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MDCCCLXXI.

A MONOGRAPH

OF THE

GYMNOBLASTIC OR TUBULARIAN

HYDROIDS.

IN TWO PARTS.

I.—THE HYDROIDA IN GENERAL.

II.—THE GENERA AND SPECIES OF THE GYMNOBLASTEA.

BY

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MDCCCLXXI.

Freuet euch des wahren Scheins,
Euch des ernsten Spieles;
Kein Lebendiges ist ein Eins,
Immer ist's ein Vieles.

Goethe, "*Epirrhema*," *in* '*Gott und Welt*.'

PRINTED BY J. E. ADLARD,
BARTHOLOMEW CLOSE

I Dedicate this Book

TO

GEORGE BUSK, ESQ., F.R.S., F.L.S., &c.,

WHOSE ABLE AND CONSCIENTIOUS LABOURS IN THE FIELD OF RESEARCH TO WHICH ITS PAGES ARE DEVOTED HAVE LARGELY CONTRIBUTED TO OUR KNOWLEDGE OF HYDROID ZOOLOGY,

WHOSE VARIED ACQUISITIONS, GATHERED FROM MANY A REGION OF BIOLOGICAL SCIENCE, HAVE EVER BEEN, WITH GENEROUS DISINTERESTEDNESS, PLACED AT THE DISPOSAL OF ALL WHO MAY BE WILLING TO USE THEM FOR THE ADVANCEMENT OF KNOWLEDGE.

ONE OF MY EARLIEST FRIENDS AND MOST VALUED ASSOCIATES IN SCIENTIFIC WORK.

Weybridge;

1871.

PREFACE.

The present work contains the result of many years' study of the remarkable group of animals to whose elucidation it is devoted, a group in the investigation of which ready access to the sea has afforded me special facilities.

My object has been to work out as exhaustively as possible the general natural history of the HYDROIDA, and besides this to give a complete descriptive Zoology of the Gymnoblastic or Tubularian forms of this Order.

The work is thus divided into two parts—the first devoted to the Morphology, Physiology, Distribution, and other general considerations bearing on the entire Order of the HYDROIDA; the second, to descriptions of all the known genera and species which compose one of its most important and interesting Sub-orders—that of the *Gymnoblastea*.

A very large proportion of the observations here recorded are entirely original, while it has, moreover, been my aim, in giving an account of the observations of others, to take nothing for granted which it was possible for me to subject to personal verification. It will be seen that the amount of labour thus involved is far from slight. Indeed, it is only by constant and widely extended explorations of the coast, both within the tidal zone and in the deeper sea regions, followed up by laborious microscopic investigations, that results of any value are to be expected.

The plates have all been drawn from nature by myself, and are from the living animal. The soft parts, which constitute the chief interest in these wonderful organisms, are thus represented as they show themselves while the animal is still beneath the waters of its native seas. This is all the more important in animals which, like the gymnoblastic hydroids, retain in their dried state not a single character of value, and which even in specimens preserved in spirits lose almost all their beauty and many of their important zoological characters. The figures of the species, too, are all coloured from life, so that not only will a more adequate idea of the beauty of these creatures in their living state be thus conveyed, but greater facilities will be afforded to the practical zoologist in the comparison and determination of species. The plates, moreover, contain numerous anatomical and embryological details; and, besides the magnified drawings of each species, I have in every case given a figure of the animal in its natural size.

It was originally my intention to restrict the descriptive portion of the work to the British representatives of the group. Further consideration, however, has led me to believe that its value would be much increased by including descriptions of all the known *Gymnoblastea*, whether British or foreign. The plates, however, are necessarily confined to British species. Indeed, independently of other reasons, this course was inevitable so long as I had resolved to make all my drawings from living specimens. Full reference, however, is always given to the places where published figures of the foreign species are to be found.

The same reason has obliged me to leave a few British species unfigured, as I have hitherto failed in my attempts to obtain living specimens of them. References, however, are here, as in the case of foreign species, always made to the works in which figures of them are given.

Besides the plates, numerous woodcuts are introduced into the text. Though a few of these have already appeared in my published memoirs, they are all from original drawings of my own, and will, it is hoped, serve to render clear various points of structure which it would be difficult to make intelligible without the aid of figures.[1]

For obvious reasons it is only those species whose trophosomes have been discovered which form the subject of the descriptive portion of the present work. There are still known to zoologists a large number of hydroid medusæ which have not yet been traced to their trophosomes. Since Forbes's Monograph, published among the earlier volumes of the Ray Society, much additional matter has been accumulated regarding these beautiful organisms, and many of them have been figured with structural details in the first part of the present work. I have still many unpublished notes on them, and, though it was impossible to treat them here systematically, I cannot dismiss the hope of being yet able to supplement the present volume by another which would be devoted to the natural history of these free hydroid medusæ, whether they have been traced to their trophosomes or not.

