of *Ephyra* has so long been applied to the young Medusæ freed from this axis before they assume their final form, that no further argument is needed to sanction their further use. Let it only be remembered, that, as there are Insects with imperfect metamorphosis in which no pupa state is observed, so are there Acalephs in which the larva, overleaping the Strobila segmentation, passes directly from the Scyphostoma to the Ephyra state. This is the case in Pelagia (Pl. XII. *Figs.* 4–11). For the adult Acalephs there can be no more appropriate name than that of *Medusæ*, under which they have always been known. The name of *Pyrulum* for the Medusæ buds of the Hydroids, and that of *Tintinnabulum* for their free Medusæ, are entirely superfluous.

Were all Acalephs simple animals, this nomenclature would be quite sufficient to describe them accurately. But in this class, as among Polyps, there are a great many species in which the individuals combine to form more or less extensive communities; and the Acalephs present this additional peculiarity, that the indi-

[1] This name should be written Scyphostoma, in accordance with its etymology.

viduals of one and the same community are by no means so uniform among themselves as in the class of Polyps. The Acalephian communities are, indeed, generally polymorphous, and cases of great uniformity among their individuals are rare. For these communities we need comprehensive names, as much as for the Polyp communities. Now, just as the name *Polyparium* has been framed to designate a *Polyp community*, we may apply the name of *Hydrarium* to a *community of combined Hydræ*. In this sense, a bunch of Corynæ or of Tubulariæ united by their stems and stolons, a patch of Hydractiniæ rising from their common basis, a branching Campanularia or a Laomedea communicating with others by stolons, or even a single stem with its lateral buds, constitutes *Hydraria*. And so also are Sertulariæ and Plumulariæ genuine *Hydraria*. The same name must also apply to the Siphonophoræ as far as they are communities. But here a distinction is at once suggested, in accordance with the special character of the individuals forming these communities. As long as the combined individuals are all Hydræ, the name Hydrarium correctly applies; but among Siphonophoræ, as among Corynoids and Tubularioids, there arise Medusæ buds from the Hydræ, and these buds are either single, or form by themselves communities of individuals in no way to be distinguished from genuine Medusæ, to which the name of Hydraria cannot be applied, but for which that of *Medusarium* seems very appropriate. I would therefore call *Medusarium* every bunch of Medusæ buds arising from a Hydra, in contradistinction to the single Medusæ buds produced by other kinds of Hydræ. For instance, the Hydræ of a Coryne Hydrarium never produce *Medusaria*, but always single Medusæ buds, while the Hydræ of a Tubularia Hydrarium always produce *Medusaria*. The structural combinations in these animals are so complicated, that, unless we make these distinctions, it will become necessary to resort to long circumlocutions correctly to describe them, and duly to discriminate the true nature of the different kinds of individuals united in one and the same community. It is evident, that a Tubularia community, so long as it produces no Medusæ buds, is simply a Hydrarium; but presently it brings forth Medusæ buds in large clusters, hanging from the single Hydræ in the form of Medusaria, and each Hydra produces several such Medusaria, which are as much parts of the enlarged community as the single Hydræ themselves. By this time the community is no longer a mere Hydrarium, but a Hydrarium bearing Medusaria. It is now a community of heterogeneous communities, which may well be called a *Hydro-Medusarium*.

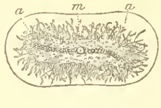
The use of such names for these different communities and their combinations will greatly simplify our descriptions, and add much precision to our characteristics of the different families and genera of the Hydroids. For instance, the *Tubularioids* as a family may be described as *Hydro-Medusaria* arising from single *Hydræ* which by budding and by stolons become *Hydraria*; each adult Hydra producing in time several pendent *Medusaria*. The different genera of the family may then be characterized by the peculiarities of their Hydræ and of their Medusæ. The *Campanularians* as a family may be described as *Hydraria* with two kinds of *Hydræ:* some being sterile and more numerous, while others are fertile and produce Medusæ from their proboscis. The different genera may easily be distinguished by the peculiarities of the two kinds of Hydræ, as well as by their Medusæ. Similar differences exist among the Siphonophoræ. The *Velellidæ* are simply *Hydraria* arising from a single *Hydra* which grows larger and larger until it produces other *Hydræ* of a different form, and from these single Medusæ buds spring forth and finally free themselves. The *Physalidæ*, on the contrary, are *Hydro-Medusaria*, arising, like the Velellidæ, from a single *Hydra*, which also grows larger and larger, and even acquires an enormous size, forming in the end the large swimming-bag, from which single additional Hydræ at first arise, and afterward a larger and larger number, forming several distinct *Hydraria* suspended from the original enlarged Hydra. These Hydraria themselves consist of heterogeneous Hydræ, though of Hydræ only. Others produce *Medusaria*, and thus become *Hydro-Medusaria;* so that a Physalia community is really made up of many heterogeneous communities attached to a gigantic Hydra. The *Diphyidæ* are also *Hydro-Medusaria*, but of a very different kind from those of the Physalidæ. Here the community begins with a medusoid individual, from which arises another Medusa, thus forming Medusæ twins. This twin community produces a string of medusoid Hydroids, from each of which arises another kind of Medusæ, in close connection with their Hydroids, thus forming secondary twin communities, each of which consists of a medusoid Hydra and a genuine Medusa. In the *Physophoridæ*, the combinations are still different. The community constitutes also a *Hydro-Medusarium;* but it arises from a single *Hydra*, from the upper part of which bud sterile *Medusæ*, while other *Hydræ* arise from its lower part, between which, finally, a number of *Medusaria* make their appearance.

As soon as it is conceded that the so-called sexual organs of the Siphonophoræ are themselves individual animals provided with ovaries and spermaries, there is no possibility of avoiding the conclusions presented in the preceding paragraphs respecting the structural constitution of the Acalephs, and the close affinity of the Siphonophoræ and Hydroids proper becomes very striking. For, notwithstanding the extraordinary diversity of the form of these animals, there are, properly speaking, only two kinds of individuals among them: the sterile ones, for which the name *Hydræ* is most appropriate; and the fertile ones, which we may best call *Medusæ*. I must, however, qualify this statement somewhat, in order to avoid every possible misapprehension. There are fertile Hydræ, if the production of buds constitutes fertility, for most Hydræ produce Medusæ buds; but Hydræ are themselves destitute of sexual organs, there being neither males nor females among them; and yet, some of these Hydræ — Hydractinia, for instance — produce only male Medusæ buds, and others only female Medusæ buds, and in this genus the individuals producing either male or female Medusæ buds form distinct communities. Again, not all Medusæ are fertile; for instance, the so-called swimming-bells of the Diphyidæ and Siphonophoræ, though evidently medusoid in their structure, have neither male nor female organs.

After this digression, which was indispensable as an introduction to a critical survey of the prevalent nomenclature of the Acalephs, let us now consider the different names under which the different elements forming the communities of the Siphonophoræ have been described, that we may hereafter more readily compare them with the other members of the class; for the chief difficulty in harmonizing the nomenclature of the Acalephs arises from the complication of the names applied to the Siphonophoræ. In these communities we have at first to distinguish the medusoid and the hydroid individuals, in the same manner as among the Hydroids proper; and, to do this with accuracy, we must recall the comparison already made (p. 50) between Siphonophoræ and Hydroids as compound communities, and remember the prevalence of polymorphism in most of these animals.

The extensive investigations of Leuckart, Vogt, Kölliker, Gegenbauer, and Huxley upon Siphonophoræ, and the many species now known in all their stages of growth, furnish the most welcome materials upon which to base further comparisons. The young Velella, as described and figured by Huxley (Oceanic Hydrozoa, Pl. XI. *Figs.* 9 and 14), is unquestionably a simple genuine Hydra, provided at first with only few tentacles, and in that condition comparable to any single head of a common Hydroid freed from its stem. An adult Velella, on the contrary, is a Hydrarium, that is, a community of secondary Hydræ grown up between the actinostome and the tentacles of the primary Hydra, and from which in due time genuine Medusæ buds arise. The presence of a shield with a crest in the disc or bell of the primary Hydra is only a structural peculiarity of that animal, but not any more altering its true nature and affinities, than the presence of a shell in the mantle of a Gasteropod. The enlarged primary Hydra of the Velella community, when it has become a complicated floating apparatus (*Fig.* 47) from which hang numerous fertile Hydræ, the so-called fertile tentacles, — "gonoblastidial Polypites" of Huxley, "individus reproducteurs" of Vogt, "peripherische Polypen" of Leuckart, "kleine Polypen" of Kölliker (*Fig.* 48), — is still as much a Hydra

Fig. 47.



VELELLA MUTICA, Bosc.

m So-called mouth. — *a a* So-called tentacles. Between the sterile tentacles and the mouth arise the secondary Hydræ, or so-called fertile tentacles, the gonoblastidial Polypites of Huxley.

Fig. 48.

Single so-called fertile tentacle of

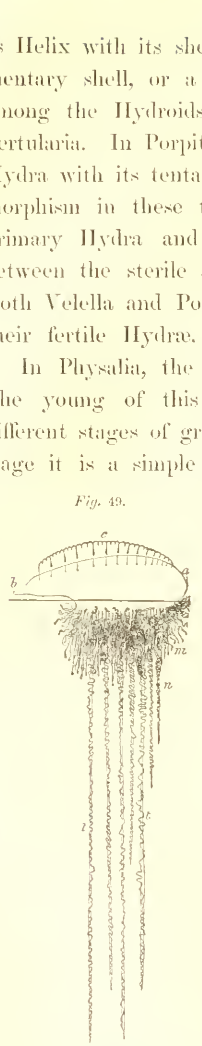
VELELLA MUTICA, Bosc,

Bearing Medusæ buds *d d*. — *a* Base of attachment. — *b* Blunt end of the tentacle, as it appears when the mouth is closed.

as Helix with its shell is an animal of the same order as a Limax with a rudimentary shell, or a Tebennophorus without any shell. Similar differences occur among the Hydroids proper in the genera Coryne, Tubularia, Campanularia, and Sertularia. In Porpita, we observe the same relations between the primary enlarged Hydra with its tentacles and the secondary fertile Hydræ, as in Velella. The polymorphism in these two genera extends only to a marked difference between the primary Hydra and the secondary Hydræ, analogous to the difference there is between the sterile and fertile Hydræ in Campanularia. (Compare *Fig.* 15, p. 46.) Both Velella and Porpita acquire their full size before Medusæ buds appear upon their fertile Hydræ.

In Physalia, the community is also formed upon an enlarged primary Hydra. The young of this genus has been described and figured by Huxley in two different stages of growth (Oceanic Hydrozoa, Pl. X. *Figs.* 1 and 2). In the earliest stage it is a simple Hydra with a single tentacle (*Fig.* 1); and while that primary

Fig. 49.

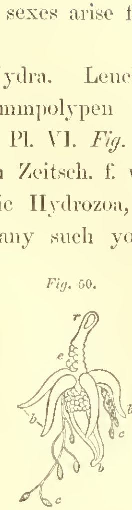


Physalia Arethusa, Til.
a Blunt end of the air sac, supporting the whole community, at which the youngest Medusæ buds may be found. — *b* Open end of the air sac, the mouth of the primary Hydra. — *c* Crest of the air sac. — *m* Bunches of single individuals; and among them the youngest Medusæ buds. — *n* Contracted tentacle. — *t t* Tentacles of the largest kind extended.

Hydra is enlarging and assuming its permanent characteristics, other secondary Hydræ, somewhat different from the first, bud forth from it, and form with it a Hydrarium (*Fig.* 2), gradually enlarging by the addition of others. But there is this difference between such a Physalia Hydrarium and a Velella Hydrarium, that in the former the successive secondary Hydræ differ among themselves greatly, — some acquiring a considerable size and having a large tentacle, while others remain small and have a small tentacle, and the proboscis of some having an open mouth, while in others it remains closed. But, as I shall show hereafter, similar differences are also observed among the Hydroids proper; so that the peculiarities noticed in the different Hydræ amount only to a more extensive polymorphism in this genus than in Velella and Porpita, akin to what we have already seen in Hydractinia. As I myself have seen a great many small Physaliæ in the Gulf of Mexico, I may add that these communities acquire a considerable size before any other but Hydræ buds are developed from their pendent bunches. But when about one fourth the size (*Fig.* 49) of the largest I have ever seen, the Medusæ buds begin to make their appearance and increase in number, until they form distinct Medusaria combined with Hydraria; and the whole community is then a most complicated Hydro-Medusarium. The androphores and gynophores of such a community are respectively the male and female Medusæ; and buds of both sexes arise from one and the same Hydra, the so-called gonoblastidium.

In Physophoridæ also, the community begins with a single Hydra. Leuckart (Zoologische Untersuchungen, I. Pl. 2, *Fig.* 23), Kölliker (Schwimmpolypen von Messina, Pl. II. *Fig.* 11), Vogt (Siphonophores de la mer de Nice, Pl. VI. *Fig.* 24; Pl. X. *Figs.* 32 and 35; and Pl. XI.), Gegenbauer (Beiträge, etc., in Zeitsch. f. wiss. Zool. vol. 5, Pl. XVII. *Figs.* 7, 8, 9, and 11), and Huxley (Oceanic Hydrozoa, Pl. VI. *Fig.* 12, and Pl. VIII. *Fig.* 2), have described and figured many such young Physophoridæ, exhibiting the primary Hydræ of different genera more or less free from the secondary productions budding from their sides. In the youngest of them the Hydra character is quite plain, and their resemblance to the young Physalia most striking (*Fig.* 50). But their resemblance to the Hydroid of Nemopsis Gibbesii *McCrady* is still more important, since it shows, beyond the possibility of a doubt, the close affinity of the naked-eyed Medusæ and the Siphonophoræ. Thus far, all the Medusæ known as originating from Hydroids had been observed to bud from Hydroids attached by their basis; but, in a recent paper (Gymnophthalmata of Charleston harbor, published in the Proceedings of the Elliott Society of Nat. Hist. for 1858), Mr. McCrady has described a species of Nemopsis, which originates from a floating, locomotive Hydroid, so similar to a young Physophora with incipient buds of swimming-bells, that, had he not traced the connection of the free Medusa to its Hydroid, or had the Hydroid alone, with its young Medusæ buds, been observed, it would unquestionably have been considered as a distinct genus belonging to the Siphonophoræ. A more direct proof that the so-called swimming-bells (Nectocalyces) of the Physophoridæ are genuine Medusæ buds remaining connected with the elongated axis of the primary Hydra (the Coenosarc) from which they grow, cannot be desired. And the only marked generic difference between Nemopsis and Physophora consists in the presence of tentacles and sexual organs in the Medusæ of the former which become free, while those of the latter are sterile and remain attached. But such differences are not essential among animals in which polymorphism occurs so extensively as in the lower Acalephs.

Fig. 50.



YOUNG PHYSOPHORA,
(*Copied from Gegenbauer.*)
e Buds of so-called swimming-bells. — *b b* So-called tentacles; lower *b* so-called Polyp. — *c c* Feelers with lasso cells. — *r* Air sac. — *r*, lower *b*, and *c*, the primary Hydra; *b* and *b* secondary Hydræ; *e* the Medusæ buds.

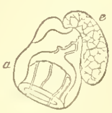
Very early the single Hydræ, from which arise the communities of Physophoridæ, bring forth two kinds of buds, — Medusæ buds on their abactinal pole, and Hydræ buds on their actinal pole. Thus the community at once becomes a Hydro-Medusarium, consisting of one kind of Medusæ which remain sterile and never free themselves, and of two kinds of Hydræ; namely, the primary Hydra, which is gradually enlarged and elongated and from which hang all the other secondary buds, and the secondary Hydræ, which are more or less similar to one another and remain small through life.

The next step in the complication of these communities consists in the appearance of other kinds of Medusæ and other kinds of Hydroids, variously combined in different genera: the additional Medusæ being genuine sexual Medusæ, and the additional Hydroids partaking also, more or less, of the character of Medusæ. A comparison of these sexual Medusæ buds of Siphonophoræ with the Medusæ buds of ordinary Hydroids must satisfy any one, equally familiar with the mode of development of the two types, that there is no essential difference between them. The illustrations published by Kölliker in the "Schwimmpolypen" (Pl. VIII. *Figs.* 4 and 5) afford the best example on record for a comparison with *Figs.* 13, 14, 15, and 16 of Pl. XVIII. of this work. *Fig.* 4 of Kölliker represents what he calls the testis of Vogtia pentacantha; it is the exact counterpart of my *Figs.* 13 and 14, which represent a male Medusa of Coryne mirabilis. Kölliker's *Fig.* 5 represents what he calls the ovary of the Vogtia; it corresponds exactly to my *Figs.* 15 and 16, which represent the female Medusa of Coryne. Now this so-called testis and this so-called ovary consist of a genuine Medusa bell, with four radiating chymiferous tubes and a circular tube, identical in their structure and arrangement with the chymiferous tubes of all the naked-eyed Medusæ. The resemblance extends even further: Kölliker's *Fig.* 4 shows distinctly the proboscis of this supposed testis; it is marked *c* in his figure and described as sperm sac, and its vibratile cavity is marked *d*. The proboscis of the supposed ovary is not less distinct in *Fig.* 5; it is marked *c*, and described as an egg sac. But had Kölliker examined more fully these prominent sacs arising from the centre of their Medusæ bells, he would have satisfied himself that the sperm cells and the eggs are not contained in the cavity of the sacs, but arise, as the eggs and sperm cells of the Coryne, in the outer wall of the sacs; that is, upon the proboscis of the Medusæ, as in Coryne and a large number of other genera of naked-eyed Medusæ.

The second kind of secondary Hydræ, upon the actinal prolongation of the axis of the primary Hydra of many Physophoridæ, differs from those already described in having a so-called covering scale (Deckblatt, Hydrophyllium) by the side of their pendent proboscis. As I have already shown (pp. 54 to 56), this is a kind of open bell, intermediate in its character between the calyx of an ordinary Hydroid and the bell of an ordinary Medusa, more medusoid than the calyx of a Hydroid but less so than a Medusa proper, having no radiating chymiferous tubes, and differing from both in being one sided and more or less flattened. But as one-sided calyces occur also among Hydroids, this does not constitute an important difference, nor a distinguishing feature for Siphonophoræ.

It has already been stated, that the communities of Diphyidæ [1] begin with a Medusa (*Fig.* 51), judging from the investigations of Gegenbauer detailed above

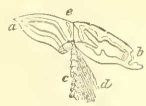
Fig. 51.



Embryo of
Diphyes Sieboldii, Köll.
(*Copied from Gegenbauer.*)

e Remnant of the embryonal body. — *a* Swimming-bell developed from the embryonal body.

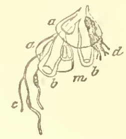
Fig. 52.



Galeolaria filiformis, Leuck.
Diphyes quadrivalvis, Gegenb.
(*Copied from Gegenbauer.*)

a b Anterior and posterior swimming-bells. — *c* String of twin individuals. — *d* Feelers with lasso cells. — *e* Cæcal termination or base of the connecting tube or axis of the community.

Fig. 53.



Two twin individuals of the pendent string of the community of
Diphyes Sieboldii, Köll.

a a The so-called scales. — *b b* The so-called Polyps. — *m* The so-called sexual capsule. — *c* External feeler, with lasso cells. — *d* Feeler contracted.

(pp. 53 and 54), and that from the first twin community, formed of two sterile Medusæ (*Fig.* 52 *a b*), arise a string of similar twin communities (*Fig.* 52 *c*), consisting of a medusoid Hydra (*Fig.* 53 *a a*) and a fertile sexual Medusa (*Fig.* 53 *m*), the so-called Gonocalyx, dropping off together and living for a time as independent beings, several of which have been described as distinct genera.

If the views I have here presented of the nature of the Siphonophoræ are correct, there is no need of a special nomenclature to describe the different individuals of their communities; and we shall hereafter deal with them as with different kinds of Hydræ and of Medusæ, describing successively their polymorphous individuals as we would describe different genera and species of Hydroids and of free Acalephs belonging to other families of the class, and introduce only one new element in these descriptions, on account of the different modes of association of the many individuals united together in one and the same community, as it becomes necessary here to allude to their various combinations.

[1] Since the preceding pages were printed I have received two interesting papers upon Diphyidæ and Physophoridæ from their distinguished author, Dr. C. Gegenbauer: Ueber Abyla trigona und deren Eudoxiernbrut, Jena, 4to. fig.; and Neue Beiträge zur nähern Kenntniss der Siphonophoren; separately printed from the Act. Nov. Acad. Natur. Curios. for the current year.

SECTION V.

INDIVIDUALITY AND SPECIFIC DIFFERENCES AMONG ACALEPHS.

The morphological phenomena discussed in the preceding section naturally lead to a consideration of individuality, and of the extent and importance of specific differences among the Acalephs. A few years ago the prevailing opinion among naturalists was, that, while genera, families, orders, classes, and any other more or less comprehensive division among animals, were artificial devices of science to facilitate our studies, species alone had a real existence in nature. Whether the views I have presented in the first volume of this work (p. 163), where I showed that species do not exist in any different sense from genera, families, etc., etc., had any thing to do with the change which seems to have been brought about upon this point among scientific men, is not for me to say. But, whatever be the cause, it is certainly true, that, at the present day, the number of naturalists who deny the real existence of species is greatly increased.

Darwin, in his recent work on the "Origin of Species,"[1] has also done much to shake the belief in the real existence of species; but the views he advocates are entirely at variance with those I have attempted to establish. For many years past I have lost no opportunity to urge the idea, that while species have no material existence, they yet exist as categories of thought, in the same way as genera, families, orders, classes, and branches of the animal kingdom. Darwin's fundamental idea, on the contrary, is, that species, genera, families, orders, classes, and any other kind of more or less comprehensive divisions among animals, do not exist at all, and are altogether artificial, differing from one another only in degree, all having originated from a successive differentiation of a primordial organic form, undergoing successively such changes as would at first produce a variety of species; then genera, as the difference became more extensive and deeper; then families, as the gap widened still farther between the groups; until, in the end, all that diversity was produced which has existed or which now exists. Far from agreeing with these views, I have, on the contrary, taken the ground that all the natural divisions in the animal kingdom are primarily distinct, founded upon different categories of characters, and that all exist in the same way, that is, as categories of thought embodied in individual living forms. I have attempted

[1] DARWIN (CHARLES), On the Origin of Species by means of Natural Selection, or the Preservation of favored Races in the Struggle for Life. London, 1860. 1 vol. 8vo.

to show that branches in the animal kingdom are founded upon different plans of structure, and for that very reason have embraced from the beginning representatives between which there could be no community of origin; that classes are founded upon different modes of execution of these plans, and therefore they also embrace representatives which could have no community of origin; that orders represent the different degrees of complication in the mode of execution of each class, and therefore embrace representatives that could not have a community of origin any more than the members of different classes or branches; that families are founded upon different patterns of form, and embrace representatives equally independent in their origin; that genera are founded upon ultimate peculiarities of structure, embracing representatives, which, from the very nature of their peculiarities, could have no community of origin; and that, finally, species are based upon relations and proportions that exclude, as much as all the preceding distinctions, the idea of a common descent.