As the descriptive portion of this Monograph is based upon the entire organism, both trophosome and gonosome affording characters equally essential in the diagnosis, I have never been contented with specimens in which the gonosome as well as the trophosome was not present. It is only in one or two cases that I have failed in

[1] The use of the blocks employed in the illustration of my "Report on the Hydroida," published in the 'Transactions of the British Association for the Advancement of Science,' has been liberally granted by the Council of that body.

procuring examples provided with their gonosomes, and that I have been obliged to confine my figures to the trophosome alone.

The additions which the last few years have made to our knowledge of hydroid morphology have necessitated the introduction of new terms. Such terms as I have found it necessary to construct have been made as far as possible etymologically significant of the ideas intended to be expressed by them, while I have endeavoured to define them with a rigidity which may allow of no ambiguity in their application. The advantages to be derived from a significant and rigidly defined terminology are great, for it not only facilitates the recording and communication of scientific truths, but it even becomes, like the symbols in algebra, a direct aid in original research.

With the view of making the terminology as perfect as possible, I have not hesitated to alter some of the terms formerly introduced by myself. Terminology differs from nomenclature in priority of use not necessarily giving a fixity of tenure; and while capricious change of terms must be deprecated, no one ought to be precluded from substituting a better term for one already in use.

The labour of the drawings, which I could entrust to no hand but my own, and the necessity of procuring in every case living specimens as the subjects of them, have caused the work to be longer in preparation than I had originally anticipated, and I cannot avoid here expressing my obligations to the Council of the Ray Society for the patience with which they have borne the delay. One advantage, however, has followed from it, for I have been thereby enabled to carry up to the present standpoint of our knowledge this exposition of a rapidly developing department of research, in which every year has been bringing out new facts and more or less modifying old views.[1]

The coasts of the British Isles have afforded me the chief fields for exploration, and my dredgings and tidal coast work have extended from the south-western extremity of Cornwall to the furthest outliers of the Shetland Isles. Some investigations, however, have been also carried on in the Mediterranean, and I have thus obtained many facts in hydroid zoology from the northern shores of the Adriatic, from the coast of Naples, and from the eastern and western Riviera.

Continental museums, wherever accessible, have been consulted. These, on the whole, are very poor in all that concerns the zoology of the Hydroida, and few of them possess anything beyond some dried specimens of such common species as may be casually picked up on the sea-beach.

Some, however, have repaid the trouble of consultation, and I must here express my thanks to M. Milne-Edwards and to M. Lacase Duthiers for the liberal manner in

[1] Quite recent additions to our knowledge of hydroid life render necessary some modification of the statements contained in pp. 22, 23 regarding our want of evidence of the direct development of the medusa from the egg, without the intervention of a hydriform trophosome. The reader will accordingly correct and supplement these statements by the results of later observations detailed in p. 100.

which they placed the collections of the Jardin des Plantes at my disposal, and for the opportunity thus afforded me of critically examining the authentic specimens of Lamarck, as well as other interesting hydroid collections in the museum. To Professor Stossich, of Triest, I am also indebted for an opportunity of examining the collection of hydroids in the museum of that town, one of the best collections of these animals contained in any Continental museum which I have been able to consult.

To Professor Paolo Panceri, of the University of Naples, my thanks are especially due, not only for the liberal way in which he placed in my hands specimens for investigation, but for the valuable assistance I received from him in the examination of the Neapolitan coast.

To my friend Professor Schiff, of Florence, I owe my hearty acknowledgments for aid in consulting the museum of that city, and for many other ways in which he has facilitated my researches.

To the Marquis Giacomo Doria, who, in the disinterested love of science, has devoted his time and property to the advancement of natural history, pursued, at the sacrifice of health, amid the malaria of East Indian jungles, and has thus added another laurel to those which have already made the name of Doria illustrious in the annals of the great Genoese Republic, as well as to Dr. Gestro, his assistant, and to Professor Trinchesi, of the University of Genoa, I am indebted for much kindness, and for valuable guidance to the zoological localities of the Gulf.