As the community of characters among the beings belonging to these different categories arises from the intellectual connection which shows them to be categories of thought, they cannot be the result of a gradual material differentiation of the objects themselves. The argument on which these views are founded may be summed up in the following few words: species, genera, families, etc., exist as thoughts; individuals, as facts. It is presented at full length in the first volume of this work (pp. 137–168), where I have shown that individuals alone have a definite material existence, and that they are for the time being the bearers, not only of specific characteristics, but of all the natural features in which animal life is displayed in all its diversity; individuality being, in fact, the great mystery of organic life.

Since the arguments presented by Darwin in favor of a universal derivation, from one primary form, of all the peculiarities existing now among living beings, have not made the slightest impression on my mind, or modified in any way the views I have already propounded, I may fairly refer the reader to the paragraphs alluded to above as containing sufficient evidence of their correctness; and I will here only add a single argument, which seems to leave the question where I have placed it. Had Darwin or his followers furnished a single fact to show that individuals change, in the course of time, in such a manner as to produce, at last, species different from those known before, the state of the case might be different.[1] But it stands recorded now as before, that the animals known to the

[1] It seems to me that there is much confusion of ideas in the general statement, of the variability of species, so often repeated of late. If species do not exist at all, as the supporters of the transmutation theory maintain, how can they vary? And if individuals alone exist, how can the differences

ancients are still in existence, exhibiting to this day the characters they exhibited of old. The geological record, even with all its imperfections exaggerated to distortion, tells now, what it has told from the beginning, that the supposed intermediate forms between the species of different geological periods are imaginary beings, called up merely in support of a fanciful theory. The origin of all the diversity among living beings remains a mystery, as totally unexplained as if the book of Darwin had never been written; for no theory, unsupported by fact, however plausible it may appear, can be admitted in science.[1]

which may be observed among them prove the variability of species? The fact seems to me to be, that, while species are based upon definite relations among individuals, which differ in various ways among themselves, each individual, as a distinct being, has a definite course to run from the time of its first formation to the end of its existence, during which it never loses its identity nor changes its individuality, nor its relations to other individuals belonging to the same species, but preserves all the categories of relationship which constitute specific or generic or family affinity, or any other kind or degree of affinity. *To prove that species vary, it should be proved that individuals, born from common ancestors, change the different categories of relationship which they bore primitively to one another;* while all that has thus far been shown is, that there exists a considerable difference among individuals of one and the same species. This may be new to those who have looked upon every individual picked up at random, as affording the means of describing satisfactorily any species; but no naturalist who has studied carefully any of the species now best known, can have failed to perceive that it requires extensive series of specimens accurately to describe a species, and that the more complete such series are, the more precise appear the limits which separate species. Surely the aim of science cannot be to furnish amateur zoölogists or collectors a *recipe* for a ready identification of any chance specimen that may fall into their hands. And the difficulties with which we may meet in attempting to characterize species do not afford the first indication that species do not exist at all, as long as most of them can be distinguished, as such, almost at first sight. I foresee that some convert to the transmutation creed will at once object, that the facility with which species may be distinguished is no evidence that they were not derived from other species. It may be so. But, as long as no fact is adduced to show that any one well-known species among the many thousands that are buried in the whole series of fossiliferous rocks is actually the parent of any one of the species now living, such arguments can have no weight; and thus far the supporters of the transmutation theory have failed to produce any such facts. Instead of facts, we are treated with marvellous bear, cuckoo, and other stories. Credat Judæus Apella!

[1] It seems generally admitted, that the work of Darwin is particularly remarkable for the fairness with which he presents the facts adverse to his views. It may be so; but I confess that it has made a very different impression upon me. I have been more forcibly struck with his inability to perceive when the facts are fatal to his argument, than with any thing else in the whole work. His chapter on the Geological Record, in particular, appears to me to be, from beginning to end, a series of illogical deductions and misrepresentations of the modern results of Geology and Palæontology. I do not intend to argue here, one by one, the questions he has discussed. Such arguments end too often in special pleading; and any one familiar with the subject may readily perceive where the truth lies, by confronting his assertions with the geological record itself. But, since the question at issue is chiefly to be settled by palæontological evidence, and I have devoted the greater part of my life to the special study of the fossils, I wish to record my protest against his mode

It would be out of place to discuss here in detail the arguments by which Darwin attempts to explain the diversity among animals. Suffice it to say

of treating this part of the subject. Not only does Darwin never perceive when the facts are fatal to his views, but, when he has succeeded by an ingenious circumlocution in overleaping the facts, he would have us believe that he has lessened their importance, or changed their meaning. He would thus have us believe that there have been periods during which all that had taken place during other periods was destroyed; and this solely to explain the absence of intermediate forms between the fossils found in successive deposits, for the origin of which he looks to those missing links, whilst every recent progress in Geology shows more and more fully how gradual and successive all the deposits have been which form the crust of our earth. — He would have us believe that entire faunæ have disappeared before those were preserved, the remains of which are found in the lowest fossiliferous strata; when we find everywhere non-fossiliferous strata below those that contain the oldest fossils now known. It is true, he explains their absence by the supposition that they were too delicate to be preserved; but any animals from which Crinoids, Brachiopods, Cephalopods, and Trilobites could arise, must have been similar enough to them to have left, at least, traces of their presence in the lowest non-fossiliferous rocks, had they ever existed at all. — He would have us believe that the oldest organisms that existed were simple cells, or something like the lowest living beings now in existence; when such highly organized animals as Trilobites and Orthoceratites are among the oldest known. — He would have us believe that these lowest first born became extinct, in consequence of the gradual advantage some of their more favored descendants gained over the majority of their predecessors; when there exist now, and have existed at all periods in past times, as large a proportion of more simply organized beings, as of more favored types; and when such types as Lingula were among the lowest Silurian fossils, and are alive at the present day. — He would have us believe that each new species originated in consequence of some slight change in those that preceded; when every geological formation teems with types that did not exist before. — He would have us believe that animals and plants became gradually more and more numerous; when most species appear in myriads of individuals, in the first bed in which they are found. — He would have us believe that animals disappear gradually; when they are as common in the uppermost bed in which they occur, as in the lowest, or any intermediate bed. Species appear suddenly and disappear suddenly in successive strata. That is the fact proclaimed by Palæontology; they neither increase successively in number, nor do they gradually dwindle down; none of the fossil remains thus far observed show signs of a gradual improvement or of a slow decay. — He would have us believe that geological deposits took place during periods of subsidence; when it can be proved that the whole continent of North America is formed of beds which were deposited during a series of successive upheavals. I quote North America in preference to any other part of the world, because the evidence is so complete here that it can be overlooked only by those who may mistake subsidence for the general shrinking of the earth's surface, in consequence of the cooling of its mass. In this part of the globe, fossils are as common along the successive shores of the rising deposits of the Silurian system, as anywhere along our beaches; and each of these successive shores extends from the Atlantic States to the foot of the Rocky Mountains. The evidence goes even further; each of these successive sets of beds of the Silurian system contains peculiar fossils, neither found in the beds above nor in the beds below, and between them there are no intermediate forms. And yet Darwin affirms that "the littoral and sub-littoral deposits are continually worn away, as soon as they are brought up by the slow and gradual rising of the land within the grinding action of the coast waves." Origin of Species, p. 290. — He would also have us believe that he has lost sight of the most striking of the features, and the one which pervades the whole, namely, that there runs throughout nature unmistakable evidence of thought, corresponding to the mental operations of our own mind, and therefore intelligible to us as thinking beings, and unaccountable on any other basis than that they owe their existence to the working of intelligence; and no theory that overlooks this element can be true to nature.[1] It is true, Darwin

that the most perfect organs of the body of animals are the product of gradual improvement; when eyes as perfect as those of the Trilobites are preserved with the remains of these oldest animals. — He would have us believe that it required millions of years to effect any one of these changes; when far more extraordinary transformations are daily going on, under our eyes, in the shortest periods of time, during the growth of animals. — He would have us believe that animals acquire their instincts gradually; when even those that never see their parents, perform at birth the same acts, in the same way, as their progenitors. — He would have us believe that the geographical distribution of animals is the result of accidental transfers; when most species are so narrowly confined within the limits of their natural range, that even slight changes in their external relations may cause their death. And all these, and many other calls upon our credulity, are coolly made in the face of an amount of precise information, readily accessible, which would overwhelm any one who does not place his opinions above the records of an age eminently characterized for its industry; and during which, that information was laboriously accumulated by crowds of faithful laborers.

[1] There are naturalists who seem to look upon the idea of creation — that is, a manifestation of an intellectual power by material means — as a kind of bigotry; forgetting, no doubt, that whenever they carry out a thought of their own, they do something akin to creating; unless they look upon their own elucubrations as something in which their individuality is not concerned, but arising without an intervention of their mind, in consequence of the working of some "bundles of forces," about which they know nothing themselves. And yet such men are ready to admit that matter is omnipotent, and consider a disbelief in the omnipotence of matter tantamount to imbecility; for, what is the assumed power of matter to produce all finite beings, but omnipotence? And what the outcry raised against those who cannot admit it, but an insinuation that they are *non compos?* The book of Mr. Darwin is free of all such uncharitable sentiments towards his fellow-laborers in the field of science; nevertheless, his mistake lies in a similar assumption that the most complicated system of combined thoughts can be the result of accidental causes: for he ought to know, as every physicist will concede, that all the influences to which he would ascribe the origin of species are accidental in their very nature; and he must know, as every naturalist familiar with the modern progress of science does know, that the organized beings which live now, and have lived in former geological periods, constitute an organic whole, intelligibly and methodically combined in all its parts. As a zoölogist he must know, in particular, that the animal kingdom is built upon four different plans of structure; and that the reproduction and growth of animals take place according to four different modes of development; and that, unless it is shown that these four plans of structure and these four modes of development are transmutable one into the other, no transmutation theory can account for the origin of species. The fallacy of Darwin's theory of the origin of species by means of natural selection may be traced in the first few pages of his book, where he overlooks the difference between the voluntary and deliberate acts of selection applied methodically by man to the breeding of domesticated animals and the growing of cultivated plants, and the chance influences which may affect animals and plants in a state of

states that the close affinity existing among animals can only be explained by a community of descent, and he goes so far as to represent these affinities as evidence of such a genealogical relationship; but I apprehend that the meaning of the words he uses has misled him into the belief that he had found the clue to phenomena which he does not even seem correctly to understand. There is nothing parallel between the relations of animals belonging to the same genus or the same family, and the relations between the progeny of common ancestors. In the one case we have the result of a physiological law regulating reproduction, and in the other, affinities which no observation has thus far shown to be in any way connected with reproduction. The most closely allied species of the same genus or the different species of closely allied genera, or the different genera of one and the same natural family, embrace representatives, which, at some period or other of their growth, resemble one another more closely than the nearest blood relations; and yet we know that they are only stages of development of different species distinct from one another at every period of their life. The embryo of our common fresh-water turtle (*Chrysemis picta*) and the embryo of our snapping turtle (*Chelydra serpentina*) resemble one another far more than the different species of Chrysemis in their adult state; and yet not a single fact can be adduced to show that any one egg of an animal has ever produced an individual of any species but its own. A young snake resembles a young turtle or a young bird much more than any two species of snakes resemble one another; and yet they go on reproducing their kinds, and nothing but their kinds. So that no degree of affinity, however close, can, in the present state of our science, be urged as

nature. To call these influences "natural selection," is a misnomer which will not alter the conditions under which they may produce the desired results. Selection implies design; the powers to which Darwin refers the origin of species can design nothing. Selection is no doubt the essential principle on which the raising of breeds is founded; and the subject of breeds is presented in its true light by Darwin: but this process of raising breeds by the selection of favorable subjects is in no way similar to that which regulates specific differences. Nothing is more remote from the truth than the attempted parallelism between the breeds of domesticated animals and the species of wild ones. Did there exist such a parallelism as Darwin maintains, the differences among the domesticated breeds should be akin to the differences among wild species; and afford a clue to determine their relative degree of affinity by a comparison with the pedigrees of well-known domesticated races. Again, if there were any such parallelism, the distinctive characteristics of different breeds should be akin to the differences which exist between fossil species of earlier periods, and those of the same genera now living. Now, let any one familiar with the fossil species of the the genera Bos and Canis compare them with the races of our dogs and of our cattle, and he will find no correspondence whatever between them; for the simple reason, that they do not owe their existence to the same causes. It must therefore be distinctly stated, that Darwin has failed to establish a connection between the mode of raising domesticated breeds and the cause or causes to which wild animals owe their specific differences.

exhibiting any evidence of community of descent; while the power that imparted all their peculiarities to the primitive eggs of all the species now living side by side, could also impart similar peculiarities with similar relations, and all degrees of relationship, to any number of other species that have existed previously. Until, therefore, it can be shown that any one species has the ability to delegate such specified peculiarities and relations to any other species or set of species, it is not logical to assume that such a power is inherent in any animal, or that it constitutes part of its nature.[1] We must look to the original power that imparted life to the first being for the origin of all other beings, however mysterious and inaccessible the modes by which all this diversity has been produced, may remain for us. A plausible explanation is no explanation at all, if it does not cover the whole ground.[2]

[1] The difficulty of ascertaining the natural limits of some species, and the mistakes made by naturalists when describing individual peculiarities as specific, have nothing to do with the question of the origin of species; and yet, Darwin places great weight, in support of his theory, upon the differences which exist among naturalists in their views of species. Some of the metals are difficult to distinguish, and have frequently been mistaken, and the specific differences of some may be questioned; but what could that have to do with the question of the origin of metals, in the minds of those who may doubt the original difference of metals? Nothing more than the blunders of some naturalists, in identifying species, with the origin of species of animals and plants. The great mischief in our science now lies in the self-complacent confidence with which certain zoölogists look upon a few insignificant lines, called diagnoses, which they have the presumption to offer as characteristics of species, or, what is still worse, as checks upon others to secure to themselves a nominal priority. Such a treatment of scientific subjects is unworthy of our age.

[2] All the attempts to explain the origin of species may be brought under two categories: some naturalists admitting that all organized beings are created (that is to say, endowed from the beginning of their existence with all their characteristics), while others assume that they arise spontaneously. This classification of the different theories of the origin of species may appear objectionable to the supporters of the transmutation theory; but I can perceive no essential difference between their views and the old idea that animals may have arisen spontaneously. They differ only in the modes by which the spontaneous appearance is assumed to be effected. Some believe that physical agents may so influence organized beings as to modify them; this is the view of DeMaillet, and the Vestiges of Creation: others believe that the organized beings themselves change in consequence of their own acts, by changing their mode of life, etc.: this is the view of Lamarck: others still assume that animals and plants tend necessarily to improve, in consequence of the struggle for life, in which the favored races are supposed to survive; this is the view lately propounded by Darwin. I believe these theories will, in the end, all share the fate of the theory of spontaneous generations, so called, as the facts of nature shall be confronted more closely with the theoretical assumptions. The theories of DeMaillet, Oken, and Lamarck, are already abandoned by all those who have adopted the transmutation theory of Darwin; and unless Darwin and his followers succeed in showing that the struggle for life tends to something beyond favoring the existence of certain individuals over that of other individuals, they will soon find that they are following a shadow. The assertion of Darwin, which has crept into the title of his work, is, that favored

Whatever views are correct concerning the origin of species, one thing is certain, that as long as they exist they continue to produce, generation after generation, individuals which differ from one another only in such peculiarities as relate to their individuality. The great defect in Darwin's treatment of the subject of species lies in the total absence of any statement respecting the features that constitute individuality. Surely, if individuals may vary within the limits assumed by Darwin, he was bound first to show that individuality does not consist of a sum of hereditary characteristics, combined with variable elements, not necessarily transmitted in their integrity, but only of variable elements. That the latter is not the case, stands recorded in every accurate monograph of all the types of the animal kingdom upon which minute embryological investigations have been made. It is known that every individual egg undergoes a series of definite changes before it reaches its mature condition; that every germ formed in the egg passes through a series of metamorphoses before it assumes the structural features of the adult; that in this development the differences of sex may very early become distinct; and that all this is accomplished in a comparatively very short time, — extremely short, indeed, in comparison to the immeasurable periods required by Darwin's theory to produce any change among species; and yet all this takes place without any deviation from the original type of the species, though under circumstances which would seem most unfavorable to the maintenance of the type. Whatever minor differences may exist between the products of this succession of generations are all *individual peculiarities,* in no way connected with the essential features of the species, and therefore as

races are preserved; while all his facts go only to substantiate the assertion that favored *individuals* have a better chance in the struggle for life than others. But who has ever overlooked the fact that myriads of individuals of every species constantly die before coming to maturity? What ought to be shown, if the transmutation theory is to stand, is, that these favored individuals diverge from their specific type; and neither Darwin nor anybody else has furnished a single fact to show that they go on diverging. The criterion of a true theory consists in the facility with which it accounts for facts accumulated in the course of long-continued investigations, and for which the existing theories afforded no explanation. It cannot, certainly, be said that Darwin's theory will stand by that test. It would be easy to invent other theories that might account for the diversity of species quite as well, if not better, than Darwin's preservation of favored races. The difficulty would only be to prove that they agree with the facts of nature. It might be assumed, for instance, that any one primary being contained the possibilities of all those that have followed, in the same manner as the egg of any animal possesses all the elements of the full-grown individual; but this would only remove the difficulty one step further back. It would tell us nothing about the nature of the operation by which the change is introduced. Since the knowledge we now have, that similar metamorphoses go on in the eggs of all living beings, has not yet put us on the track of the forces by which the changes they undergo are brought about, it is not likely that by mere guesses we shall arrive at any satisfactory explanation of the very origin of these beings themselves.

transient as the individuals; while the specific characters are for ever fixed. A single example will prove this. All the robins of North America now living have been for a short time in existence; not one of them was alive a century ago, when Linnæus for the first time made known that species, under the name of Turdus migratorius, and not one of the specimens observed by Linnæus and his contemporaries was alive when the pilgrims of the Mayflower first set foot upon the rock of Plymouth. Where was the species at these different periods, and where is it now? Certainly nowhere but in the individuals alive for the time being; but not in any single one of them, for that one must be either a male or a female, and not the species; not in a pair of them, for the species exhibits its peculiarities in its mode of breeding, in its nest, in its eggs, in its young, as much as in the appearance of the adult; not in all the individuals of any particular district, for the geographical distribution of a species over its whole area forms also part of its specific characters.[1] A species is only known when its whole history has been ascertained, and that history is recorded in the life of individuals through successive generations. The same kind of argument might be adduced from every existing species, and with still greater force, by a reference to those species already known to the ancients.

Let it not be objected, that the individuals of successive generations have presented marked differences among themselves; for these differences, with all the monstrosities that may have occurred during these countless generations, have passed away with the individuals as individual peculiarities, and the specific characteristics alone have been preserved, together with all that distinguishes the genus, the family, the order, the class, and the branch to which the individual belonged. And all this has been maintained through a succession of repeated changes, amounting in each individual to the whole range of transformations through which an individual passes, from the time it is individualized as an egg to the time it is itself capable of reproducing its kind, and, perhaps, with all the intervening phases of an unequal production of males and females, of sterile individuals, of dwarfs, of giants, etc., etc., during which there were millions of chances for a deviation from the type. Does this not prove, that, while individuals are perishable, they transmit, generation after generation, all that is specific or generic, or, in one word, *typical* in them, to the exclusion of every *individual peculiarity*, which

[1] We are so much accustomed to see animals reproducing themselves generation after generation, that the fact no longer attracts our attention, and the mystery involved in it no longer excites our admiration. But there is certainly no more marvellous law in all nature than that which regulates this regular succession. And upon this law the maintenance of species depends; for observation teaches us that all that is not individual peculiarity is unceasingly and integrally reproduced, while all that constitutes individuality, as such, constantly disappears.

passes away with them; and that, therefore, while individuals alone have a material existence, species, genera, families, orders, classes, and branches of the animal kingdom, exist only as categories of thought in the Supreme Intelligence, and, as such, have as truly an independent existence, and are as unvarying, as thought itself after it has once been expressed.

Returning, after this digression, to the question of individuality among Acalephs, we meet here phenomena far more complicated than among higher animals. Individuality, as far as it depends upon material isolation, is complete and absolute in all the higher animals, and there maintained by genetic transmission, generation after generation. Individuality, in that sense, exists only in comparatively few of the Radiates. Among Acalephs it is ascertained only for the Ctenophoræ and some Discophoræ. In others, the individuals born from eggs end by dividing into a number of distinct individuals. In others still, the successive individuals derived from a primary one remain connected to form compound communities. We must, therefore, distinguish different kinds and different degrees of individuality, and may call *hereditary individuality* that kind of independent existence manifested in the successive evolutions of a single egg, producing a single individual, as is observed in all the higher animals. We may call *derivative* or *consecutive individuality* that kind of independence resulting from an individualization of parts of the product of a single egg. We have such derivative individuals among the Nudibranchiate Mollusks, whose eggs produce singly, by a process of complete segmentation, several independent individuals. We observe a similar phenomenon among those Acalephs, the young of which (Scyphostoma) ends in producing, by transverse division (Strobila), a number of independent free Medusæ (Ephyræ). We have it also among the Hydroids which produce free Medusæ. Next, we must distinguish *secondary individuality*, which is inherent in those individuals arising as buds from other individuals, and remaining connected with them. This condition prevails in all the immovable Polyparia and Hydraria, and I say intentionally in the immovable ones; for, in the movable communities, — such as Renilla, Pennatula, etc., among Polyps, and all the Siphonophoræ among Acalephs, — we must still further distinguish another kind of individuality, which I know not how to designate properly, unless the name of *complex individuality* may be applied to it. In complex individuality a new element is introduced, which is not noticeable in the former case. The individuals of the community are not only connected together, but, under given circumstances, they act together as if they were one individual, while at the same time each individual may perform acts of its own.

As to the specific differences observed among Acalephs, there is as great a diversity between them as between their individuals. In some types of this class the species are very uniform, — all the individuals belonging to one and the same species resembling one another very closely, and exhibiting hardly any differences among themselves, excepting such as arise from age. This identity of the individuals of one and the same species is particularly striking among the Ctenophoræ. In this order, there are not even sexual differences among the individuals, as they are all hermaphrodites. In the Discophoræ proper, a somewhat greater diversity prevails. In the first place, we notice male and female individuals; and the difference between the sexes is quite striking in some genera, as, for instance, in Aurelia. Next, there occur frequent deviations among them in the normal number of their parts, — their body consisting frequently of one or two spheromeres more than usual, sometimes even of double the normal number, or of a few less. And yet year after year the same Discophoræ reappear upon our shores, with the same range of differences among their individuals. Among Hydroids, polymorphism prevails to a greater or less extent, besides the differences arising from sex. Few species have only one kind of individuals. Mostly the cycle of individual differences embraces two distinct types of individuals, one recalling the peculiarities of common Hydræ, the other those of Medusæ; but even the Hydra type of one and the same species may exhibit more or less diversity, there being frequently two kinds of Hydræ united in one and the same community, and sometimes even a larger number of heterogeneous Hydræ. And this is equally true, though to a less extent, of the Medusa type. Yet, among Siphonophoræ, there are generally at least two kinds of Medusæ in one and the same community. But, notwithstanding this polymorphism among the individuals of one and the same community genetically connected together, each successive generation reproduces the same kinds of heterogeneous individuals, and nothing but individuals, linked together in the same way. Surely, we have here a much greater diversity of individuals, born one from the other, than is exhibited by the most diversified breeds of our domesticated animals; and yet all these heterogeneous individuals remain true to their species, in one case as in the other, and do not afford the slightest evidence of a transmutation of species.

Would the supporters of the fanciful theories lately propounded, only extend their studies a little beyond the range of domesticated animals, — would they investigate the alternate generations of the Acalephs, the extraordinary modes of development of the Helminths, the reproduction of the Salpæ, etc., etc., — they would soon learn that there are in the world far more astonishing phenomena, strictly circumscribed between the natural limits of unvarying species, than the slight differences produced by the intervention of men, among domesticated animals; and, perhaps, cease to be so confident, as they seem to be, that these differences are trustworthy indications of the variability of species. For my own part, I must emphatically declare that I do not know a single fact tending to show that species do vary in any way, while it is true that the individuals of one and the same species are more or less polymorphous. The circumstance that naturalists may find it difficult to trace the natural limits of any one particular species, or the mistakes they may make in their attempts to distinguish them, has nothing whatsoever to do with the question of their origin.

There is another feature of the species of Acalephs, which deserves particularly to be noticed. All these animals are periodical in their appearance, and last for a short period in their perfect state of development. In our latitude, most Medusæ make their appearance as Ephyræ early in the spring, and rapidly enlarge to their full size. In September and October, they lay their eggs and disappear; while the young hatched from the eggs move about as Planulæ for a short time, and then become attached as Scyphostomes, and pass the winter in undergoing their Strobila metamorphosis. The Ctenophoræ appear also very early, and lay their eggs in the autumn, passing the winter as young, and growing to their full size towards the beginning of the summer. Among the Hydroids there is more diversity in their periodicity. Hydraria are found all the year round; but the Medusæ buds, the free Medusæ, and the Medusaria make their appearance in different seasons, in different species. Some bring forth Medusæ buds and free Medusæ or Medusaria during winter; others, and in our latitude this is the case with by far the largest number of the Hydroids, produce their Medusæ brood in the spring; while a few breed later, in the summer or in the autumn: so that, notwithstanding the regularity of their periodical return, Acalephs may be studied, in some condition or other, during the whole year.

SECTION VI.

NATURAL LIMITS OF THE CLASS OF ACALEPHS.

The principles upon which the natural limits of this class may be determined have already been discussed (Sect. I. p. 36). They are based upon our knowledge of the structure and embryonic growth of these animals. Upon both points our information is both satisfactory and sufficient. The anatomical researches of the writers quoted from p. 18 to p. 28, and the additional facts I have traced in the preparation of this monograph, cover the ground sufficiently to open a fair view, not only into the general structure of the whole class, but also into the correspondence of the structural features of the different groups of the class, as compared with one another. The same may be said of the embryology of these animals. Besides the data furnished by the investigations already referred to from p. 28 to p. 35, I had most desirable facilities for tracing the embryonic changes of a considerable number of Acalephs. Indeed, I have been able to investigate the embryonic growth of all the types of the class, with the sole exception of the Diphyidæ and Physophoridæ. But Leuckart, Kölliker, Vogt, Gegenbaur, and Huxley have published such full accounts and exhausting researches upon these very families, that little is now wanting to complete the anatomical and embryological history of the whole class. At all events, our comparisons may now extend to every type belonging to this class. And the anatomy and embryology of the other classes of Radiates — the Polyps and Echinoderms — are also sufficiently well known to enable us to institute comparisons between them and the Acalephs, and to trace the differences which bear upon the limitation of their respective classes and subordinate groups. In attempting these comparisons, it is, however, indispensable to bear in mind the difference there is between general and special homologies.

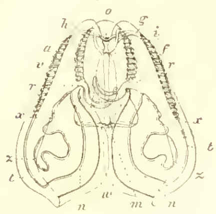
General homologies lead to the knowledge of the identity of such systems of organs as present special structural combinations, and are perhaps adapted to different functions. The extremities of Vertebrates afford a good example of this kind of homologies; the pectoral fins with the thoracic arch of a fish, the wing of a Bird or that of a Bat, and the arms of Man, are identical organs, however different they may appear, between all of which general homologies may be traced. Special homologies, on the contrary, indicate the correspondence of identical parts, differing only in their relative proportions and special adaptations. The different systems of teeth, characteristic of the different genera and families of Mammalia, afford good examples of special homologies; and may be studied from the extensive investigations of Professor Owen upon that subject. Now, the more animals are compared in all their structural details, as well as in their various kinds and different degrees of relationship, the more distinctly does it appear that general homologies are co-extensive with the branches of the animal kingdom, while special homologies are circumscribed within the limits of the classes; or, in other words, that all the classes of one and the same branch have identical systems of organs, however different the organs themselves may be, while the representatives of one and the same class only exhibit identical adaptations in the structure of their organs. Such a distinction, as far as it may be carried out, affords, therefore, a valuable additional test in the delimitation of the classes of animals.

What the types are, which should be referred to the class of Acalephs, will already appear from what has been stated in Section II., p. 41, where I have compared the different types of Radiates with one another. It remains, however, for me to prove that the assertions there made are founded in nature; or, in other words, that the structural features of the animals represented as belonging to the class of Acalephs are not only homologous to one another, in a general way, for this would only prove that they belong to the same branch of the animal kingdom, but that they are homologous in the strictest sense, which will prove them to be members of the same class, if special homologies are really a criterion of class affinities.

The animals which I have considered above as belonging to the class of Acalephs are the Ctenophoræ, the Discophoræ, the Hydroids proper, and the Siphonophoræ, within the limits ascribed to these groups by most authors. I have no hesitation in referring all these to the Acalephs; nor do I think there can be any doubt left that Hydra and the Tabulata, still referred to the class of Polyps by Milne-Edwards, also belong to that of Acalephs. To these I would further add the Rugosa, a type of Corals first recognized as distinct by Milne-Edwards, and referred by him to the class of Polyps. Respecting these last, some uncertainty still remains, since they are all fossil, and their affinities can only be inferred from the structure of their solid parts. As to all the other groups, the evidence that they belong to the class of Acalephs seems to me satisfactory, though it is not throughout of the same kind. For instance, the evidence that the Ctenophoræ are Acalephs is altogether anatomical, and chiefly based upon the special homologies of their parts: it receives no additional confirmation from Embryology, as the young at birth are already very similar to the parent, and do not exhibit those complex relations which we observe in other Acalephs. The affinities of the Discophoræ, Siphonophoræ, and Hydroids, on the contrary, are established upon embryological as well as anatomical evidence.

Beginning with the Ctenophoræ, we have first to sift the arguments brought forward to support their connection with the Mollusks. The idea that the Ctenophoræ are allied to the Tunicata, and especially to the Salpæ, was first suggested by Quoy in the Zoölogy of the Astrolabe (vol. 4, p. 36), and afterwards more fully developed by Vogt in his Zoölogical Letters (vol. 1, p. 254), where he represents them as a distinct class, intermediate between the Bryozoa and the Tunicata, which are themselves also considered as distinct classes. The ground upon which they are brought to the branch of Mollusks is chiefly their bilateral appearance; and it is there stated, that, with the exception of their glassy transparency, they have not one trait of their organization in common with the Acalephs. Such an assertion, from a naturalist to whom science owes important contributions to our present knowledge of an extensive and most intricate group of Acalephs (the Siphonophoræ), cannot be passed unnoticed. That Bryozoa and Tunicata are bilateral animals and truly belong to the type of Mollusks, is unquestionable; and that the Ctenophoræ share the peculiar consistency of their body as fully with the Salpæ as with the common Acalephs, might appear true were it not known that the Ascidians, to which Salpæ belong, have a mantle consisting of Cellulose,[1] while of all Acalephs the Ctenophoræ are the most perishable, and dissolve entirely in water, — their body, however, consisting of cells of the same kind as those of the other Acalephs.

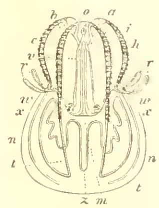
Fig. 54.



BOLINA ALATA, Ag.
(Seen from the broad side.)

a and *f* Long rows of locomotive fringes. — *g* and *h* Short rows of locomotive fringes. — o Central black speck (eye-speck ?). — *i* to *m* Triangular digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity. — *v* Chymiferous tube of the tentacular apparatus. — *m* Tentacular apparatus on the side of the mouth. — *r r* Ear-like lobe, or auricles, in the prolongation of the short rows of locomotive fringes. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same tubes turning upwards. — *x x* Bend of the same tubes. — *z z* Extremity of the same tubes meeting with those of the opposite side. — *w* Recurrent tube anastomozing with those of the auricles.

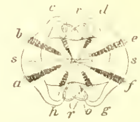
Fig. 55.



BOLINA ALATA, Ag.
(Seen from the narrow side.)

a b Long rows of locomotive fringes. — *c h* Short rows of locomotive fringes. — *o* Central black speck (eye speck ?). — *i* Upper end of the digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity of the body. — *m* to *i* Digestive cavity. — *r r* Auricles. — *m* Mouth. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same turning upwards. — *x x* Bend of the same tubes. — *z* Anastomosis of the two longitudinal tubes *t t*. — *w w* Recurrent tube, anastomozing with those of the auricles. — A comparison of this figure with *Fig.* 4 gives a distinct idea of the relative position of the digestive cavity *m* to *i*, and the chymiferous tubes of the tentacular apparatus *v*.

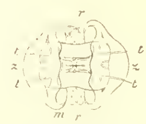
Fig. 56.



BOLINA ALATA, Ag.
(Seen from above.)

o Central black speck (eye speck ?). — *a b e f* Long rows of locomotive fringes. — *c d g h* Short rows of locomotive fringes. — *r r* Auricles. — *s s* Circumscribed area of the upper end of the body.

Fig. 57.



BOLINA ALATA, Ag.
(Seen from below.)

m Mouth. — *r r* Auricles. — *t t t t* Prolongation of the vertical chymiferous tubes. — *z z* Anastomosis of these tubes.

As to the assertion that the Ctenophoræ are bilateral animals, it is only in so far correct that the body is more or less compressed, as the adjoining wood-cuts show (*Figs.* 54, 55, 56, and 57), which represent a Bolina most common along the northern Atlantic coast of America. But the arrangement of all the parts of these animals is truly radiate. Their bilateral appearance is only the result of the inequality of their spheromeres, as is the case with the Spatangoids also, and, in a less degree, with all Echinoderms. But in all these animals the structure is typically radiate, and the bilaterality subordinate to the plan of radiation, in the same manner as in Cephalopods and in Bryozoa the radiated arrangement of the arms and tentacles is subordinate to their bilateral type. The closest comparison of the structure of the Ctenophoræ with that of the Bryozoa and Tunicata on one side and the common Medusæ on the other, will show, that, while all their

[1] See the memorable paper of KÖLLIKER and LÖWIG: De la composition et de la structure des enveloppes des Tuniciers. Ann. Sc. Nat. 3e sér. vol. 5, p. 193.

parts are strictly homologous to those of the Acalephs, they bear no resemblance to those of Mollusks. I have purposely selected, for this comparison, one of the Ctenophoræ in which the bilateral symmetry is most prominent, that the bilateral appearance may not seem intentionally lessened. In our Bolina alata seen from above (*Fig.* 49), there appear eight rays, diverging from the centre: these are formed by the eight rows of locomotive flappers which extend, like meridians, upon the sides of the body. Under these flappers extend eight chymiferous tubes, which are symmetrically radiate in their arrangement, like the ambulacral rows upon the sides of a Sea-urchin. But this is not all. These tubes are also homologous to the radiating chymiferous tubes of the ordinary Medusæ, and to the ambulacral system of the Echinoderms; and while they bear only a general homology to the latter, they have the most special homology to the radiating tubes of the Medusæ. In both they arise from the main cavity of the body; in both they diverge from that centre towards the periphery; in both they connect through anastomoses at the periphery; in both they carry the nutritive fluids to all parts of the body; in both they are accompanied by the sexual organs; while neither Bryozoa nor Tunicata, nor any other Mollusks, have such radiating tubes. In the Ctenophoræ, as in the other Acalephs, the digestive cavity is hollowed out of the mass of the body, with the single difference that the abactinal end of that cavity is freed from the spherosome in Ctenophoræ, while it is not so in the other Acalephs. The Bryozoa and Tunicata, on the contrary, have a distinct alimentary canal entirely free from the walls of the body, and provided with two openings; besides which Tunicata have a heart and a gill, and muscular bundles arranged symmetrically upon the two sides of the body. Fuller evidence of the bilateral structure of the Bryozoa and Tunicata, and of their typical difference from the Ctenophoræ, could hardly be desired.

Assuming, then, that the Ctenophoræ are genuine Radiates, it remains to be seen whether they form a class by themselves, as not only Vogt, but also Leuckart and Gegenbaur, will have it, or whether they are only members of the class of Acalephs: for I hold that naturalists have no more right to please themselves in the limitation of the classes, than in the limitation of genera and species, or any part of a systematic exposition of the relations of animals; and that their task should simply consist in ascertaining, upon clearly defined principles, what nature teaches us respecting these affinities. They may, no doubt, disagree in the application of these principles; but a purely arbitrary classification is no longer admissible. The validity of every group proposed hereafter by an investigator must be discussed before it is admitted or rejected; and the principles upon which the discussions are conducted will themselves become more precise, and be settled more firmly by these discussions.

If, then, classes are characterized by the mode of execution of a given plan, the Ctenophoræ being radiated animals, we have only one point more to ascertain respecting them. Does their structure exhibit only a general homology to that of the Acalephs, or are the Ctenophoræ linked to the ordinary Acalephs by special homologies? What has already been said when considering their typical relations seems to me conclusive in that respect. Ctenophoræ differ only in degree, and not in kind, from the animals thus far generally considered as true Medusæ; they must, therefore, be considered as belonging to the class of Acalephs, in which, as we shall see in the next section, they constitute a natural order.

As the Discophoræ have always been considered as the typical group of the class of Acalephs, and as the Acalephian character of all the other groups that have successively been associated with them, or removed from them, has uniformly been measured by the degree of their affinity to the Discophoræ, as soon as it is ascertained that these animals exhibit a special mode of execution of the plan of radiation, the independence of the Acalephs, as a class, is also proved. And this has already been done in a preceding section (p. 65). In the next, we shall consider the position of the Discophoræ in their class, amidst all the other representatives of that class.

The evidence that the Hydroids should be associated in one and the same class with the Discophoræ and Ctenophoræ is of two kinds. In the first place, Hydroids produce Medusæ; next, they are not themselves Polyps, as was long admitted. The first of these facts furnishes a direct argument for the necessity of uniting that kind of Hydroids with the other Acalephs; and the circumstance that the Hydroids from which free Medusæ arise are not identical in their structure with Polyps, but themselves resemble Medusæ more than Polyps, in connection with what is already known of the reproduction of the latter, shows that Polyps never produce free Medusæ, but that the Polyp-like animals, from which free Medusæ arise, are themselves Acalephs.

It is hardly necessary, nowadays, to demonstrate that such animals as Sarsia, Lizzia, Zanclea, Cladonema, Hippocrene, Nemopsis, Hybocodon, Tiaropsis, Thaumantias, etc., are genuine Medusæ. Their close affinity to the highest representatives of this order of Acalephs has been recognized by all the investigators of this class of animals. Péron and LeSueur, Eschscholtz, deBlainville, Milne-Edwards, Lesson, Sars, Forbes, Dujardin, Leuckart, Gegenbaur, and others have expressed their conviction that they are such, not only by direct declarations, but also in various other ways, when alluding to them. To the arguments adduced by other investigators, new facts have been more recently added: their mode of reproduction has been made known; their sexual organs have been studied; the development of their eggs has been traced through every stage of growth; the formation of their spermatic particles in the sperm cells has been observed; their special homologies with the highest Discophoræ have been made out; and nothing is wanting to prove that the naked-eyed Medusæ, in their adult condition, are genuine Acalephs, closely allied to the covered-eyed Discophoræ. The naturalists who, having identified them with the so-called sexual bunches of the Siphonophoræ, would consider them as free sexual organs because these bunches appear to them to be sexual organs, and not clusters of sterile Medusæ, are bound to show that spermaries and ovaries may have the structure of perfect Medusæ, that is, a gelatinous bell, radiating and circular chymiferous tubes, and a proboscis; not simply by affirming that certain low sessile Medusæ are sexual organs, but by adducing the evidence of a similar structure of the sexual organs in other Acalephs. The burden of furnishing that proof rests with them, because other naturalists have already shown that these supposed free sexual organs, including the gonocalyx of the Diphyidæ and the androphores and gynophores of the Physophoridæ, not only exhibit all the characteristic structural features of genuine Acalephs, but are themselves either male or female individuals provided with ovaries and spermaries.

As the divergence of opinions upon this point has arisen from the peculiar phenomena known as alternate generations, it is proper that we should now turn our attention to this subject for a moment, and examine critically the distinctive features of the various facts now generally considered as constituting one peculiar mode of reproduction; since, from the beginning, heterogeneous phenomena have been confounded under that name. Without stepping beyond the limits of the class of Acalephs, we have, in the first place, the case of the higher Discophoræ, in which, as for instance in Aurelia and Cyanea, the young born from eggs (Pl. X. *Figs.* 1 and 2, and Pl. X^a. *Figs.* 16–24) as independent, locomotive, single individuals (Pl. X. *Figs.* 3 to 10, and Pl. X^a. *Figs.* 25 to 36), become attached (Pl. X. *Figs.* 11, 12, 13, and 14), and then tentacles appear gradually (Pl. X. *Figs.* 13 and 14), the young thus assuming the form of Hydræ, with an increasing number of tentacles (Pl. X. *Figs.* 16 to 37, and Pl. X^a. *Figs.* 11 to 15). The body is next furrowed by transverse grooves, and assumes an annulate appearance, and the rings thus formed (Pl. XI. *Fig.* 19) become gradually more distinct and more numerous, until the Hydra is changed into a Strobila, which is only a Hydra undergoing a process of transverse segmentation. As the process of isolation resulting from a deeper and deeper contraction of the ambulacral segments becomes more complete, the whole resembles a pile of scalloped saucers, with a fringe of tentacles; next, the uppermost segment drops off; then the next disk, then the next, and so on until in the end, each disk has separated successively from that below (Pl. XI. *Fig.* 29), and the base of the original Hydra, having reproduced tentacles, remains alone, perhaps with a few disks attached to it (Pl. XI. *Figs.* 1, 4, and 17), or with a single disk, as in *Fig.* 13. These free disks are genuine Medusæ, and have long been known as Ephyræ (Pl. XI[a]).— *Figs.* 58, 59, and 60, below, represent a summary history of this mode of reproduction. — The Ephyræ are, in course of time, transformed into common Medusæ: those of our Aurelia flavidula, *Pér. and LeS.*, *Fig.* 60, assume the characters of that genus, consisting in innumerable small tentacles all along the margin of the disk, with four long, pendent so-called arms around the mouth, etc. (comp. Plates VI., VII., and VIII.); while those of Cyanea arctica, which at first hardly differ from those of Aurelia, are transformed into the largest Jellyfish of our coast, and end in having the appearance of Pl. III., III.[a], IV., and V.

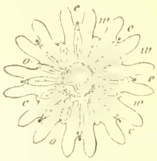
Fig. 58.

Scyphostoma of
Aurelia flavidula, Pér. & LeS.
In this stage of growth, Aurelia is simply a Hydroid.

Fig. 59.

Strobila of
Aurelia flavidula, Pér. & LeS.
a Scyphostoma reproduced at the base of a Strobila *b b*, all the disks of which have dropped off but the last.

Fig. 60.



Ephyra of
Aurelia flavidula, Pér. & LeS.
c Mouth. — *e e* Eyes — *o o* Ovaries. — *w w* Tentacular spaces.

We have thus a *complete metamorphosis of an Ephyroid animal into a perfect Medusa* entirely different from it both in form and complication of structure, and this metamorphosis is the sequel of another series of genetic phenomena, during which *one single being* arising from an egg of Aurelia or Cyanea, at first free and afterwards attached, *ends in dividing into a dozen and more, may be twenty and more, distinct free Ephyræ*, without ceasing to live, for the Strobila reproduces tentacles below the last Ephyra (*Fig.* 59) before this drops off, and resumes its Scyphostoma or Hydra form. Now, this part of the process is neither a metamorphosis proper nor an alternate generation comparable to that of the ordinary Hydroids, for here the body of the Hydra is partially lost in the formation of the Ephyræ. The crown, or row of tentacles, at its actinal end, after separating, dies and decomposes; while the central portion of the Hydra, intermediate between the tentacles and its abactinal end, divides into numerous free, active Ephyræ, which continue to live until they have completed their metamorphosis, and laid an immense number of eggs. The base of the Hydra, with its new tentacles, also survives, and may live for years. Its further history, to which I shall allude again hereafter, still presents, however, some mystery.

In the Hydroids proper, which also produce free Medusæ, the origin of the free brood is entirely different, and truly leads to a succession of alternate generations. Arising from the eggs of their free Medusæ, these Hydroids, when mature, bring forth buds from different parts of their axis, in different families, and even in different genera of the same family. These buds start either from the stem or from the upper part of the body, or even from the proboscis of the Hydra: they gradually enlarge, and assume the appearance of Medusæ, even while still connected with the Hydra, and free themselves finally, and become independent animals, undergoing but slight changes comparatively after their separation, except that they grow larger, develop their sexual organs, and finally lay eggs, out of which arise new Hydræ. The Hydræ themselves undergo no changes whatever in consequence of this production of free Medusæ: they neither lose their tentacles nor any part of their body, and continue to live for an indefinite period of time, and may produce other crops of free Medusæ,—although I have not traced directly such a repetition of their reproduction.

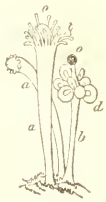
Here, as in the case of Aurelia and Cyanea, the connection of the free Medusæ and the Hydræ is unquestionable, and hardly less direct in the one than in the other; for, though the Ephyræ are parts of the body of Hydræ, the free Medusæ of the common Hydroids are buds from Hydræ, some of which differ but slightly from the Hydræ of Aurelia and Cyanea. If, therefore, the Hydræ from which Ephyræ arise, belong to the class of Acalephs as young of the highest type of Discophoræ, surely the Hydræ born from the eggs of naked-eyed Medusæ, though reproducing again the same kind of Medusæ only through buds, must equally belong to that class; and this the more since these Hydræ themselves have already been shown to be strictly homologous to Acalephs, and not to Polyps (p. 44). The doubts entertained by some naturalists respecting the systematic position of the Hydroids have arisen from a belief that Hydroids were Polyps, in connection with the fact, disclosed during the last twenty years, that they produce free Medusæ, when the following alternative seemed inevitable: either must Polyps and Acalephs be united as a class, or, if considered distinct, it must be acknowledged that Polyps produce Medusæ. But neither is true. Hydroids are not genuine Polyps, and the true Polyps may be considered as a distinct class, without forcing upon us the conclusion that they produce Medusæ; since the Polyp-like Radiates from which free Medusæ arise are themselves a low type of Acalephs, remarkable for the polymorphism of its representatives. And yet, however great the diversity of the individuals of one and the same kind of these Acalephs may be, it is easily reduced to two forms, one of which belongs to the Hydra type, the other to the Medusa type.

The genetic connection of certain Hydroids and certain free Medusæ once established, it remains only to be settled what are the kinds of Acalephs which should be considered as belonging to their type, among those Hydroids not known to produce free Medusæ and among those Medusæ not known to originate from

Hydroids; and also under what common name they should be designated. The answer to these two questions is not difficult.

Since the free Medusæ known to originate from Hydroids all belong to the type of the *Discophoræ Cryptocarpæ* of Eschscholtz, the *Gymnophthalmata* of Forbes, or *Craspedota* of Gegenbaur, there is presumptive evidence that the final investigation of the true affinities of these Medusæ will lead to a natural association of all those which are really and closely related to one another, to the exclusion of the possible foreign admixtures now left in this group, and that such a natural group will in the end embrace all the Medusæ originating from Hydroids. It is also possible, however, that such a natural group of Medusæ may embrace genera undergoing a direct metamorphosis from the egg to the perfect Medusa without intervening Hydra stock, as we already know that there are higher Discophoræ, such as Pelagia, which reproduce themselves without passing through the Strobila state. But this would not alter the case of the affinity of such Medusæ: it would only show that the natural group to which they belong exhibits a wider range in its modes of development. The systematic position of any Medusa must be determined by an investigation of its special structure, and if there are any Medusæ, not arising from Hydroids, but growing up directly from eggs to their permanent form, and presenting the same special structure as those that arise from Hydroids, there is no reason why they should be separated. Upon this view we shall hereafter consider the affinities of the Æquoridæ, the mode of development of which is not yet fully ascertained, and those of the Æginidæ, some of which are known to undergo a direct metamorphosis. As to the Polyp-like Acalephs already known to produce free Medusæ, they have all been united by Johnston into one natural division, which he has called *Hydroidea*. But among these Hydroidea there are those which produce no free Medusæ, and yet as Hydroids in no way differ from those that produce them. There is, therefore, no reason why they should be separated: the less since, instead of free Medusæ, they produce sessile Medusæ buds identical in their structure with the free Medusæ originating from the other Hydroids. On account of its resemblance to Siphonophoræ, Hydractinia (*Figs.* 61 and 62) affords an excellent example of this type.

Fig. 61.



HYDRACTINIA POLYCLINA, Ag.

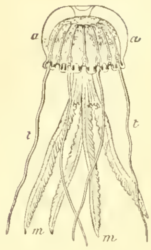
a a Sterile individuals. — *b* Fertile individual, producing male Medusæ. — *d* Clusters of male Medusæ. — *o o* Proboscis, with the mouth at the apex. — *t* Elongated tentacles of the sterile individuals; in the fertile one *b*, they are simple knobs *o*.

Fig. 62.

HYDRACTINIA POLYCLINA, Ag.

a Sterile individual. — *b* Fertile individual producing female Medusæ. — *d e* Female Medusæ, containing advanced eggs. — *f g h i* Cluster of female Medusæ with less advanced eggs. — *o* Peduncle of the mouth with short globular tentacles. — *c* Individual, with globular tentacles, upon which no Medusæ have as yet appeared, or from which they have already dropped

Fig. 63.



PELAGIA CYANELLA, Pér. and LeS.

a a Umbrella. — *m m* Mouth tentacles or arms; the prolongation of the angles of the mouth. — *t t* Marginal tentacles.

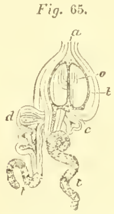
It appears thus, that, whether originating from Hydroids or not, all genuine Gymnophthalmata, the Discophoræ Cryptocarpæ of Eschscholtz, must be united into one great natural division with all the genuine Hydroids, whether these produce free Medusæ or not. But, while I acknowledge that the free Medusæ born from Hydroids show their Acalephian

Fig. 64.

HYBOCODON PROLIFER, Ag.

a Stem of a single Hydra. — *o* Its mouth surrounded with tentacles. — *t t* Its marginal tentacles. — *d d d* The most advanced of its Medusæ buds.

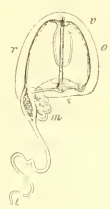
Fig. 65.



Medusa bud of
HYBOCODON PROLIFER, Ag.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *c* Circular chymiferous tube. — *b* Radiating chymiferous tube. — *d t* Proliferous Medusa with its single tentacle. — *t* Single tentacle of the primary Medusa. — Near *c* Another small proliferous Medusa-bud.

Fig. 66.

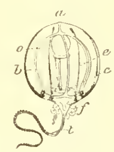


Free Medusa of
HYBOCODON PROLIFER, Ag.

The longest vertical tube being seen in profile.

v Proboscis. — *r o* Radiating tubes. — *s* Circular tube. — *t* Tentacle. — *m* Buds of Medusæ, proliferous from its base.

Fig. 67.

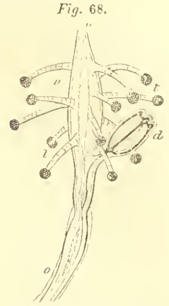


Free Medusa of
HYBOCODON PROLIFER, Ag.

Facing the longest chymiferous tube.

a Point of attachment before its separation. — *b c* Radiating or vertical chymiferous tubes, *c* pointing to the circular tube. — *t* Tentacle. — *f* Bunch of proliferous Medusæ buds. — *e* Rows of epithelial cells forming distinct bands at the surface. — *o* Proboscis.

Fig. 68.

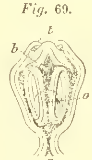


CORYNE MIRABILIS, Ag.

Hydra with a Medusa bud. This bud when freed becomes a Sarsia, *Fig.* 70.

a Stem of the Hydra. — *v* Its club-shaped body. — *o* Its mouth. — *t t* Tentacles scattered over the body. — *d* Medusa bud.

Fig. 69.



Medusa bud of
CORYNE MIRABILIS, Ag.

The bud represented here separately, with its base of attachment *a* cut through, is younger than that represented in its natural connection in *Fig.* 68 *d*. The free Medusa is represented *Fig.* 70, and described as *Sarsia mirabilis* in the Contributions to the Nat. Hist. of the Acalephs.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *b* Radiating chymiferous tubes. — *t* Tentacles. — All the intermediate forms, from the youngest buds to the adult Medusæ, will be described in the next volume.

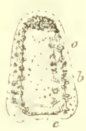
Fig. 70.

The free Medusa, SARSIA, of
CORYNE MIRABILIS, Ag.

o Proboscis. — *b* Vertical chymiferous tube. — *c* Circular tube. — *e e* Diaphragm. — *t t* Tentacles.

nature in the resemblance they bear to the common Medusæ of the type of Aurelia, Cyanea, and Pelagia (*Fig.* 63), I do not believe that their affinity to the latter is sufficiently close to justify their association with them in one and the same order. (Compare *Figs.* 65, 66, and 67, which are the Medusæ buds and the free Medusa of the Hydroid of *Fig.* 64; and *Figs.* 69 and 70, which are the Medusæ buds and free Medusa of the Hydroid of *Fig.* 68, with genuine Discophoræ as represented in *Fig.* 63.) I take here, therefore, the group of Discophoræ Cryptocarpæ (*Figs.* 66, 67, and 70) as entirely distinct from that of Discophoræ Phanerocarpæ (*Fig.* 63), for which alone, I shall retain the name of Discophoræ. For the present, I desired only to trace the natural limits of the class of Acalephs, to give examples of their various types, and to prove that the Hydroids cannot be separated from the naked-eyed Medusæ any more than from the Siphonophoræ. We shall see presently that this natural division differs essentially, as an order, from the *Discophoræ* proper, the *Steganophthalmata* of Forbes, or *Acraspeda* of Gegenbaur.

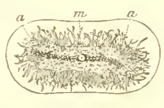
Fig. 71.



Free Medusa of Velella mutica, Bosc.

o Proboscis. — *b* Radiating chymiferous tubes. — *c* Circular tube.

Fig. 72.



Velella mutica, Bosc.

m So-called mouth. — *a a* So-called tentacles. Between the sterile tentacles and the mouth arise the secondary Hydræ, or so-called fertile tentacles, the gonoblastidial Polypites of Huxley.

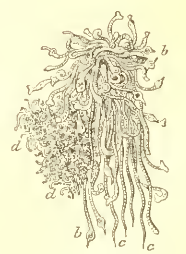
Fig. 73.

Bunch of Medusæ of Physalia Arethusa, Til.

In various stages of development.

a Common hollow base of attachment of the whole bunch, communicating with the chymiferous cavity of the air sac. — *b* So-called Polyp, or sucker. — *d d d d* The Medusæ buds arising from the simplest kind of Hydræ existing in the whole community.

Fig. 74.



Bunch of single Hydræ and clusters of Medusæ of Physalia Arethusa, Til.

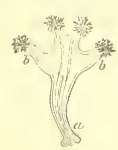
b b The Hydræ, with their tentacles *c c*. — *d d* The bunches of Medusæ.

For the united Gymnophthalmata and Hydroidea, there is only one name acceptable, according to the law of priority: they must be called Hydroidæ. But this order must further include the Siphonophoræ, since they likewise exhibit two structural types, some individuals of their communities being Hydræ and others Medusæ, variously combined, and the Medusæ either becoming free (*Fig.* 71, derived from *Fig.* 72) or remaining sessile (*Figs.* 73 and 74), as among the majority of the Hydroids proper.

As soon as the different families of this order are brought together side by side, and their structure and modes of development are compared, it is impossible to overlook the typical conformity which exists among them, and unites them all into one natural group. Had the peculiar modes of reproduction of the Acalephs been known as early as their adult condition, this affinity would have been much sooner recognized. The idea of pedunculated Acalephs, attached to the ground, must have appeared unnatural to those who were familiar with the large free Medusæ so common everywhere; and it is hardly a matter of surprise that even now, there should be naturalists who oppose the views I have here presented. Let it be remembered, however, that it is not so very long since the pedunculated Crinoids were arranged among the Polyps, and that it has only required a direct comparison between them and the free Crinoids to show their close affinity with the other members of the class of Echinoderms. Now, the pedunculated Hydroids bear the same relation to the swimming Hydroids (the Siphonophoræ) as the pedunculated Crinoids bear to the free Crinoids; and, the close affinity of the Siphonophoræ and Hydroids proper once admitted, their mode of reproduction renders their separation from the higher Acalephs forever impossible, while it forbids, at the same time, their association with the Polyps.

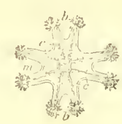
That Lucernaria (*Figs.* 75 and 76) and Millepora (*Figs.* 77, 78, and 79) belong to the Hydroids proper has already been shown (pp. 59 and 61). The nearest affinity of Millepora is with Hydractinia (compare *Figs.* 61 and 62); but its mode of reproduction has thus far remained unknown.

Fig. 75.



LUCERNARIA,
Seen in profile.
a Peduncle. — *b b* Tentacular bunches.

Fig. 76.



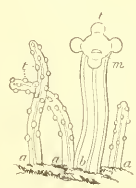
LUCERNARIA,
Seen from above.
m Mouth. — *c c* Ovaries. *b b* Tentacular bunches.

Fig. 77.

MILLEPORA ALCICORNIS, Lmk.

A branch of the Coral of that name, natural size. The little projections along the edge are meant for the extended Polyps. They are extremely shy and delicate, and never show themselves again after a branch has once been taken out of the water.

Fig. 78.



MILLEPORA ALCICORNIS, Lmk.

Magnified view of the extended Polyps or Hydroids of the same Coral stock.

a a Smaller Hydroids. — *b* Larger Hydroid, *m* its mouth, *t* its tentacles.

Fig. 79.

MILLEPORA ALCICORNIS, Lmk.

Transverse section of a branch of the Coral stock, magnified.

a a Pits of the Hydroids, with their successive floors. It is very difficult to obtain sections of the pits occupied by the smaller Hydroids.

The structural features of all these various representatives of the class of Acalephs will, of course, be more fully illustrated in the following chapters. My object here was mainly to show, upon the most general evidence, what are the types of Radiates that constitute the class of Acalephs, and incidentally to call attention to their special affinities. If the views I entertain upon this subject are correct, this class embraces three orders, — the CTENOPHORÆ, the DISCOPHORÆ proper, to the exclusion of the naked-eyed Medusæ, and the HYDROIDÆ, including the naked-eyed Medusæ, the Hydroids proper, the Siphonophoræ, the Milleporidæ with all the Tabulata of Milne-Edwards, and perhaps the Rugosa also, if their true affinity is actually indicated by the peculiarities of their solid parts and their resemblance to those of the Tabulata.

When considering Individuality and Specific Differences as manifested in the class of Acalephs, I have taken an opportunity of showing, upon general grounds, how futile the arguments are upon which the theory of transmutation of species is founded. Having now shown that that class is circumscribed within definite limits, I may be permitted to add here a few more objections to that theory, based chiefly upon special grounds, connected with the characteristics of classes. If there is any thing striking in the features which distinguish classes, it is the definiteness of their structural peculiarities; and this definiteness goes on increasing, with new and additional qualifications, as we pass from the class characters to those which mark the orders, the families, the genera, and the species. Granting, for the sake of argument, that organized beings, living at a later period, may have originated by a gradual change of those of earlier periods, one of the most characteristic features of all organized beings remains totally unexplained by the various theories brought forward to explain that change, — the definiteness of their respective groups, be these ever so comprehensive or ever so limited, combined with the greatest inequality in their numeric relations. There exist a few thousand Mammalia and Reptiles, and at least three times their number of Birds and Fishes. There may be about twenty thousand Mollusks; but there are over one hundred thousand Insects, and only a few thousand Radiates. And yet the limits of the class of Insects are as well defined as those of any other class, with the sole exception of the class of Birds, which is unquestionably the most definite in its natural boundaries. Now, the supporters of the transmutation theory may shape their views in whatever way they please, to suit the requirements of the theory, instead of building the theory upon the facts of nature, and they can never make it appear that the definiteness of the characters of the class of Birds is the result of a common descent of all Birds; for the first Bird must have been brother or cousin to some other animal that was not a Bird, since there are other animals besides Birds in the world, to no one of which does any Bird bear so close a relation as it bears to its own class. The same argument applies to every other class. And as to the facts, they are fatal to such an assumption; for Geology teaches us that among the oldest inhabitants of our globe known, there are representatives of nine distinct classes of animals, which by no possibility can be descendants of one another, since they are contemporaries.

The same line of argument and the same class of facts forbid the assumption that either the representatives of one and the same order, or those of one and the same family, or those of one and the same genus, should be considered as lineal descendants of a common stock; for orders, families, and genera are based upon different categories of characters, and not upon more or less extensive characters of the same kind, as I have shown years ago (vol. 1, p. 150–163), and numbers of different kinds of representatives of these various groups make their appearance simultaneously in all the successive geological periods. There appear together Corals and Echinoderms of different families and of different genera in the earliest geological formation, and this is equally true of Bryozoa, Brachiopods, and Lamellibranchiates, of Trilobites and the other Crustacea, in fact of the representatives of all the classes of the animal kingdom, making due allowance for the period of the first appearance of each; and at all times and in all classes, the representatives of these different kinds of groups are found to present the same definiteness in their characteristics and limitation. Were the transmutation theory true, the geological record should exhibit an uninterrupted succession of types, blending gradually into one another. The fact is, that throughout all geological times, each period is characterized by definite, specific types, belonging to definite genera, and these to definite families, referable to definite orders, constituting definite classes, and definite branches built upon definite plans. Until the facts of nature are shown to have been mistaken by those who have made them known, and that they have a different meaning from that now generally assigned to them, I shall, therefore, consider the transmutation theory as a scientific mistake, untrue in its facts, unscientific in its method, and mischievous in its tendency.

SECTION VII.

GRADATION AMONG ACALEPHS.

Confident that I have correctly ascertained the limits of the class of Acalephs, and that the method I have followed in that investigation is the only one that may furnish the means of avoiding arbitrary decisions with reference to the natural affinities of animals, I now proceed to an inquiry into the gradation or relative standing of the different members of this class. Keeping in view the principles laid down in the first volume of this work (p. 150), this inquiry should lead us to a knowledge of the *Orders* among Acalephs, if orders, as natural divisions, are based upon the different degrees of complication of the structure of the members of one and the same class; and that this is the true view to take of orders, I have at present not the least doubt. It is certainly so in all the classes, of which the natural orders have been most fully investigated. It is so among Polyps, if the Actinoids and Halcyonoids constitute natural orders in that class; for the Halcyonoids, with their eight spheromeres, and lobed tentacles, stand higher than the Actinoids. It is so among Echinoderms, the orders of which truly correspond to different degrees of complication of their structure, and most naturally mark the relative rank of these animals. It is so among Crustacea, taking the Rotifera, the Entomostraca, the Isopods, the Amphipods, the Stomatopods, and the Decapods as their natural orders. It is so among Acephala, if the Bryozoa, the Brachiopods,[1] the Tunicata, and Lamellibranchiata constitute natural orders. This gradation, in accordance with the complication of structure, is equally apparent among the Batrachians and the true Reptiles; and if it is not traceable at present with the same certainty in all the classes of the animal kingdom, I am inclined to believe that it is not because this principle is incorrect, but because we have not yet obtained a satisfactory standard, by which to determine the relative importance of their structural differences. At all events, a majority of the classes, and those best known to me, coincide with the view I have expressed respecting the meaning of orders. It would be surprising should there be some classes in which no such gradation exists, when it is so apparent in others. Let us now see what are the different degrees of complication of structure observed among Acalephs.

After tracing the special homologies of the Ctenophoræ, and ascertaining their close relationship to the ordinary Medusæ, it is evident that they belong to the class of Acalephs; but in this class they constitute a natural and distinct order. Their chief difference from the Discophoræ consists in the mode of ramification of the chymiferous tubes, originating in two main trunks, in opposite directions, each of which is divided into two horizontal branches, and each branch into two horizontal forks; so that the number of horizontal chymiferous tubes is always eight. But, unlike other Acalephs, these tubes do not terminate at the periphery, but open into eight vertical branches, converging in opposite directions towards the actinal and the abactinal ends of the body, and giving out minor branches into the spherosome. The main trunks of these vertical branches are parallel to the surface of the spherosome, and follow the same course as the rows of locomotive flappers, which extend, like eight ribs, upon the surface of the body. Towards the actinal and towards the abactinal poles of the spherosome, the vertical branches of

[1] The position I have assigned to the Brachiopods, near the Bryozoa, has been confirmed by a paper just published, in which a Brachiopod is described, resembling so closely a young Bryozoan just hatched from the egg, that the conclusion is irresistible that Bryozoa and Brachiopods are more closely related to one another than any other groups of Acephala. See Beschreibung einer Brachiopodenlarve von Fritz Müller in Desterro (Brasilien), in Archiv für Anat. Phys. und wiss. Med. 1860, p. 72.

the chymiferous tubes terminate in different ways in different genera; anastomozing in a more or less direct manner with one another around the actinostome. Besides the vertical chymiferous tubes which follow the course of the rows of flappers, there are two other vertical chymiferous tubes, presenting various degrees of complication in different genera. These two tubes are placed opposite to one another, in the same direction as the main branches of the whole system. All Ctenophoræ have a decided tendency to a bilateral symmetry, their body being more or less compressed. In some the outline is spheroidal, in others more cylindrical, while in others still, the spherosome expands on the actinal side of the body into wing-like appendages.

The most prominent peculiarities of the Ctenophoræ as an order consist, therefore, in the complication of their system of chymiferous tubes, in the presence of locomotive flappers on the surface, and in a tendency to a bilateral symmetry, resulting from the inequality of their spheromeres.

All these peculiarities show distinctly that the Ctenophoræ are superior to the Discophoræ; for in the latter the chymiferous tubes simply radiate from the main cavity towards the periphery, and, when branching, divide in one and the same plane. Moreover, Discophoræ have no rows of locomotive flappers, and move only by the contraction of their spherosome, which assumes the form of a hemispheric disk, spreading uniformly in every direction, without exhibiting the slightest tendency to bilateral symmetry. It is true that in Discophoræ the actinostome is apparently more complicated than in Ctenophoræ, because it is surrounded by long appendages hanging below the main cavity; but, notwithstanding this seeming superiority of development, it will be shown hereafter that the actinostome of the Ctenophoræ is in reality more highly organized than that of the Discophoræ, although the bulk of its appendages in the latter gives it a greater prominence. It is true also that in a large number of Discophoræ the margin of the disk is provided with numerous tentacles, but these tentacles are only peripheric diverticles of the chymiferous tubes, and in no way constitute a higher complication of that system than the vertical branches of the chymiferous tubes of the Ctenophoræ with their locomotive flappers. It is true also that the Discophoræ have distinct sexes, their ovaries and spermaries forming large bunches, in separate cavities, while the Ctenophoræ are hermaphrodites; but the special arrangement of the ovaries and spermaries in the latter, placed as they are on opposite sides of the vertical branches of the chymiferous tubes, contributes to render the complication of the structure of each individual more apparent in Ctenophoræ than in Discophoræ. It is true also that the Discophoræ have eight, and sometimes twelve or even more distinct eyes at the end of their radiating chymiferous tubes, while in Ctenophoræ there is a single eye at the abactinal pole; but then that single eye stands in direct communication with a special stem of the chymiferous system, occupying a central position in the axis of the body, while in Discophoræ there is one eye to each simple radiating tube.

Thus, whatever be the special combination of the organs in the Discophoræ proper, and however high they may appear to stand on account of the extraordinary development of some of their parts, the sum total of the structural complication in the Ctenophoræ is unquestionably greater than that of the Discophoræ. This will appear more distinctly, when we consider the similarity in general appearance of the Discophoræ to the naked-eyed Medusæ born from Hydroids. In this connection it must also be remembered, that, while the majority of Discophoræ enjoy only a consecutive individuality (see p. 97), since several Medusæ arise from the division of one single larva, in Ctenophoræ the reproduction takes place by a direct metamorphosis, each egg producing a single individual.

If multiplication of identical parts is everywhere an indication of inferiority, and definite numbers with definite relations a mark of superiority, Ctenophoræ will undoubtedly take the lead in that respect also over the Discophoræ, in which repetition of identical parts prevails, without a perceptible difference in their relations; while in Ctenophoræ the number of spherosomes never varies, and there exist between them such definite relations as simulate bilateral symmetry.

The Hydroids, as a whole, and considered within the limits assigned to that order in the preceding section, unquestionably occupy the lowest place in the class. For, in addition to the permanent character of indefinite repetition of identical parts, we observe among them, almost universally, a more or less characteristic polymorphism, sometimes to such an extent that it becomes difficult to distinguish secondary individuals from actual organs. Individuality is almost lost in the dependence in which the members of a community stand toward each other. Even when individuality becomes most prominent, it is so in individuals which are short-lived, in comparison to the duration of the combined individuals to which they owe their existence.

That the Discophoræ proper constitute a distinct order by themselves, appears plainly from the higher complication of their structure when compared to that of the naked-eyed Medusæ. In the latter, the radiating chymiferous tubes are all alike, equally distant one from another, simple, and either few or very numerous, and meet with a simple circular tube, instead of forming a complicated network of anastomoses along the margin of the disk, as in the Discophoræ proper, whose radiating tubes are alternately more or less complicated in their course, some extending as straight tubes to the margin of the disk and communicating with the base of the eyes, while others branch in various ways, and end in a network of anastomoses at the margin. In Discophoræ proper, there exist always highly organized eyes, in definite number, and these eyes are always placed at the marginal end of some specially organized radiating tube, alternating with other tubes of a different character; thus exhibiting a higher complication of these parts, not only in their structure, but also in the definiteness of their relations to one another, in their alternation with one another, and in their numeric limitation. Some Discophoræ have no other marginal organs besides eyes; but there are those that are provided with variously combined tentacles also: in none, however, are the eye-specks connected with tentacles, though the eyes are themselves modified tentacles.

In the naked-eyed Medusæ, the ovaries and spermaries follow the track of the radiating chymiferous tubes, and are variously circumscribed in their extent: in some, they are limited to the walls of the proboscis, in others they extend all along the chymiferous tubes proper, and in others they occupy only a part of the course of these tubes; but they are never circumscribed within distinct pouches, as in the Discophoræ proper. In these, the ovaries and spermaries bear identical homological relations to the chymiferous tubes, as far as their position is concerned; but, owing to their higher development and to their isolation, they form distinct bunches, hanging in distinct pouches on the lower side of the disk, and stand in definite relations to the parts surrounding the actinostome, through which the eggs are laid, while in the naked-eyed Medusæ the eggs simply drop from the ovary into the water without ever passing through the actinostome. Imperfect and injured specimens may leave a different impression respecting the mode of escape of the eggs from the ovaries; but I shall show hereafter that these egg pouches are really closed, and do not naturally open outward, as Ehrenberg represents them, but communicate only with the main cavity of the body, and through it with the actinostome, through which the eggs or the young finally make their escape into the water, after having remained for a longer or shorter time suspended in the peripheric folds of the actinostome.

In Discophoræ proper, the actinostome is far more complicated than in the naked-eyed Medusæ. In the latter, it is only a projecting fold of the lower wall of the spherosome, either extending simply as a circular rim beyond the main cavity, with or without fringes, or forming a more or less elongated proboscis. In Discophoræ proper, the actinostome is as it were suspended between distinct pillars hanging from the spherosome, which expand into more or less complicated leafy folds, the edges of which are either free, as in Aurelia, Pelagia, Cyanea, etc., or partially soldered together, as in Rhizostoma, Polyclonia, etc., thus forming either open or partially closed channels leading from their peripheric termination to the main cavity, which is itself wide and capacious, and supported laterally by the pillars of the actinostome. The cavities formed by the leafy folds of the actinostome are so far distinct from the main cavity, that they only communicate with it through the channels extending along the centre of these folds; while in the naked-eyed Medusæ the actinostome opens broadly into the main cavity. The chymiferous tubes arise from the upper part of the sides of the main cavity.

It thus appears that the Discophoræ proper have a far more complicated structure than the naked-eyed Medusæ, and that, in a natural classification, they cannot therefore be united into one and the same order, as has thus far been done by most naturalists. Moreover, the Discophoræ resemble one another very much in their general appearance and in their motions, which are effected by a slow alternate expansion and contraction of the disc.

The Hydroids, as the lowest order of the class of Acalephs, are far more diversified among themselves than either the Ctenophoræ or Discophoræ.[1] In the first place we find among them simple Hydroids, in the next place more or less medusoid Hydroids, then communities of variously combined individuals with more or less medusoid or hydroid characters; and among these communities there are

[1] It is a striking fact, conflicting with all preconceived ideas, that throughout the animal kingdom, the lower types, in every class, are far more diversified than their higher representatives. It is so among Polyps, if the Actinoids are inferior to the Halcyonoids; it is so again among the Actinoids, if the Madrepores are the highest among them. It is so among the Acalephs, if the Ctenophoræ are the highest and the Hydroids the lowest. It is so among Echinoderms, if the Holothurians stand highest and the Crinoids lowest. It is so among Acephala, if the Bryozoa belong to that class. It is so among Gasteropods, if the Pulmonates are superior to the Branchiates. It is so among Cephalopods, if the Dibranchiates deserve to be placed above the Tetrabranchiates. It is so among Worms, if the Helminths belong to the same class with the Annelids. It is so among Crustacea, if Rotifera and Entomostraca are their lowest representatives. It is so among Insects, if the Myriapods and Arachnids are united into one class with the Insects proper; and it would still be so if the winged Insects were considered as a class by themselves, for the madibulate Insects are more numerous and more diversified than the sucking Insects, and those which undergo the most complete metamorphoses fewer and less diversified than those whose metamorphoses are less complete. It is so among Fishes, if the bony Fishes are inferior to the Selachians. It is so among Amphibians, if the caudate Amphibians are inferior to the Frogs and Toads. It is so among Reptiles proper, if the Chelonians deserve the highest, and the Ophidians the lowest, place in that class. It is so among Birds, if the Palmipeds are their lowest representatives. It is so among Mammalia, if we contrast the Marsupials with the higher Mammalia; or if, among the latter, we compare the Rodents with the Human family. Of course, this greater diversity does not involve respectively greater differences among the lower representatives of any class when compared to one another, than among the highest: since their very inferiority, combined with great diversity, renders the possible amount of difference among the many lower ones less than among the fewer more highly organized ones. This very extraordinary diversity among the lowest types of all the classes of the animal kingdom stands in flagrant contradiction with Darwin's theory of the origin of species, according to which the lowest types should gradually give way to higher and higher types, in consequence of the struggle for life.

those which produce free Medusæ, and others which do not; some which consist entirely of Hydræ, and others of combined Hydræ and Medusæ; some start from Hydræ, others from Medusæ, — the communities themselves consisting either of a larger number of Hydroids, or of a larger number of Medusæ, when the two types are combined. These various combinations lead naturally to the formation of subordinate groups among Hydroids. Considering the mode of reproduction of the Acalephs in general, the highest Hydroids would, of course, be those in which the medusoid elements prevail, and the lowest, those in which the hydroid elements are most prominent. We have, therefore, to inquire first whether there are any genuine naked-eyed Medusæ which do not originate from Hydræ, in order to answer a question already raised respecting the true limits of the order of Hydroids, and the true position of the Æquoridæ and Æginidæ.

There are Æginidæ, unquestionably, which undergo a direct metamorphosis, and it is probable that this is the case with all of them. But are the Æginidæ genuine naked-eyed Medusæ, or a low type of the Discophoræ allied to the Charybdeidæ? My knowledge of this family is too limited to enable me to speak confidently upon that point; but I am inclined to consider them as belonging rather to the Discophoræ proper than to the Hydroids. In the first place the Æginidæ have no radiating chymiferous tubes, as all true naked-eyed Medusæ have; but instead of them there arise broad, flat pouches from the main cavity, extending toward the margin of the disk, as in Ephyra, the young of Aurelia and Cyanea, and as in the adult of the latter and of many other genera of Discophoræ proper. The Æginidæ have no circular chymiferous tube, as all true naked-eyed Medusæ have. Again, the tentacles of the Æginidæ are not strictly marginal, and, in the absence of a circular tube, cannot be closely connected with it as is the case in all true naked-eyed Medusæ, but are in direct communication with the radiating pouches of the main cavity, as in Pelagia and Cyanea. If, then, for these reasons, the Æginidæ should be associated with the higher Discophoræ, instead of occupying a place among the naked-eyed Medusæ, the importance attached by Gegenbaur to the marginal seam of the umbrella, as a distinctive character of the lower Discophoræ, would be greatly lessened; and I rather think rightly so, for many of the higher Discophoræ, and among them our common Aurelia, have the margin of their umbrella not only very thin, but turned inward and downward as in all Craspedota, and their tentacles arise between indentations of the disc (Pl. VII. *Figs.* 2, 3, and 4; Pl. VIII. *Fig.* 5, and Pl. IX. *Fig.* 4), at some distance from its margin, as is the case in the Æginidæ.

As to the Æquoridæ, I have no doubt that they are genuine Hydroids, though I have not been able to trace with certainty the origin of the Æquorea of our coast to any true Hydroid. But the structure of Æquorea, in its adult

Medusa state, is so strictly homologous to that of all other naked-eyed Medusæ, that, even if it were ascertained that it undergoes a direct metamorphosis from the egg to the perfect Medusa, I would not hesitate to consider it as a member of the order of Hydroids, since it has simple radiating chymiferous tubes, a circular tube, and marginal tentacles closely connected with it, and provided with mere pigment specks upon their base.

It will require a more extensive knowledge than we now possess of the development of all Hydroids, before the relative standing of their various types can definitely be ascertained. As far as our information goes, the rank of Hydroids among themselves does not seem to be determined primarily by the production of free Medusæ, since Campanulariæ produce free Medusæ; while among Tubulariæ we have those which bring forth free Medusæ, and others which do not. The distinctness of the medusoid and hydroid elements, without reference to the liberation of the Medusæ, seems more significant; for, unquestionably, a Physalia with its extraordinary polymorphism has an organization inferior to that of a Sarsia born from a Coryne. In the first case we have a very complicated community, it is true, but it consists chiefly of low, heterogeneous elements variously combined, and the Medusæ buds themselves are of the simplest kind, and without tentacles; while in the second case the hydroid and medusoid elements are quite distinct, and the Medusæ arising from the simple Hydrarium are as perfect as any other naked-eyed Medusæ. The same may be said of Lizzia, Hippocrene, and Hybocodon, all of which have a limited and definite number of radiating chymiferous tubes, a limited and definite number of tentacles or bunches of tentacles, all characters which seem to assign to them a marked superiority over Tiaropsis and Thaumantias with their numerous marginal tentacles which arise from Campanulariæ, that is, from Hydroids exhibiting already signs of polymorphism, while the Hydraria from which Sarsia, Lizzia, etc., arise, consist only of one kind of Hydræ.

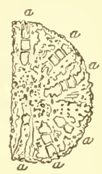
It would thus appear that the distinctness of the hydroid and medusoid elements in this order is inverse to the polymorphism of their communities. The Medusæ buds of most Siphonophoræ play a rather indifferent part in their economy; and yet their prominence coincides with the degree of complication of the hydroid and medusoid elements of their communities. Velella, the community of which consists only of two kinds of Hydræ, produces distinct free Medusæ; while the Diphyidæ and the Physophoridæ, in which the hydroid and medusoid elements are most completely mixed, are also those which are most remote from the true type of Discophoræ, and resemble most, in their mode of living, the free locomotive Polyp communities. But even as compound communities consisting of heterogeneous elements, it is remarkable that those in which the medusoid elements prevail are also the most active, while those in which the hydroid elements are predominant, are more floating than active. A comparison between Porpita, Velella, and Physalia on one side, and the Diphyidæ and Physophoridæ on the other side, cannot fail to convince any one who has seen any of these animals alive of the truth of this general statement. When describing, in the sequel, the North American Hydroids in detail, I shall have an opportunity of showing that the subdivisions founded upon the differences here noticed among these animals are genuine sub-orders, and neither orders nor families.

Though I have not the remotest doubt that the Tabulata (*Figs.* 81 and 82) are genuine Hydroids, I am not quite so confident that the Rugosa (*Fig.* 80) also belong

Fig. 80.

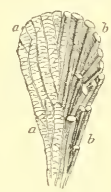
GONIOPHYLLUM PYRAMIDALE,
(*Copied from M.-Edwards & Haime.*)
Upper figure, view from above; lower figure, profile. Fossil of the Silurian period. Comp. Lucernaria, p. 111, *Figs.* 75 and 76.

Fig. 81.



MILLEPORA ALCICORNIS, Lmk.
Transverse section of a branch of the Coral stock, magnified.
a a Pits of the Hydroids, with their successive floors. It is very difficult to obtain sections of the pits occupied by the smaller Hydroids.

Fig. 82.



BEAUMONTIA EGERTONI,
(*Copied from M.-Edwards & Haime.*)
Fossil of the Carboniferous period. It resembles so closely the living Pocillopores, that it certainly belongs to the same sub-order.

to this class. I have not had sufficient opportunity of studying the Rugosa anew, since I have known the acalephian affinities of the Tabulata, to feel justified in expressing a decided opinion upon that point. I will therefore simply present my reasons for believing that the Rugosa belong to the same class as the Tabulata. The cavity occupied by the animal is divided by horizontal floors, evidently built successively as in course of its growth the animal rose higher and higher, and these floors are continuous from wall to wall across the whole width of the cavity of the Coral; and wherever there exist radiating partitions, they rise only from the surface of these floors, without extending through them to any other floor above or below. No Coral known to be the solid frame of a Polyp has such a structure. On the contrary, in Polyparia the radiating partitions of the individual cavities occupied by distinct animals extend uninterruptedly from top to bottom of their cavities, and if there exist horizontal floors, these stretch only across the intervals between two radiating partitions, and never across the whole cavity occupied by the Polyp. The radiating partitions of the Rugosa, beside being limited to successive floors, present another striking peculiarity, never observed among the Polyps, — they are arranged in fours, or multiples of four. This quadripartite structure of the Rugosa is an acalephian feature, nowhere observed among true Polyps, but characteristic of Lucernaria, which is a genuine Hydroid Acaleph. I may also allude to a more remote argument for referring the Rugosa to the Acalephs. There are simple ones among them, and others forming rather loose communities, composed of comparatively few individuals; but, whether simple or combined, each individual of this type, with its successive floors, presents a striking resemblance to a Strobila. Rugosa, indeed, may be considered as a prototype of the Acalephs, combining the most characteristic embryonic features of the class with the simplicity and peculiarity of structure of its lowest type.

When considering the different orders of Acalephs singly, I shall show that their families are founded upon different patterns of form, their genera upon ultimate structural details, and their species upon the proportions of their parts, and the relations of individuals to one another and to the surrounding mediums. To introduce these topics here, would involve me in an amount of details, which are best referred to the special parts of this monograph.

Although an order in Zoölogy especially signifies the relative rank of the members of a class, as exhibited in the complication of their structure, it is not in the orders alone that we recognize different degrees and different kinds of superiority or inferiority. As I have already stated elsewhere (vol. 1, p. 152), groups of a more or less comprehensive value may exhibit a relative superiority or inferiority; nor is an order a natural group that has no other meaning but that which it derives from its higher or lower position. The primary branches of the animal kingdom do not all stand on a level: Radiates, as such, are unquestionably inferior to Mollusks or Articulates or Vertebrates, even though some Radiates may have a more highly complicated organization than some of the lowest Fishes. We assign to the Radiates a lower position than that of the other branches, because the elements of their plan of structure are of an inferior stamp; and we place the Vertebrates highest, because the plan of their structure is in itself the most complicated: but it would be difficult to weigh the different organic tendencies combined in either the Mollusks or Articulates so nicely as to prove that either of them is superior to the other, though, unquestionably, as primary divisions of the animal kingdom, they are superior to the Radiates and inferior to the Vertebrates. The idea of placing either the Mollusks or the Articulates immediately above the Radiates, so as to establish a gradual transition between them and the Vertebrates, seems entirely out of the question, since the most distinguished naturalists who have attempted to arrange the first primary divisions of the animal kingdom in a series have failed to produce convincing arguments in favor of the superiority of the Mollusks over the Articulates, or of the latter over the former. The fact is, there is quite as high authority for one as for the other position of these two branches. The most natural view seems to me to be that which assigns to them an equal standing, and recognizes their difference in the different tendencies of their plan; so that, taking the sum of their characteristics, the four primary branches of the animal kingdom should not be placed in one series. Their true relations seem to be best expressed by a diagram like this:—

VERTEBRATES,

MOLLUSKS,————————ARTICULATES,

RADIATES.

Again, the different classes of each branch show a relative superiority one above the other. Polyps as a class are certainly inferior to Acalephs as a class, and these, again, inferior to Echinoderms. Acephala as a class are unquestionably inferior to Gasteropoda, and these, again, inferior to Cephalopoda. Worms as a class are certainly inferior to Crustacea, and these in their turn inferior to Insects, etc. And yet there are Worms, such as the higher Annelids, in which the structural complication much exceeds that of the lowest Crustacea, such as the Rotifera. Some Lamellibranchiates are much more highly organized than some of the Phlebenterate Gasteropods. Some of the Fishes may be considered superior to some Batrachian Reptiles; but no Reptile seems to rise to a level with Birds. Here again we see, therefore, that difference of rank is only a secondary feature for classes. The same may be said of families and of genera, as well as of species, and it is much to be lamented that our language has not a greater variety of words to express the many shades of relative standing; so that we are limited to the almost exclusive use of the words *superior* and *inferior*, which are inadequate to render the comparative relations of beings in themselves so exquisitely organized as are the representatives of every class in the animal kingdom. In the groups called orders, however, the idea of superiority and inferiority seems to be the prevalent feature. Yet orders themselves exhibit also another kind of relations, to which I have already incidentally alluded in an article on the Categories of Analogy, added to the London edition of my Essay on Classification.[1] It is curious to observe how the views entertained by Oken[2] respecting certain affinities among animals, resulting, in his opinion, from the repetition of the same principle in groups of different value, loom up again in the relations of the orders of certain classes to other groups, to which they themselves do not belong.

If it be true that Hydroids, Discophoræ, and Ctenophoræ are three distinct orders among Acalephs, it cannot be overlooked, that, by their general appearance,

[1] Essay on Classification, by L. Agassiz, London, 1849, 8vo., pp. 271–284.

[2] Compare vol. 1, p. 211. See also OKEN'S Physio-philosophy, London, 1847, 1 vol. 8vo.

the Hydroids resemble the Polyps, with which, indeed, they have been united as members of the same class; while the Discophoræ proper constitute the characteristic group of Acalephs, the group which has always been considered the typical group of this class. The Ctenophoræ bear the same relation to Echinoderms as the Hydroids bear to the Polyps; and this resemblance of the Ctenophoræ and Echinoderms is especially recognizable in the peculiarity of their vertical chymiferous tubes with their locomotive flappers, and the homology there is between them and the ambulacral system of the Echinoderms. But neither the resemblance of Hydroids to Polyps nor that of Ctenophoræ to Echinoderms is a real indication of affinity: it is only an analogy, arising from a similarity of form in parts which have only a general homology, and no special homology with one another. But this analogy, once recognized, has its significance. It confirms the views presented above respecting the relative standing of the three orders of Acalephs. Hydroids, as the lower order of Acalephs, are analogous to the Polyps, the lowest class of Radiates; Discophoræ, the most characteristic type of Acalephs, occupy a middle position between them and the Polyps, as the Acalephs, considered as a class, occupy an intermediate position between the Polyps and Echinoderms; and the Ctenophoræ, as the highest order in the class of Acalephs, correspond to the Echinoderms, and especially to the Holothurioids, the highest order of the highest class among Radiates.

Such analogies may be traced in other classes of the animal kingdom. Assuming that the Articulates embrace only three classes, — the Worms, Crustacea, and Insects; and that the Insects themselves form only three orders, — Myriapods, Arachnids, and Insects proper, no one can fail to perceive the analogy between the Myriapods as the lowest order of Insects, and the Worms as the lowest class of Articulates, or between the Arachnids as the second order of Insects, and the Crustacea as the second class of Articulates; and the highest order among Insects consists of those best representing the character of the class of Insects, which stands highest among Articulates. Perhaps objections may be raised against this primary division of the Insects into three orders, and perhaps also against the division of Articulates into three classes; but to my mind these analogies would have great weight in establishing this classification as correct. Whatever may be said of the analogies alluded to between the orders of Acalephs and the classes of Radiates, I have no hesitation in affirming that there are only three orders in the class of Acalephs, and that these orders stand to one another in the position I have assigned to them, — the Hydroids being the lowest, the Discophoræ next, and the Ctenophoræ highest.

SECTION VIII.

SUCCESSION OF ACALEPHS.

Thirty-three years ago, while examining the Museum of the Grand Duke of Baden, in Carlsruhe, my attention was attracted by two slabs of limestone slate from Solenhofen, the counterparts of one another, upon which a perfect impression of a Discophorous Acaleph was distinctly visible. The impression made upon my mind by the preservation, through countless ages, of an animal so soft as a jelly-fish, was so vivid, that, though I have never seen those fossils since, I well remember their general appearance. I regret the more, however, that I did not at the time make a sketch of them, since to this day they have remained undescribed; and, so far as I know, no allusion to genuine fossil Acalephs is to be found anywhere except in the first volume of this work (p. 24), where I mention the occurrence of Medusæ in the limestone of Solenhofen as indicative of the earliest period of the existence of that class upon earth. At the time I saw these fossils, our knowledge of the Acalephs was very scanty; few good illustrations existed; and the works of Eschscholtz and his followers had not yet been published: so that, had I even been conversant with every thing then known about this class of animals, I could not have determined to what family they belonged. I earnestly hope that some of the German naturalists, who of late have so largely contributed to the advancement of our knowledge of that class, may be induced by this notice to hunt up those fossils, and publish an accurate description of them with good illustrations, that their close affinity to the numerous families now distinguished among Acalephs may be ascertained. It is now a matter of great importance, for it may afford indications of the connection between the living types of Acalephs and their oldest representatives on earth; since it has been ascertained that certain Coral stocks, a large number of which occur in the Palæozoic rocks, called Tabulata by Milne-Edwards, and thus far referred to the class of Polyps, are genuine Hydroid Acalephs, while a comparison of another type of Corals, called Rugosa by Milne-Edwards, with the Tabulata, makes it highly probable that they also are Acalephs, rather than Polyps.

As shown before, the Tabulata, unquestionably, are Hydroids. Direct evidence to that effect has been obtained by an examination of the animal of Millepora; and as all the other Tabulata, both living and fossil, have the same structure of their solid Polyparium as Millepora, it is evident that the whole group must be considered as essentially acalephian. As far as the Polyparium of the Rugosa is concerned, the evidence of their acalephian nature is hardly less strong than that adduced for the acalephian affinities of the fossil Tabulata. The only difference in the evidence is, that for the Tabulata we have the confirmation of these affinities in the structure of the animal of one of their living members, while that evidence is wanting for the Rugosa. But, as I have already stated, the Coral stock of the Rugosa coincides so far with that of the Tabulata, that it is built up with successive floors, extending uninterruptedly across the bottom of the whole cavity, which was evidently occupied by the animal; while the Coral stock of all genuine Polyps presents radiating partitions extending uninterruptedly from top to bottom of the cavity occupied by the animal, and the horizontal floors that may exist, stretch only from one of these radiating partitions to the other.

Now, if both Rugosa and Tabulata are Acalephian Corals, it is very desirable that correct views of their affinities with the other Acalephs should be obtained, in order to arrive at correct conclusions respecting the order of succession of the Acalephs in past geological times, and of their connection, through the only known fossil Discophorous Medusa, with the living representatives of the class.

Scanty as is our information of the fossil Acalephs beyond the knowledge of the order of the succession of the Rugosa and the Tabulata, it is already highly interesting, even with these imperfect data, to institute comparisons between all the members of the class respecting their order of succession. We have seen that the Ctenophoræ are the highest order of Acalephs, and that the Discophoræ proper are next to these in standing; while the Hydroids, including the naked-eyed Medusæ and the Siphonophoræ, constitute the lowest order of the class. We have seen, further, that among the Hydroids themselves, those in which the medusoid elements prevail over the hydroid elements should be considered as the superior ones. Taking, now, the only indication we have in Millepora as our guide to an appreciation of the standing of the Tabulata among the Hydroids, it is plain, from the circumstance that these Hydræ communities form large, permanent Coral stocks, living probably for centuries, that they have a character of inferiority as contrasted with the short-lived Hydro-Medusaria, and especially with those which produce free Medusæ in alternate generations. But if the Tabulata stand low in the lowest order of Acalephs, we have in this fact a striking coincidence with the character of the representatives of other classes in earlier periods. Since Crinoids prevail in Palæozoic times, while free Star-fishes and Echinoids make their appearance later; — since Bryozoa and Brachiopods prevail during the same old periods, while Lamellibranchiates become prominent in later geological epochs; — since Trilobites are the earliest Crustaceans, followed by gigantic Entomostraca, and higher Crustacea appear only in the middle geological ages, etc., etc., we should expect that Acalephs also should make their appearance with the representatives of their lowest order; and we have just seen that the Tabulata occupy an inferior position in that lowest order.

Assuming that Rugosa are Hydroids also, the question of their standing in their order is not difficult to determine, if we take into consideration the general character of the class, and its relations both to the class of Polyps and to that of Echinoderms. I have already alluded to the analogy between the Hydroids and the Polyps, and to that between the Ctenophoræ and Echinoderms. Starting from this fact, let us see what are the elements of superiority and inferiority among the Radiates, at the two ends of the type. In Polyps we distinguish two orders, the Actinoids and the Halcyonoids. Taking their whole structure into consideration, the Actinoids with their simple tentacles and the indefinite repetition of similar parts in most of them, are, unquestionably, inferior to the Halcyonoids with their eight-lobed tentacles and invariable eight spheromeres. Now, among Halcyonoids there are no simple individuals: all the types of this order consist of compound communities, while among the Actinoids we have both simple individuals and compound communities. But here again it is among the compound communities that we find the higher organic combinations: for certainly the Madrepores, with their twelve tentacles, alternately larger and smaller, are superior to the Astræoids, and these again superior to the Actinioids; and that these latter are the lowest will hardly be doubted, if we consider the absence of solid deposits in them, and the equally characteristic absence of horizontal floors between their radiating partitions. It will be conceded also that the Fungidæ stand next above them, since they have a large number of tentacles, like the Actiniæ, and only transverse beams extending from one radiating partition to the other, instead of continuous floors as in the Astræoids, which stand above them on that account, as well as on account of their limited number of tentacles. The Madrepores, unquestionably, are the highest among the Actinoids, since they not only present a limited number of tentacles, but a number which is always constant, and, in addition to this, another higher combination of structural features, arising from an alternation of larger and smaller tentacles and a marked one-sidedness of their calycles.

It is thus plain that the gradation among Actinoids, — that is, the higher and higher rank they occupy when compared with one another, — stands in direct ratio to their complication and to their combination into communities, and in an inverse ratio to their individual independence. The simple Polyps, such as Actiniæ, are the lowest; the Fungidæ, among which there are simple types, such as the genus Fungia proper, are next in rank; the Astræoids and allied families, which form always compound communities, with a reduced but more definite number of tentacles, come next; and the Madrepores, forming among the Actinoids the most complicated communities, stand highest.

There is still another feature among Polyps, which ought to be considered in this connection. Not only do the Halcyonoids, the higher order among Polyps, form compound communities in all their representatives, but we find that these compound communities tend to acquire a marked individual independence, which is fully reached in those types of this order which, like Veretillum, Renilla, and Pennatula, move about freely, and these are the highest among the Halcyonoids. A similar tendency to individualization of communities is also observed in the highest Actinoids; for some Madrepores not only form complicated communities, but exhibit, at the top of their branches, an individual which, though forming part of the community, is larger than all the lateral individuals, and gives, as it were, individuality to each branch.

With these facts before us, it will not be difficult to determine the relative standing of the Rugosa and Tabulata. The Rugosa differ from the Tabulata in having a considerable number of representatives which are simple individuals; or, when they form communities, these are a loose aggregation of a few individuals maintaining a certain degree of independence: we never find among them communities formed of innumerable closely combined individuals, such as occur among Tabulata, in many of which there exists a direct communication between adjoining individuals through pores in their walls. I am, therefore, inclined to consider the Rugosa as inferior to the Tabulata; and their prevalence in the oldest rocks and their early extinction in geological times, while Tabulata are continued to this day, confirm this view. The Rugosa seem to me to stand in the same relation to the Lucernarioids among Hydroids, as the Actiniæ stand to the Fungidæ among genuine Polyps. And here, again, we have a remarkable analogy between the two types, in the circumstance that Fungidæ are the oldest genuine Corals known, as the Rugosa are the oldest type among Hydroids.

All this is in perfect accordance with the character of the higher Acalephs. As we have seen before, the Ctenophoræ are analogous to Echinoderms; but Echinoderms have reached a degree in organic complication in which individuality, as such, becomes a character of superiority. In conformity with this analogy, we find that all Ctenophoræ are free individuals, and so are the Discophoræ also; while the free naked-eyed Medusæ arising from Hydroids occupy, in that respect, an intermediate position between the higher Acalephs and the lower Hydroids, which form large and highly complicated communities, and bear, in their perfect state, sessile Medusæ buds only. I do not see that any objection can be made to the rank here assigned to the Acalephs in general. It seems to me to be determined by their whole structure, as well as by their mode of development, and must be considered as the true expression of their natural affinities, if the lowest Hydroids are those in which the hydroid elements prevail over the medusoid elements, and if free Medusæ born from Hydroids are inferior to the Discophoræ proper, and these, again, inferior to the Ctenophoræ. It is certainly a most striking circumstance, that the only fossil free Acalephs known should be a Discophorous Medusa, for it is the type we should naturally expect to follow Hydroids in course of time, when it has once been ascertained that the earliest representatives of all classes are either the lowest of their type, or embryonic in their character or synthetic in the complication of their structure, as I have shown in the first volume of this work (pp. 107–122).

Some general remarks upon the geographical distribution of the Acalephs should naturally find a place here; but it is so indispensable to a true appreciation of the mode of distribution of animals, that their types should be correctly referred to their respective natural divisions, that, before considering the classification of the Acalephs in its details down to the genera and species, no accurate picture of their geographical range and mutual relations in space can fairly be presented. I must, therefore, postpone the consideration of this subject to another part of this monograph, when, in addition to the information already collected, I shall be able to avail myself of the investigations made by my son upon the Acalephs of the Pacific coast of North America. It is a matter of great interest to me thus to have the means of comparing critically the Acalephs of the temperate zone, not only of the two sides of the Atlantic, but also of the Pacific, and to be able to complete, in a measure, the statements of Brandt relating to the Discophorous Medusæ collected by Mertens, most of which were described, after his death, from the drawings made by the naturalists of the Seniavin.

SECTION IX.

CLASSIFICATIONS OF ACALEPHS.

The improvements in the classification of the Acalephs have been the consequence of a gradual and successive expansion of the boundaries of that class, resulting from the recognition of Acalephian characters in animals at first not suspected to be at all related to them. The class, as such, has not been at once recognized as a natural group, in consequence of the want of such a striking similarity of its members, as is observed, for instance, among Birds or Insects; but it has grown by successive additions, forced, as it were, by internal evidence upon the notice of naturalists, and slowly acquired, at long intervals, by laborious, successive steps. However, the very character of this gradual progress renders the study of the classifications of Acalephs the more interesting to the philosophical student; and a comparison of these different arrangements may teach us how to proceed in our attempts to improve the classification of animals generally.

Though, from the beginning of his brilliant career, Cuvier had turned his attention to the study of the Acalephs, and published his anatomy of Rhizostoma long before the "Règne animal" appeared, his "Tableau élémentaire," published in 1798, contains nothing of importance upon these animals. It was Lamarck who took the lead in their systematic arrangement.

CLASSIFICATION OF LAMARCK, 1801 and 1816.

In his "Système des Animaux sans Vertèbres," published in 1801, Lamarck unites the Acalephs and Echinoderms in one and the same class under the name of RADIAIRES, separating them, however, as two distinct orders of that class, as *Radiaires Echinodermes* and *Radiaires Mollasses*. The second order, which corresponds to the Acalephs, embraces the following genera: Medusa, Rhizostoma, Beroe, Lucernaria, Porpita, Velella, Physalia, Thalis, and Physophora. The Hydroids proper are referred to the class of Polyps. In proposing this arrangement, Lamarck made the first step towards recognizing the natural limits of the class of Acalephs.

In the "Histoire naturelle des Animaux sans Vertèbres," published from 1815 to 1822, he adopts the same general classification of these animals; but subdivides the Acalephs in the following manner: —

1st Section. RADIAIRES ANOMALES: — 1° Stephanomia. 2° Cestum, Callianira, Beroe, Noctiluca, Lucernaria. 3° Physophora, Rhizophysa, Physalia, Velella, and Porpita.

2d Section. RADIAIRES MÉDUSAIRES: — 1° Eudora, Phorcynia, Carybdea, Æquorea, Callirhoe, Dianea. 2° Ephyra, Obelia, Cassiopea, Aurelia, Cephea, Cyanea.

The classification of Lamarck is evidently based upon a mere general appreciation of the relationship of the animals considered by him in detail. Comparative anatomy was not yet sufficiently advanced to furnish definite characteristics of the different groups adopted by the systematic writers of that period. The reunion of the Acalephs and Echinoderms as one class, for instance, is undoubtedly a great exaggeration of their affinity; but it marks, nevertheless, an important progress in the natural history of the lower animals, since such a combination could only be proposed by one who had already freed himself, at least partially, from the impression that the presence or absence of a solid frame was an essential character of these animals, and who began to perceive that the plan of structure, or at least the degrees of complication of that structure, was of higher importance, in a natural classification, than such secondary features. In this connection, it is important to remember that Lamarck was one of the naturalists who knew the Echinoderms best, and that he never could have united the Medusæ with them, had he not perceived the structural relation which forever will unite into one and the same great division such animals as Aurelia and Scutella.

The naturalists who have known the Acalephs best during the first quarter of this century are unquestionably Péron and LeSueur, and their publications are, to this day, among the most important upon all the members of this class, with the sole exception of the Hydroids.

CLASSIFICATION OF THE MEDUSÆ PROPER BY PÉRON AND LESUEUR, 1809.

Though Péron and LeSueur have contributed, more extensively than any other naturalists of the beginning of this century, to the advancement of our knowledge of the Acalephs, their systematic efforts were limited to the classification of the Medusæ proper, of which they have published the following diagram in the 14th vol. of the Annales du Muséum, 1809, 4to.: —

Première division. Méduses agastriques.
- *a.* Non pédonculées.
  - + Non tentaculées. Eudora.
  - + + Tentaculées. Berenix.
- *b.* Pédonculées.
  - + Non tentaculées. Orythia, Favonia.
  - + + Tentaculées. Lymnorea, Geryonia.

Seconde division. Méduses gastriques.

Première section. Gastriques monostomes.
- *a.* Non pédonculées.
  - + Non brachidées.
    - ⊕ Non tentaculées. Carybdea, Phorcynia, Eulimenes.
    - ⊕ ⊕ Tentaculées. Æquorea, Foveolia, Pegasia.
  - + + Brachidées.
    - ⊕ Non tentaculées. Callirhoe.
- *b.* Pédonculées.
  - + Non brachidées. Non représentées.
  - + + Brachidées.
    - ⊕ Non tentaculées. Melitea, Evagora.
    - ⊕ ⊕ Tentaculées. Oceania, Pelagia, Aglaura, Melicerta.

Seconde section. Gastriques Polystomes.
- *a.* Non pédonculées.
  - + Non brachidées.
    - ⊕ Non tentaculées. Euryale, Ephyra.
    - ⊕ ⊕ Tentaculées. Obelia.
  - + + Brachidées.
    - ⊕ Non tentaculées. Ocyroe, Cassiopea.
    - ⊕ ⊕ Tentaculées. Aurelia.
- *b.* Pédonculées.
  - + Non brachidées.
  - + + Brachidées. Non représentées.
    - ⊕ Non tentaculées. Cephea, Rhizostoma.
    - ⊕ ⊕ Tentaculées. Cyanea, Chrysaora.

The peculiar form of the diagram of Péron and LeSueur recalls the character of the classifications generally adopted in France at the time of its publication, consisting in dichotomic divisions and subdivisions, providing even for the position of unknown representatives of the methodical framework. and exhibiting more ingenuity than insight into the nature of true classifications. The chief object naturalists had in view in devising such arrangements was rather to facilitate the identification of genera and species, than to ascertain their natural relations. At that time Cuvier had not published his views upon classification; so that the idea of the subordination of characters, so fruitful in important results, did not yet pervade the systematic works of the beginning of this century.

It is much to be regretted, that the very extensive investigations of Péron and LeSueur, and the many admirable drawings of Acalephs made from nature by the latter during his travels in every part of the world, should have been but partially published, and should have remained unknown to most naturalists outside of France.

CLASSIFICATION OF THE SIPHONOPHORÆ BY LESUEUR.

Lesson, in his "Histoire naturelle des Zoophytes, Acalèphes," has published a classification of the Siphonophoræ by LeSueur, the original of which I have been unable to obtain. LeSueur calls these animals Radiaires mollasses composés, and divides them in the following manner: —

1st Group. *Isolated*: 1° Porpita and Velella. 2° Rhizophysa and Physalia.
United: 1° Physophora and Stephanomia. 2° Protomedea and Amphiroa.

From the place this paper occupies in Lesson's account, I am induced to believe that it must have been drawn up about the time of the publication of the classification of the Medusæ proper by Péron and LeSueur.

Cuvier's influence upon the progress of the natural history of the Acalephs is not to be measured by the amount of special information he has contributed to the stock of our knowledge of these animals, but rather by the spirit he has infused into the study of Natural History. His recognition of the four primary groups of animals, based upon four different plans of structure, not only justified the separation of the Acalephs as a class, but established at the same time their true relation to the Echinoderms and Polyps in one great natural division: and though Cuvier made the mistake of uniting with them the Helminths and Infusoria, on account of the simplicity of their structure, he nevertheless disclosed the principle upon which their classification is finally to be settled; and the mistake he made on that occasion was only the result of his own departure from that very principle, when he allowed the consideration of the simplicity of the structure of the Intestinal Worms and of the Infusoria to overrule that of the plan of their structure.

CLASSIFICATION OF CUVIER, 1817 and 1830.

It was Cuvier who first separated the Acalephs as a distinct class, in the first edition of the "Règne animal," published in 1817. There he divides these animals into three orders, as follows:—

1st Order. FIXED ACALEPHS:—Actinia, Zoanthus, Lucernaria.

2d Order. FREE ACALEPHS:—Medusæ: Medusa, Æquorea, Phorcynia, Foveolia, Pelagia; Cyanea, Rhizostoma, Cassiopea; Geryonia, Lymnorea, Favonia, Orythia, Berenice, Eudora; Carybdea; Beroe, Callianira, Cestum;—Diphyes;—Porpita, Velella.

3d Order. HYDROSTATIC ACALEPHS:—Physalia, Physophora, Rhizophysa, Stephanomia.

The Hydroids are referred to the class of Polyps; and some genuine Polyps, Actinia, and Zoanthus are ranked among the Acalephs.

In the second edition of that work, published in 1830, Cuvier, excluding now the Actiniæ from this class, but still leaving the Hydroids out of consideration, admits the following arrangement for the genuine Acalephs:—

1st Order. SIMPLE ACALEPHS:—Medusa, Æquorea, Pelagia, Cyanea, Rhizostoma, Cephea, Cassiopea. —Astomes: Lymnorea, Favonia, Geryonia, Orythia, Berenice, Eudora.—Carybdea.—Beroe, Idya, Doliolum, Callianira, Janira, Alcinoe, Ocyroe, Cestum.—Porpita, Velella.

2d Order. HYDROSTATIC ACALEPHS:—Physalia, Physophora, Hippopus, Capulites, Racemides, Rhizophysa, Stephanomia.—Diphyes, Calpe, Abyla, Cuboides, Navicule.

A glance at the works of Schweigger is sufficient to satisfy any one that his investigations are to be valued chiefly for their minuteness and accuracy, and that his systematic arrangement of the lower animals is not the result of matured principles, or deep insight into their affinities.

CLASSIFICATION OF SCHWEIGGER, 1820.

Schweigger was one of the naturalists who knew the soft-bodied Invertebrates best, during the first quarter of this century. In his extensive journeys on the coast of the Mediterranean, he had collected vast stores of materials to illustrate their natural history, and his "Handbuch der Naturgeschichte der skelettlosen ungegliederten Thiere, Leipzig, 1820, 1 vol. 8vo." is chiefly based upon original investigations; wherefore I allude to it here, even though he has done nothing to improve the classification of the Acalephs: but he gives the best summary of their structure for that period. The animals now included in the type of Radiata are referred by him to three classes,—the Zoophytes, the Acalephs, and the Radiata; and under the last name the Echinoderms are combined with Actinia, Zoanthus, and Lucernaria. To the Zoophytes he refers the Hydroids and Polyps, with which he also associates Infusoria; but he judiciously removes from them the Ascidians, which he considers as Mollusks. The Crinoids he rightly regards as Echinoderms allied to Comatula, and the Corallinæ as Algæ.

The Acalephs are arranged nearly as in the system of Lamarck.

I. Stephanomia—Physophora—Physalia, Velella, Porpita—Cestum, Callianira, Diphyes, Beroe, Noctiluca.

II. *Medusa, Lin.*, and subdivided as in Péron and LeSueur.

Goldfuss was one of the most eminent zoölogists of the German school of Physio-philosophers. Adopting the general view of Oken, that the animal kingdom is an organic whole, representing as it were the individualized parts of the highest living beings, he considers the classes and their subdivisions as determined by the nature of the organs through which animal life is maintained. In the special parts of his Text-book he displays an extensive acquaintance with the whole animal kingdom, and suggests many important improvements over the classifications of his predecessors. His arrangement of the Acalephs especially, discloses a better appreciation of their affinities than any previous system.

CLASSIFICATION OF GOLDFUSS, 1820.

In his "Handbuch der Zoologie," published in 1820, Goldfuss unites into one class, under the name of Protozoa, the following groups of animals, which he considers as orders of that class: 1° Infusoria, 2° Phytozoa, 3° Lithozoa, 4° Medusinæ. This fourth order embraces the Acalephs proper, which are divided into the following families:—

1st Family. Æquoreæ: Eudora, Ephyra, Æquorea, Orythia, Oceania, Cephea, Pelagia, Cassiopea, Callirhoe.

2d Family. Beroes: Idia, Beroe, Cestum, Callianira.

3d Family. Physophoræ: Rhizophysa, Physophora, Stephanomia, Arethusa.

4th Family. Porpitæ: Porpita, Velella.

The Hydroids are divided among the orders Infusoria and Phytozoa, and the Corallinæ and Crinoids among the Lithozoa. The separation of the Beroes and Porpitæ from the Medusæ proper is a marked improvement over the classification of Cuvier.

As naturalist of the expedition of the Rurick around the world, Chamisso had excellent opportunities for studying the Acalephs, and his special investigations of many new forms are truly valuable. His paper upon Salpa, also the result of this voyage, is the most important contribution of the poet-naturalist to the advancement of science. In working up his materials relating to the Acalephs, he was assisted by his friend Eysenhardt, himself the author of an excellent paper upon the anatomy of Rhizostoma.

CLASSIFICATION OF CHAMISSO AND EYSENHARDT, 1821.

Medusæ. Vesiculares: Physalia, Physophora, Rhizophysa.
Medusæ proper: Rhizostoma, Cephea, Pelagia, Cyanea, Aurelia, Æquorea.
Vibrantes: Beroe, Callianira, Cestum, Appendicularia.
Chondrophoræ: Velella, Porpita.
Anomalæ: Diphyes, Stephanomia.

This classification is a mere reproduction of that of Goldfuss, with a change of names and an injudicious separation of Stephanomia and Diphyes from the other Siphonophoræ.

Were not Latreille the first entomologist of all ages, and had he not shown himself a master in describing species, characterizing genera, defining natural families, and improving generally the classification of Insects, it would hardly be worth our while to consider his attempt at classifying the Acalephs. But this attempt of his may serve as a warning against the temptation, too frequently indulged by eminent men, to express opinions upon matters with which they are not familiar, or to cover their ignorance by an easy display of high-sounding but empty words. On looking at the diagram of Latreille's classification of the Acalephs, it might seem, at first sight, that he presents in it a new and original arrangement of these animals. The names *Poecilomorpha* and *Cyclomorpha*, with which he designates the two orders into which the class is divided, are certainly new to science, but they are utterly useless and superfluous, inasmuch as they neither represent a new view nor a new combination in the classification of these animals, and are in no way better than those which had already been proposed by Lamarck and Cuvier for the very same division. The limitation of the families is, if possible, worse, and the names applied to them are liable to the same objections as those of the orders.

CLASSIFICATION OF LATREILLE, 1825.

The views of Latreille upon the affinities of the Acalephs were published in his "Familles naturelles du Règne animal," Paris, 1825, 1 vol. 8vo. Adopting the class of Acalephs as circumscribed by Cuvier, he divides them into two orders and six families.

1st Order. POECILOMORPHA, corresponding to the Radiaires Mollasses Anomales of Lamarck, exclusive of Lucernaria.

- 1st Family. Ciliata: Beroe, Callianira, Cestum, Diphyes.
- 2d Family. Papyracea: Porpita, Velella, Noctiluca.
- 3d Family. Hydrostatica: Physalia, Physophora, Rhizophysa, Stephanomia.

2d Order. CYCLOMORPHA, corresponding to the Radiaires Mollasses Médusaires of Lamarck.

- 1st Family. Monocotyla: Medusa, Æquorea, Foveolia, Phorcynia.
- 2d Family. Polycotyla: Cyanea; Rhizostoma.
- 3d Family. Acotyla: Lymnorea, Favonia, Geryonia; Berenice, Eudora, Carybdea.

The families of the Cyclomorpha are entirely artificial, and in no way express the natural affinities of the animals; and the families of the Poecilomorpha are borrowed from other writers, — the name of *Beroes*, proposed by Goldfuss, being changed to *Ciliata*, that of *Porpitæ* to *Papyracea*, and the name *Hydrostatica* retained from Cuvier. The Hydroids are referred partly to the class of Polyps, in the tribe Vaginiformia, and partly to his class Helianthoidea, which embraces Actinia, Zoanthus, and Lucernaria.

The animals belonging to the class of Acalephs are so peculiarly delicate, so difficult to handle, and so perishable, that the circumstances under which they may be studied, form almost as important an element in their investigation, as the aptitude of the observer to trace their history. But when the naturalist who devotes years to their study is not only an eminent physician, but at the same time a minute, accurate, and philosophical observer, pursuing his task under the most favorable circumstances, great results may be expected. This was the case of Eschscholtz, who, during two voyages around the world, applied himself chiefly to the investigation of these animals, and had better opportunities for studying their various types in their natural element than any other man had enjoyed before, not even excepting Péron and LeSueur. Aside from the large amount of information it contains, the "System der Acalephen" of Eschscholtz is a model work for the manner in which the subject is treated. Full, minute, explicit, decided, where he speaks from personal observation; unpretending, candid, and fair, where he alludes to the investigations of other distinguished authors; cautious and reserved where he has reasons to question the correctness of the statements of others, — he secured the admiration of his contemporaries and the gratitude of his followers, and those who have known him lament his early loss.

CLASSIFICATION OF ESCHSCHOLTZ, 1829.

The limits of the class of Acalephs, as circumscribed by Eschscholtz in 1829, coincide with those assigned to it by Cuvier from the beginning, with the only exception that the Actiniæ are excluded. The Hydroids are entirely ignored by Eschscholtz, as if they had no relations to the Acalephs. He divides, for the first time, this class into three natural orders, and distinguishes a number of natural families. All later classifications of the Acalephs are mere modifications or improvements of that of Eschscholtz.

1st Order. Ctenophoræ.

- 1st Family. Callianiridæ, with three genera: Cestum, Cydippe, Callianira.
- 2d Family. Mnemiidæ: Eucharis, Mnemia, Calymma, Axiotima.
- 3d Family. Beroidæ: Beroe, Medea, Pandora.

2d Order. Discophoræ.

First Division. *Discophoræ phanerocarpæ.*

- 1st Family. Rhizostomidæ: Cassiopea, Rhizostoma, Cephea.
- 2d Family. Medusidæ: Sthenonia, Medusa, Cyanea, Pelagia, Chrysaora, Ephyra.

Second Division. *Discophoræ cryptocarpæ.*

- 1st Family. Geryonidæ: Geryonia, Dianæa, Linuche, Saphenia, Eirene, Lymnorea, Favonia.
- 2d Family. Oceanidæ: Oceania, Callirhoe, Taumantias, Tima, Cytæis, Melicertum, Phorcynia.
- 3d Family. Æquoridæ: Æquorea, Mesonema, Ægina, Cunina, Eurybia, Polyxena.
- 4th Family. Berenicidæ: Eudora, Berenice.

3d Order. Siphonophoræ.

- 1st Family. Diphyidæ: Eudoxia, Ersæa, Aglaisma, Abyla, Diphyes, Cymba.
- 2d Family. Physophoridæ: Apolemia, Physophora, Hippopodius, Rhizophysa, Epibulia, Agalma, Athorybia, Stephanomia, Discolabe, Physalia.
- 3d Family. Velellidæ: Rataria, Velella, Porpita.

CLASSIFICATION OF DeBLAINVILLE, 1830–1834.

DeBlainville has introduced great modifications in the classification of the Acalephs, part of which he removed to the Mollusks. The following diagram gives a general idea of his views respecting the classification of the lower animals: —

Zoophytes. 1. *False Zoophytes,* to be referred to the Mollusks: Physogrades and Diphyes, or perhaps to the Holothurians: Ciliobranches.
" " " " to the Articulates. Entozoa.
" " forming a heterogeneous assemblage of very small animals. Infusoria.
2. *Genuine Zoophytes.* Actinozoaria, containing 5 Classes: Cirrhodermaria, Arachnodermaria, Zoantharia, Polypiaria, and Zoophytaria.
Amophozoaria: Spongiæ.
3. *False Zoophytes,* to be referred to the vegetable kingdom: Corallinæ, Nematozoa, Psychodiaria.
" " neither animals nor plants. Zoösperms and Nullipores.

It appears from this sketch of DeBlainville's system, that he considers the Siphonophoræ of Eschscholtz as Mollusks, and the Ctenophoræ either as Mollusks or Echinoderms. The other Acalephs he calls Arachnodermaria, and divides them in the following manner: —

1st Order. Pulmograda.
1st Section. *Simple Pulmogrades:* Eudora, Ephyra, Phorcynia, Eulimenes, Carybdea, Euryale.
2d Section. *Tentaculate Pulmogrades:* Berenice, Æquorea, Mesonema, Polyxena, Ægina, Cunina, Faveolia, Eurybia, Pegasia, Obelia.
3d Section. *Subproboscidate Pulmogrades:* Oceania, Aglaura, Melicerta, Cytæis, Thaumantias, Tima, Campanella.
4th Section. *Proboscidate Pulmogrades:* Orythia, Geryonia, Saphenia, Dianea, Linuche, Favonia, Lymnorea, Sthenonia.
5th Section. *Brachiate and pedunculate Pulmogrades:* Ocyroe, Cassiopea, Aurelia, Melitea, Evagora, Cephea, Rhizostoma, Chrysaora, Pelagia.
2d Order. Cirrhograda. Velella, Rataria, Porpita.

The Hydroids are referred to the class of Polypiaria. An earlier diagram of these animals was published by DeBlainville in 1822, in his work "De l'Organisation des Animaux." See vol. 1 of this work, p. 198.

DeBlainville did not enjoy the same favorable opportunities for the study of the Acalephs as Eschscholtz; and yet he is the author of an original classification of these animals, which differs entirely from those of his predecessors. Eminent as a closet student, and deeply imbued with the conviction that Zoölogy required great reforms, and that methods may supply the deficiency of actual knowledge, he never hesitated in introducing great changes in the classification of the animal kingdom whenever a suggestion was presented to his mind, and without awaiting the opportunity for making the necessary investigations to test its accuracy and correctness. His views respecting some of the animals referred to the class of Acalephs, which he would remove from it, exemplify this disposition of his; and the many unnecessary changes which he made in the nomenclature of the lower animals are another evidence of that unhappy propensity. There are few examples of a more appropriate name for a new class in the animal kingdom, than that of Acalephæ, selected by Cuvier to designate, in general, all the animals allied to those known by the ancients under that name. It was at once adopted by all naturalists. The most important work ever published upon this class, as a whole, bears that name upon its very title; and yet DeBlainville does not hesitate to substitute for it a new, ill-sounding name, Arachnodermaria, the meaning of which, if it suggests any thing, recalls affinities with another type of animals, with which the Acalephs have no affinity.

CLASSIFICATION OF OKEN, 1835.

The views held by Oken upon classification and the affinities of animals have already been presented in my first volume (p. 212). It remains only to give a special account of his arrangement of the animals belonging to the type of Radiata. Oken does not unite the Echinoderms with the other radiated animals; but, founding upon the manner in which the parts of their solid envelope are movably united, and also upon the worm-like form of the Holothuriæ, unites them with the Articulates, in one and the same class with the Worms, as a distinct order of that class. The Acalephs are united, with the Polyps and Infusoria, into another primary division, the *Intestinal animals*, divided into three classes: the Infusoria, as Stomach-animals; the Polyps, as Intestine-animals; and the Acalephs, as Lacteal-animals. The class of Acalephs is itself subdivided into three orders:—

1st Order. The *Infusorial Acalephs*, or Siphonophoræ.
- 1st Tribe. Diphyes, Calpe, Abyla, Cymba, Aglaisma, Eudoxia.
- 2d Tribe. Rhizophysa, Stephanomia,— Physophora,— Physalia.
- 3d Tribe. Porpita, Lithactinia, Rataria, Velella.

2d Order. The *Polypoid Acalephs*, or Ctenophoræ.
- 1st Tribe. Eucharis, Cydippe,— Idya,— Medea, Pandora.
- 2d Tribe. Mnemia, Callianira, Cestum.
- 3d Tribe. Axiotima, Calymma, Alcinoe, Ocyrhoe.

3d Order. The *Acalephs proper*, or Discophoræ.
- 1st Tribe. Eudora, Berenice,— Geryonia,— Rhizostoma, Cassiopea, Cephea.
- 2d Tribe. Phorcynia, Melicertum, Thaumantias, Oceania, Callirhoe — Æquorea,— Ægina, Cunina, Polyxenia.
- 3d Tribe. Ephyra,— Aurelia,— Pelagia, Chrysaora, Cyanea.

This classification may be considered as a remodelling of Eschscholtz's, adapted to the views of the author respecting the manner in which the structure of the higher animals is represented by independent beings,— recalling, as it were, the different systems of their organs.

The history of the Acalephs has received very important accessions from the investigations of Mertens, who was naturalist in the Russian exploring expedition of the Seniavin. Unfortunately he died before having published his labors; and the only paper he left so far finished as to have appeared under his name is his "Beobachtungen und Untersuchungen über die Beroeartigen Akalephen," in 2d vol. 6e sér., Mém. Acad. Scien. Pétersbourg. Brandt, who had superintended the publication of this paper, afterwards worked up the materials left by Mertens relating to the other families of the Acalephs, and gave a full account of them in the "Ausführliche Beschreibung der von C. H. Mertens, auf seiner Weltumsegelung beobachteten Schirmquallen," 4e vol. Mém. Acad. Sc. Pétersbourg. The value of Mertens's contributions to the natural history of these animals may be inferred from the simple fact, that Brandt, without having seen the Acalephs he describes, could make elaborate descriptions of them merely from the drawings and scanty notes found among Mertens's papers. The fact is, the drawings of Mertens, and those of his travelling companion, Professor Postels, are among the most accurate and beautiful representations of Acalephs thus far published, and constitute by themselves an ample atlas of the whole order of Discophoræ.

CLASSIFICATION OF BRANDT, 1833.

Brandt, in his "Prodromus Descriptionis animalium ab H. Mertensio observatorum," published in the Memoirs of the Imperial Academy of Sciences of St. Petersburg, in 1833, has the following classification of the Acalephs, exclusive of the Beroids: —

DISCOPHORÆ. MEDUSIDÆ.

Monostomæ.

Oceanidæ: Circe, Conis.

Æquoridæ: Æquorea, Stomobrachiota, Mesonema, Zygodactyla, Æginopsis, Polyxenia.

Medusidæ: Phacellophora; Cyanea and Cyaneopsis; Aurelia: Monocraspedon, Diplocraspedon; Pelagia, Chrysaora.

Polystomæ.

Geryonidæ: Geryonia, Proboscidactyla, Hippocrene.

Rhizostomidæ: Cassiopea.

Incertæ sedis.

Berenicidæ: Staurophora.

SIPHONOPHORÆ.

Diphyidæ: Diphyes.

Physophoridæ: Physophora.

Rhizophysidæ: Epibulia: Macrosoma, Brachysoma.

Agalmidæ: Agalma.

Anthophysidæ: Athorybia, Anthophysa, Apolemiopsis.

Physalidæ: Physalia: Salacia, Alophota.

Velellidæ: *Velellinæ:* Velella, Aristerodexia; *Porpitinæ:* Porpita.

Lesson is one of the naturalists who had the best opportunities for observing the Acalephs. Embarked with Garnot on board the Coquille, he made the voyage around the world with Captain Duperrey, and prepared many beautiful illustrations of Acalephs for the zoological atlas of that expedition. On his return he made the most extensive collection of drawings of these animals ever brought together, with the intention of publishing a complete Iconography of this class; but the magnitude of the undertaking prevented its execution, and nothing was published but a "Prodrome d'une Monographie des Méduses," with a short notice of two hundred and thirty-seven species, arranged in seventy genera. Some of the plates were afterwards introduced in the "Centurie Zoologique," and the text appeared, in 1843, among the "Suites à Buffon," under the title of "Histoire naturelle des Zoophytes, Acalèphes." To this day, this is the chief work of reference for the study of the Acalephs; but it is much to be regretted that it is neither methodical in its plan nor critical in its details. It is rather a compilation than an original work; and yet it contains much that cannot be found elsewhere. Edw. Forbes has the following just but severe criticism of this extraordinary production: "This work is one of the most useful, and yet one of the most provoking, in its department of Natural History: useful, because it brings together, *verbatim*, every thing that has been written upon the Medusæ in France; provoking, because every attempt in it at an arrangement or digest of the matter so collected serves only to make the obscure more obscure and the crude more crude. It is executed without any judgment, though with considerable industry. Of what has been done outside of France it is a most imperfect account."[1]

CLASSIFICATION OF LESSON, 1843.

Like his predecessors, Lesson does not allude to the Hydroids in connection with the Acalephs.

1st Family. BEROIDEÆ.

- 1st Division. *Ciliobranches* or *Iriptères*.
  - 1st Tribe. Cestoideæ: Cestum, Lemniscus.
  - 2d Tribe. Callianiræ: Callianira, Chiaia, Polyptera, Mnemia, Bucephalon, Bolina.
  - 3d Tribe. Leucothoeæ: Leucothoea.
  - 4th Tribe. Calymmeæ: Calymma, Eucharis, Alcinoe, LeSueuria, Axiotima.
  - 5th Tribe. Neisidæ: Neis.
  - 6th Tribe. Ocyroeæ: Ocyroe.
  - 7th Tribe. Cydippæ: Mertensia, Anais, Eschscholtzia, Janira, Cydippe.
  - 8th Tribe. Beroæ: Beroe, Idya, Medea, Cydalisia, Pandora.
- 2d Division. *Acils*.
  - False Beroids: Galeolaria, Doliolum, Rosacea, Sulculeolaria, Praia, Noctiluca, Appendicularia.

[1] EDW. FORBES. A monograph of the British Naked-eyed Medusæ, London, 1848, p. 98.

2d Family. Medusæ.
- 1st Group. *Medusæ without proboscis.*
  - 1st Tribe. Eudoræ: Discus, Eudora, Eulimenes, Phorcynia, Pileola, Epomis, Ephyra.
  - 2d Tribe. Carybdeæ: Carybdea, Obelia.
  - 3d Tribe. Marsupialæ: Marsupialis, Bursarius, Mitra, Eurybia, Cytæis, Campanella, Scyphis.
  - 4th Tribe. Nucleiferæ: Turris, Circe, Conis, Tiara, Tholus, Pandea, Bougainvillia, Proboscidactyla, Melicertum, Aglaura, Laodicea, Microstoma.
  - 5th Tribe. Berenicidæ: Berenix, Staurophora.
- 2d Group. *Oceanides*, or genuine Medusæ with a round mouth but no proboscis.
  - 1st Tribe. Thalassanthæ: Pegasia, Faveolia, Cunina, Ægina, Æginopsis.
  - 2d Tribe. Æquoridæ: Æquorea, Polyxenia.
  - 3d Tribe. Oceanidæ: Stomobrachiota, Mesonema, Oceania, Patera.
- 3d Group. *Agaricine Medusæ*, or Medusæ with proboscis: Melicerta, Saphenia, Dianea, Orythia, Geryonia, Liriope, Xanthea, Sarsia, Tima, Thaumantias, Linuche, Usous, Lymnorea, Favonia.
- 4th Group. *Rhizostomeæ*, or Medusæ with a central peduncle.
  - 1st Tribe. Medusidæ, or Medusæ monostomeæ.
    - 1st Section. Without tentacles around the disc: Biblis, Melitea, Evagora, Salamis, Phacellophora.
    - 2d Section. With tentacles around the disc: Callirhoe, Sthenonia, Aurelia, Claustra, Cyanea, Cyaneopsis, Pelagia, Chrysaora.
  - 2d Tribe. Rhizostomidæ, or Medusæ Polystomeæ: Ocyroe, Cassiopea, Cephea, Rhizostoma.

3d Family. Diphyidæ.
  - 1st Tribe. Polygastricæ: Diphyes, Heterodiphyes; Calpe, Abyla.
  - 2d Tribe. Monogastricæ: Microdiphyes, Cymba, Enneagonum, Cuboides, Cucubalus, Cucullus, Eudoxia, Amphiroa, Ersæa, Aglaisma.

4th Family. Polytomæ, or Plethosomæ.
  - 1st Tribe. Plethosomæ: Plethosoma, Polytomus, Hippopodius, Elephantopes, Racemis.
  - 2d Tribe. Stephanomiæ: Stephanomia, Sarcoconus, Strobila.

5th Family. Physophoræ.
  - 1st Tribe. Rhizophysæ: Rhizophysa, Brachysoma.
  - 2d Tribe. Discolabæ: Discolabe, Diphysa.
  - 3d Tribe. Angelæ: Angela.
  - 4th Tribe. Athorybiæ: Athorybia, Anthophysa.
  - 5th Tribe. Physophoræ: Physophora.
  - 6th Tribe. Agalmæ: Agalma.
  - 7th Tribe. Apolemiæ: Apolemia, Apolemiopsis.

6th Family. Physaliæ: Physalia.

7th Family. Velellæ: Velella, Rataria.

8th Family. Porpitæ: Porpita, Ratis, Acies.

A sketch of this classification was already published in 1835 (Proceed. Zool. Soc. London, 1835, Part III. p. 2), and a special paper upon the Beroids, in Ann. Sc. Nat. 2de sér. 1837, vol. 5. The above diagram gives the classification of Lesson, as it appears in his last work, in the Suites à Buffon.

There is hardly a branch of Natural History to which Edw. Forbes has not made some valuable contribution. His investigations upon the distribution of marine animals, as bearing upon the geological changes which have affected their area, have left a permanent impression upon the progress of modern Geology. Among his special zoological studies, the natural history of the Acalephs formed always a favorite topic, to which he constantly returned with renewed interest. His monograph of the British naked-eyed Medusæ contains a summary of what he had done in that direction up to the year 1848. In the preface to this work he pays a just tribute of gratitude to his friend Mr. McAndrew, to whom he was mainly indebted for the facilities he enjoyed in collecting these materials, and whose name will forever remain associated with that of Edw. Forbes in the memory of naturalists.

CLASSIFICATION OF EDW. FORBES, 1848.

Forbes's classification, published in his "Monograph of the British Naked-eyed Medusæ," relates only to the Discophoræ, which he divides into two natural groups, corresponding to the Discophoræ phanerocarpæ and cryptocarpæ of Eschscholtz, but based upon different characters, not before taken into consideration in the arrangement of the Acalephs. They are as follows: —

I. Gymnophthalmata.
- 1st Family. Willsiadæ: Wilsia.
- 2d Family. Oceanidæ: Turris, Saphenia, Oceania.
- 3d Family. Æquoreadæ: Stomobrachium, Polyxenia.
- 4th Family. Circeadæ: Circe.
- 5th Family. Geryoniadæ: Geryonia, Tima, Geryonopsis, Thaumantias, Slabberia.
- 6th Family. Sarsiadæ: Sarsia, Bougainvillea, Lizzia, Modeeria, Euphysa, Steenstruppia.

II. Steganophthalmata. Aurelia, Pelagia, Chrysaora, Rhizostoma, Cassiopea, Cyanæa.

MY OWN VIEWS OF THE CLASSIFICATION OF ACALEPHS.

In a series of lectures, delivered before the Lowell Institute in the winter of 1848–1849, a phonographic report of which appeared first in the "Traveller" and afterwards in the form of a separate pamphlet, I have presented my views of the natural affinities of the Radiates in general, and there began to trace the homologies of these animals with the other Radiates, and introduced some changes in their classification, which an uninterrupted study for more than ten years longer, along the whole Atlantic coast of North America, from Canada to Texas, has only confirmed and enlarged by furnishing additional means of comparisons.

There I circumscribed the type of Radiata in the same manner in which I now think it should be circumscribed, admitting in it three classes only, — the Polyps, the Acalephs, and the Echinoderms. There I showed also that the Hydroids are genuine Acalephs, and should be united, not only with the naked-eyed Medusæ, but also with the Siphonophoræ. There also I traced the special homologies of the Ctenophoræ and other Acalephs, and the general homologies of all Radiata, including the Echinoderms. There I advocated the compound character of the Siphonophoræ, and carried that view even further than it is carried by some naturalists, showing, what I believe to be true, that certain parts of their communities, which are still considered by some anatomists as organs, are in reality distinct individuals.

I do not make this somewhat extended reference to my "Lectures," in order to substantiate special claims of priority, but solely to prevent any imputation of having borrowed from others the views I have derived from my own investigations, and upon which I may have to dwell more fully in the course of this work. This appears to me the more necessary, since the reports of my lectures have had only a very limited circulation in Europe.

We are indebted to Lütken for valuable contributions to the natural history of the Acalephs of Greenland and Scandinavia, in connection with which he has published a new systematic arrangement of the naked-eyed Medusæ. As I know this paper only from the abstracts given by Leuckart in the Archiv für Naturgeschichte for 1854, 2d vol., p. 424, I abstain from further remarks about it.

LÜTKEN'S CLASSIFICATION OF THE NAKED-EYED MEDUSÆ, 1850.

1st Group.	1st Family.	Æ g i n e æ : Carybdea, Eurybia, Cunina, Ægina, Æginopsis, Polyxenia.
2d Group.	1st Family.	Æ q u o r e a d æ : Æquorea, Mesonema, Stomobrachium, Thaumantias.
	2d Family.	O c e a n i d æ : Oceania, Saphenia, Turris, Modeeria.
	3d Family.	B o u g a i n v i l l e æ : Bougainvillea, Lizzia, Rathkia.
	4th Family.	G e r y o n i d æ : Geryonia, Tima, Geryonopsis, Dianæa, Circe.
	5th Family.	S a r s i a d æ : Sarsia, Slabberia, Steenstruppia, Euphysa.
3d Group.	1st Family.	W i l l s i a d æ : Willsia, Proboscidactyla, Berenice.

Milne-Edwards never attempted systematically to present his views of the affinities of the Acalephs in the form of a special classification, though we owe to him important contributions to the history of this class. Von Siebold, in his text-book of comparative anatomy, has adopted the classification of Eschscholtz, which, to this day, is followed by most naturalists.

Since, judging from my observations upon Millepora, a large number of Corals must be considered as belonging to the type of Hydroids, it is necessary to introduce here the classification of Corals by Milne-Edwards, in order more directly to show what changes are likely to be rendered necessary in the systematic arrangement of the Corals, in consequence of my discovery of the acalephian affinities of the genus Millepora.

When the two highest authorities in the natural history of Corals, Milne-Edwards and Dana, agree in considering the genus Millepora as a member of the class of Polyps, I would not venture to suggest a different view of its affinities. had I not been able leisurely to examine the animal of that kind of Coral, which had never been observed before, and satisfied myself that it has none of the typical characteristics of the Polyps, neither radiating partitions, nor digestive sac hanging in the main cavity, while it agrees so closely with the true Hydroids, and especially with the genus Hydractinia, that there can be no doubt left in what direction its natural affinities point. (Compare Pl. XV. *Figs.* 3–13 with Pl. XVI., respecting which more will be found in the sequel.) With these facts before us, Millepora must unquestionably be removed from the class of Polyps and referred to that of the Acalephs, as soon as it is conceded that the Hydroids are Acalephs, and not Polyps.

RELATIONS ASSIGNED BY MILNE-EDWARDS TO THE TABULATA AND RUGOSA, AND TO SOME OF THE HYDROIDS IN THE CLASS OF POLYPI, 1850–1852.

1st Sub-class. Corallaria.
- 1st Order. *Zoantharia.*
  - 1st Group. Malacodermata. Families: Actinidæ; Actininæ, Thalassianthinæ, Phyllactinæ, Zoanthinæ; Cerianthidæ; Minyadidæ.
  - 2d Group. Aporosa. Families: Turbinolidæ; Cyathininæ, Turbinolinæ; Pseudotur binolidæ; Oculinidæ; Pseudoculinidæ; Astræidæ; Eusmilinæ, Astræinæ; Pseudastreidæ; Fungidæ; Funginæ, Lophoserinæ.
  - 3d Group. Perforata. Families: Madreporidæ, Euspammidæ, Madreporinæ, Turbinariæ; Poritidæ; Poritinæ, Alveoporinæ.
  - 4th Group. Tabulata. Families: Milleporidæ; Favositidæ: Favositinæ, Chætitinæ, Halysitinæ, Pocilloporinæ: Seriatoporidæ; Thesidæ.
  - 5th Group. Tubulosa. Family: Auloporidæ.
  - 6th Group. Rugosa. Families: Stauridæ; Cyathaxonidæ; Cyathophyllidæ: Zaphrentinæ, Cyathophyllidæ, Axophyllinæ.
- 2d Order. *Alcyonaria.* Families: Alcyonidæ; Cornularinæ, Telesthinæ, Alcyoninæ, Tubiporinæ; Gorgonidæ; Gorgoninæ, Isidinæ, Coralliinæ; Pennatulidæ.
- 3d Order. *Podactinaria.* Family: Lucernaridæ.

2d Sub-class. Hydraria. Family: Hydridæ.

Of these groups I hold that the *Zoantharia*, Malacodermata, Aporosa and Perforata, and the *Alcyonaria* alone, are genuine Polyps; and that the Tabulata, Tubulosa, Rugosa, Podactinaria, and Hydraria are Acalephs.

Since, from this time forward, the influence of Embryology upon the classifications of Acalephs is more or less distinctly felt, I deem it necessary to introduce here some comparisons between the earlier attempts at a systematic arrangement of these animals and the later systems, in order to render more evident the progress made thus far.

The classification of Lamarck, and the names he gave to the primary subdivisions of the Acalephs, truly express the condition of our science at that period. The natural limits of the class had not yet been found, — nay, the Acalephs were not yet separated from the Echinoderms, as a class, but Medusæ had been observed, a considerable number of them were superficially known, and, next to them, many animals had been noticed, bearing evidently some relation or other to the Medusæ; but what these relations were, was not understood; and so all these species were united into one group by the side of the regular Medusæ, under the name of Anomalous Radiates.

Péron and LeSueur next investigated these groups singly, — LeSueur devoting his attention chiefly to the compound ones, which he at this early period already separated from the compound Tunicata, while, together with Péron, he illustrated the Discophoræ generally.

Cuvier's merits consist mainly in the separation of the Acalephs as a class; but the limits he assigned to it were not altogether true to nature. Schweigger only copied Lamarck and Cuvier as far as classification is concerned.

To Goldfuss, science is indebted for the first discriminating subdivision of the Acalephs. For the first time the Ctenophoræ were brought together by him and separated from the Siphonophoræ, and these again divided into two families, while all Discophoræ remained together. Chamisso and Eysenhardt copied Goldfuss, while, still later, Latreille fell back upon the first outlines of Lamarck.

Eschscholtz, next to Cuvier, may be considered as the founder of the classification of Acalephs, for while Cuvier distinguished the class, Eschscholtz first divided it into three natural orders, one of which he very properly subdivided into two divisions, already pointing in the direction of future progress; for hereafter the Discophoræ cryptocarpæ will appear more clearly allied to the Siphonophoræ than they are to the Discophoræ phanerocarpæ. His subdivision of the orders into natural families was a still greater improvement. DeBlainville did not mark a progress in the study of this class: his suggestions were mere guesses, mostly far out of the right course. Oken simply copied Eschscholtz. Brandt added a few families among the Siphonophoræ, the number of which was still further increased, often without much discrimination or criticism, by Lesson. Forbes, and Lütken also, described some new families; but Forbes made an important addition to the classification of Eschscholtz, by pointing out further differences between the two divisions of the Discophoræ, which he called Steganophthalmata and Gymnophthalmata.

With Sars and Steenstrup a new epoch begins for the history of the Acalephs, though neither of them has attempted to classify these animals; but it is to their investigations that science is indebted for the first facts bearing upon the affinities of the Hydroids to the Discophoræ cryptocarpæ, or the Gymnophthalmata of

Forbes. These affinities I have recognized in uniting the Hydroids and Gymnophthalmata with the Siphonophoræ in one order, to which I have lately added the Tabulata and Rugosa of Milne-Edwards. This step seems to me to have at last circumscribed the class within its natural limits, and fixed its boundaries on the side of the Polyps, where the dividing line had remained more vague than in any other direction.

I have already presented my objections to some points of the classification of Vogt relating to the Acalephs in general. I have only to give here an outline of the minor divisions which he admits among these animals. But while I cannot agree with his classification, it is but justice to him to say that his paper upon the Siphonophoræ of Nizza is one of the most valuable contributions of modern times to the natural history of these animals, forming, in connection with similar papers by Leuckart, Kölliker, Gegenbaur, and Huxley, a very full description of all the representatives of this type.

CLASSIFICATION OF VOGT, 1851.

Referring the Ctenophoræ to the Mollusks, Vogt, in his "Zoologische Briefe," published in 1851, has adopted the following classification for the Acalephs, after dividing the Radiata into four classes: *Polyps*, including Lucernaria but not the other Hydroids, *Hydromedusæ*, *Siphonophoræ*, and *Echinoderms*.

The class of HYDROMEDUSÆ (Quallenpolypen) is divided into two orders: —

1st Order. *Hydroids*, with three families: Hydrida, Tubularida, Campanularida.

2d Order. *Medusæ*, with six families: Medusida, Oceanida, Æquorida, Berenicida, Rhizostomida, Geryonida.

The class of SIPHONOPHORÆ (Röhrenquallen) is divided into three families: Physalida, Velellida, and Diphyida, to which Stephanomia is appended.

The class of CTENOPHORÆ (Rippenquallen) is divided into two families: Beroida and Callianirida.

In his paper upon the Siphonophoræ of Nizza, published in 1854, Vogt has appended the following classification of the order of his Hydromedusæ, which embraces them: —

Order I. POLYPI NECHALEI.

1st Division. With active natatory organs. Polyps provided with fishing threads. Swimming belly hollow.

1st Family. *Agalmides:* Apolemia, Agalma, Physophora. — The genera Rhizophysa, Brachysoma, Stephanomia, Epibulia, Sarcoconus, and Discolabe, are considered as founded upon mutilated animals.

2d Family. *Hippopodides:* Hippopodius, Vogtia. — Elephantopes and Racemis are questionable.

3d Family. *Diphyides:* Praya, Galeolaria, Diphyes. All the other genera referred to this family are rejected.

4th Family. *Athorybides:* Athorybia. — The genus Anthophysa is questioned.

2d Division. With passive natatory organs.

1st Family. *Physalides*: Physalia. — The sub-genera Salacias, Cystisoma, and Alophotes, are considered as useless; and Angela as probably near Physalia.

2d Family. *Velellides:* Velella and Porpita. — Rataria is young Velella.

The contributions of Kölliker to the natural history of the Acalephs are as varied as they are important, though sometimes consisting simply of short notices. A report of the investigations made by him in Messina, in connection with Gegenbaur and H. Müller, and published in the "Zeitschrift fur wissenschaftliche Zoologie," vol. 4, p. 299, contains a vast amount of information upon the Acalephs of the Mediterranean. In his larger work on Siphonophoræ, "Die Schwimmpolypen von Messina," however, he has not only given a very full account of the species he observed in Messina, including new genera and the characteristics of new families, but he has also published a diagram of his views respecting the affinities of the lower animals generally, as follows: —

CLASSIFICATION OF KÖLLIKER, 1853.

The members of the class of Acalephs are so combined with the Polyps and Bryozoa by Kölliker, that his views respecting their affinities can only be appreciated by a comparative study of his whole diagram of the Radiates with other classifications of the Invertebrates generally. He divides the Radiata in the following manner: —

I. RADIATA MOLLUSCOIDEA.

1st Group. HYDROIDEA. A. *Hydroidea sessilia:* Hydra.
B. *Hydroidea nechalea:* Physophora, Diphyes, Athorybia, etc.
2d Group. HYDROMEDUSIDA: Coryne, Sertularia, Tubularia, Velella, and Gymnopthalmata: Oceania, Bougainvillea, etc.
3d Group. DISCOPHORA: Steganophthalmata: Medusa, Rhizostoma, Cephæa.
4th Group. CTENOPHORA.
5th Group. ANTHOZOA.
6th Group. BRYOZOA.

II. RADIATA ECHINODERMATA.

1st Group. HOLOTHURIDA. — 2d Group. ECHINIDA. — 3d Group. ASTERIDA. — 4th Group. CRINOIDEA.

Kölliker thus coincides with Leuckart in separating the Echinoderms from the Polyps and Acalephs as a primary group of the animal kingdom, and uniting the minor sections of the two latter classes into another great division. Disregarding, however, all the categories of the system of Zoölogy by which animals may be divided into classes and orders, he divides the Hydroidea nechalea, which he calls also POLYPI NECHALEI, into five families: —

1st Family. Physophoridæ: Forskalia, Agalmopsis, Apolemia, — Physophora, — Athorybia.
2d Family. Hippopodiidæ: Hippopodius, Vogtia.
3d Family. Prayidæ: Praya.
4th Family. Diphyidæ: Diphyes, Abyla.
5th Family. Velellidæ: Velella, Porpita.

Though Leuckart has not published a general classification of the Acalephs, he has done so much for the advancement of the natural history of that class of animals, and for a more correct appreciation of the affinities of the lower animals generally, that he deserves a prominent place in a history of their classification. (Compare vol. 1, pp. 179 and 209.) His special contributions to the systematic arrangement of the Acalephs relate chiefly to the Siphonophoræ, and are expressed in the following diagram: —

LEUCKART'S CLASSIFICATION OF THE SIPHONOPHORÆ, 1854.

1st Family.	Calycophoridæ.	
	1st Sub-family.	*Diphyidæ:* Abyla, Diphyes, Galeolaria, — Praya.
	2d Sub-family.	*Hippopodiidæ:* Hippopodius.
2d Family.	Physophoridæ.	
	1st Sub-family.	*Stephanomidæ:* Apolemia, Agalma, Forskalia.
	2d Sub-family.	*Physophoridæ* proper: Physophora.
3d Family.	Rhizophysidæ: Rhizophysa.	
4th Family.	Physalidæ: Physalia.	
5th Family.	Velellidæ: Velella, Porpita.	

In the additions to the German edition of Van der Hoeven's Handbook of Zoology, Leuckart has divided the Ctenophoræ into two orders, the *Eurystomata* and *Stenostomata*, — an arrangement already hinted at by Eschscholtz and Van der Hoeven.

Since Eschscholtz, no naturalist has made more extensive and more valuable contributions to the natural history and anatomy of the Acalephs in general, than Gegenbaur, who has extended his researches to all the orders of the class, including the study of their development, in his comprehensive investigations. His classifications of the different groups of the class contain much also that is new and important, though I think he is mistaken in the rank he assigns to some of them. The different works in which he has published his researches are enumerated above (p. 27, note 13, and p. 87, note 1.) The chief importance of Gegenbaur's contributions to the classification of the Acalephs consists in the discrimination of several new families among the naked-eyed Medusæ, and more especially in the introduction of a new consideration by which to distinguish the Discophoræ proper from the naked-eyed Medusæ. It has been seen above, that Eschscholtz admitted two divisions among the Discophoræ, one of which he called Discophoræ phanerocarpæ, and the other Discophoræ cryptocarpæ, founding this distinction upon the presence or absence of special pouches for the reception of the sexual apparatus. Forbes admitted also two divisions, calling one Steganophthalmata, because the eyespecks are enclosed in a scalloped fold of the margin of the disk, and the other Gymnophthalmata, because the eyespecks are exposed along the margin, in close connection with the tentacles and the circular tubes. Gegenbaur founded a similar subdivision upon the presence or absence of an inverted rim along that same margin.

CLASSIFICATION OF GEGENBAUR, 1856–1859.

Gegenbaur is the last author to whose systematic views I have to allude, as far as they relate to the Acalephs in general: later authors have only considered parts of the subject. He, like most recent German writers, adopts the primary division of the Radiata into Cœlenterata and Echinodermata, proposed by Leuckart, and in his Textbook of Comparative Anatomy subdivides the Cœlenterata into three classes: POLYPI, HYDROMEDUSIDA, and CTENOPHORA. Here the Hydroids are all referred to the class of the Hydromedusida, with the sole exception of Lucernaria, which is left among the Polyps. The Hydromedusida themselves are divided in the following manner: —

1st Order. HYDROIDEA: Coryne, Syncoryne, Hydractinia, Sertularia, Pennaria; — Campanularia, Eudendrium, Tubularia.

2d Order. MEDUSIDA: 1° *Craspedota*: Oceania, Sarsia, Lizzia; — Geryonia; — Æquorea; — Ægineta, Cunina. 2° *Acraspeda*: Pelagia, Aurelia, Chrysaora; — Rhizostoma, Cassiopeia.

3d Order. SIPHONOPHORA: Velella, Porpita; — Diphyes, Abyla; — Agalma, Physophora, Physalia.

To the class Ctenophora the genera Cestum, Cydippe; — Mnemia, LeSueuria; — Eucharis; — and Beroe, are referred. But Gegenbaur had already published a more special account of his view of the Ctenophora in 1856, in the "Archiv für Naturgeschichte," p. 163, in which he adopts the following families: —

Callianiridæ: Callianira.

Calymnidæ: Calymna, Mnemia, Axiotima, Bolina, Eucharis, Leucothoe, Alcinoe, Chiaja, LeSueuria, and Euramphæa.

Cestidæ: Cestum.

Cydippidæ: Neis, Ocyroe, Mertensia *Less.*, Anais, Eschscholtzia, Mertensia *Gegenb.*, Janira, Cydippe, Pleurobrachia, Beroe *Mert.*, Owenia.

Beroidæ: Beroe (Idya, Cydalisa, Medea). — Sicyosoma.

In 1857, Gegenbaur published a special paper upon the Discophoræ in the Zeitschrift für wissenschaftliche Zoölogie, in which he admits two great divisions, corresponding to the *Phanerocarpæ* and *Cryptocarpæ* of Eschscholtz, and to the *Steganophthalmata* and *Gymnophthalmata* of Forbes, as follows: —

ACRASPEDA, with four families: —

- Rhizostomidæ: Rhizostoma, Cephea, and Cassiopeia.
- Medusidæ: Aurelia, Sthenonia, and Cyanea.
- Pelagidæ: Chrysaora, Pelagia, and Nausithoe (Octogonia).
- Charybdeidæ: Charybdea.

CRASPEDOTA, with seven families: —

- Oceanidæ: Oceania, Saphenia, Turris, Sarsia, Modeeria, Bougainvillea, Lizzia, Cytæis, Zanclea, Steenstruppia, Euphysa, Cladonema, Willsia, Chrysomitra; with five sub-families, *Oceanidæ* proper, *Sarsiadæ*, *Bougainvillidæ*, *Willsiadæ*, and *Cladonemidæ*.
- Thaumantidæ: Thaumantias, Staurophora, Tiaropsis, and Tima.
- Æquoridæ: Æquorea, Mesonema, Stomobrachium.
- Eucopidæ: Eucope, Sminthea, Eurybiopsis, Aglaura.
- Trachynemidæ: Trachynema, Rhopalonema.
- Geryonidæ: Geryonia, Liriope.
- Æginidæ: Cunina, Ægineta, Ægina, Æginopsis, Polyxenia.

The paper of J. McCrady upon the Gymnophthalmata of Charleston harbor, published in the Proceedings of the Elliott Society of Natural History in 1858, contains much interesting, and some highly important and novel, information upon the naked-eyed Medusæ of South Carolina, to which I shall have frequent opportunities of referring hereafter. For the present, I shall only allude to the classification he has proposed of the lowest order of the Acalephs. He is the first naturalist who has adopted the order of Hydroids with the limits I have assigned to it; but he has introduced a new arrangement of the minor groups.

CLASSIFICATION OF THE HYDROIDS BY J. McCRADY, 1858.

1st Sub-order. ENDOSTOMATA.

- 1st Family. *Corynidæ.* Oceanidæ: Oceania, Turritopsis, Turris, Modeeria, Saphenia.
  - Sarsiadæ: Sarsia, Corynitis, Dipurena, Slabberia.
  - Clavidæ: Clava.
- 2d Family. *Velellidæ.* Velella, Porpita, Chrysomitra, Rataria.
- 3d Family. *Tubularidæ.*
  - Pennaridæ: Cladonema, Zanclea, Pennaria, Willsia.
  - Tubularidæ: Steenstruppia, Euphysa, Tubularia, Corymorpha.
  - Hippocrenidæ: Nemopsis, Lizzia, Bougainvillea, Hippocrene, Cytæis, Eudendrium, Hydractinia.
- 4th Family. *Siphonophoræ.*
  - Physophoridæ: Forskalia, Agalma, Agalmopsis, Physophora, etc.
  - Hippopodidæ: Hippopodius, Vogtia.
  - Diphyidæ: Prayia, Diphyes, Eudoxia, etc.
  - Physalidæ: Physalia.

2d Sub-order. EXOSTOMATA.

- 1st Family. *Campanularidæ.*
  - Thaumantiadæ: Thaumantias, Staurophora, Tiaropsis.
  - Eucopidæ: Geryonopsis, Tima, Eucope, Eucheilota, Epenthesis, Campanularia.
- 2d Family. *Sertularidæ.* Sertularia, Halecium, Thuiaria, Plumularia, Aglaophenia, Antennularia.
- 3d Family.
  - *Circeadæ.* Circe, Persa, Aglaura.
  - *Trachynemidæ.* Trachynema, Rhopalonema.
  - *Stomobrachidæ.* Stomobrachium, Mesonema.
  - *Geryonidæ.* Geryonia, Liriope.
  - *Æquoriadæ.* Æquorea, Rhacostoma.
- 4th Family. *Æginidæ.* Cunina, Ægina, Ægineta, Æginopsis, Polyxenia.

Besides extensive and valuable contributions upon the structure and affinities of the Acalephs in general, published in the Transactions of the Royal Society of London, and of the Siphonophoræ in particular, published in Müller's Archiv, Huxley has lately proposed a new classification of the latter, which he calls Hydrozoa.

HUXLEY'S CLASSIFICATION OF THE SIPHONOPHORÆ, 1859.

HYDROZOA.

I. CALYCOPHORIDÆ.
- 1st Family. Diphydæ: Diphyes, Galeolaria, Abyla.
- 2d Family. Sphæronectidæ: Sphæronectes.
- 3d Family. Prayidæ: Praya.
- 4th Family. Hippopodiidæ: Hippopodius, Vogtia.

II. PHYSOPHORIDÆ.
- 1st Family. Apolemiadæ: Apolemia.
- 2d Family. Stephanomiadæ: Halistemma, Forskalia, Stephanomia, Agalma.
- 3d Family. Physophoriadæ: Physophora.
- 4th Family. Athorybiadæ: Athorybia.
- 5th Family. Rhizophysiadæ: Rhizophysa.
- 6th Family. Physalidæ: Physalia.
- 7th Family. Velellidæ: Velella, Porpita.

From the circumstance that his last work embraces all the animals then referred to the class, Lesson truly marks the close of a period in the history of the progress of the classification of Acalephs. From his days forward, the improvements bear chiefly upon the arrangement of the Hydroids, first brought into the sphere of attraction of the Medusæ about that time. Affinities, unsuspected before, lead to new combinations; and a more intimate acquaintance with the structure of all these animals, by the very novelty of the disclosures, suggests comparisons with the remotest types, and mere analogies are exalted into real affinities. But step by step, the test of homological relationship being applied to these aberrations, and embryological study adding its controlling influence, the Acalephs are finally circumscribed within limits which would now seem natural, and subdivided into groups which are not likely to undergo other than changes of secondary importance.

In concluding this rapid sketch of the classifications of the Acalephs I may be permitted to remark, that a retrospective glance over the many attempts thus far made to express the various degrees and different kinds of affinities of these animals, in the shape of diagrams, should satisfy any one how readily different authors, approaching the study of these animals with a very different preparation, have in the end agreed upon the natural limits of a larger and larger number of their subordinate groups, in proportion as the information concerning these groups has become more and more precise. The disagreement among authors has been most persistent upon the classification of those animals only, respecting the structure of which our knowledge has also remained deficient for a longer period; and it is cheering to see how, with increasing knowledge, the most extreme views have been gradually converging in the same direction. This condition of things excites a strong hope, that, ultimately, all differences among naturalists respecting classification may be settled; when the conformity of views will itself become an additional evidence that the system exists in nature, and not in the minds of those who have contributed to decipher it.