To Dr. Giglioli, of Florence, I owe the opportunity of inspecting an extensive collection of drawings in which he records many important observations made on hydroid planoblasts and other pelagic forms met with during the circumnavigatory voyage of the "Magenta," which he accompanied as assistant-naturalist.

Dr. Du Plessis, of Nice, who has made the hydroids of the neighbouring coast a subject of special study, and has been singularly sucessful in keeping them in a healthy state in his vivarium, kindly acted as my guide to various hydroid localities with which he had become familiar in the beautiful bay of Villafranca; while I am also under much obligation to Professor Mecznikoff, of St. Petersburgh, who happened to be at the same time residing at Villafranca, where he was engaged in researches on the lower animals of the bay, and where he communicated to me some of the important results to which he had arrived.

To Professor Van Beneden, of Louvaine, and to the late venerable Professor Sars, I am indebted for presentations of their many important memoirs, and for the communication of specimens, while my thanks are also due to Professor Agassiz and to Mr. Alexander Agassiz, as well as to Professor Kölliker and to Professor Haeckel, for copies of many valuable memoirs bearing more or less directly on hydroid zoology.

And still further, I must express my obligations to Professor Costa, of the University of Naples; to Sig. Filippo Trois, of Venice; to Professor Savi, of Pisa; to Professor Oscar Schmidt, of Gratz; to Dr. Antoine Fritsch, of Prague; to Dr.

Brauer, of Vienna; and to Dr. Marshal, of Leiden, as well as to many other continental naturalists, for friendly assistance, either by freely placing at my disposal specimens which I could not elsewhere have obtained or by otherwise aiding me in the object I had in view.

To specify here the names of our own countrymen from whom I have received assistance would be to extend this list of obligations to a much greater length than space will allow. Reference to them in other parts of the work will show that I have not been unmindful of the aid they have afforded me. I cannot, however, avoid expressing in this place my obligations to Professor Wyville Thomson, Dr. Carpenter, and Mr. J. Gwyn Jeffreys, for having placed in my hands the whole of the hydroids procured in the deep-sea dredgings of the "Porcupine" expedition; and to Mr. Busk, for allowing me the free use of his collection of hydroids obtained from various parts of the world, and affording facts of much value in the geographical distribution of the order.

The earlier sheets of the present Monograph had been already printed before the publication of Mr. Hincks's work on the British Hydroids.[1] This will account for the absence of all allusion to it in the section devoted to the history of those labours which have contributed to bring our knowledge of the HYDROIDA to its present standpoint. And yet the literature of hydroid zoology demands a special reference to this valuable work. Eminently critical, with the descriptions accurate and lucid, and with the figures abundant and expressive, it is the most complete systematic work on the HYDROIDA hitherto published. The large amount of original observations gives it a special value, and its fulness of description and illustration renders it indispensable to every student of the HYDROIDA. The delay which has occurred in the publication of the second part of the present Monograph will enable me to cite unreservedly Mr. Hincks's work, without which the synonomy and literature of many of the species here described would be very deficient.

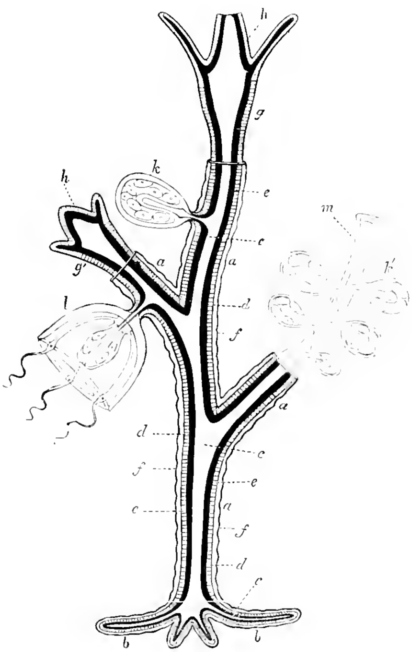
[1] 'A History of the British Hydroid Zoophytes.' By Thomas Hincks. London, Van Voorst, 1868.

GLOSSOLOGY.

Imaginary generalised Diagrams of Hydroids to illustrate the terminology.

In order better to distinguish the various parts and to render the respective limits of the trophosome and gonosome at once apparent, the endoderm and ectoderm of the gonosome are in both figures represented by simple outline, while in the trophosome the endoderm is throughout distinguished by a heavy line, the ectoderm by transverse hatching, and the perisarc by a simple wavy line.

I.



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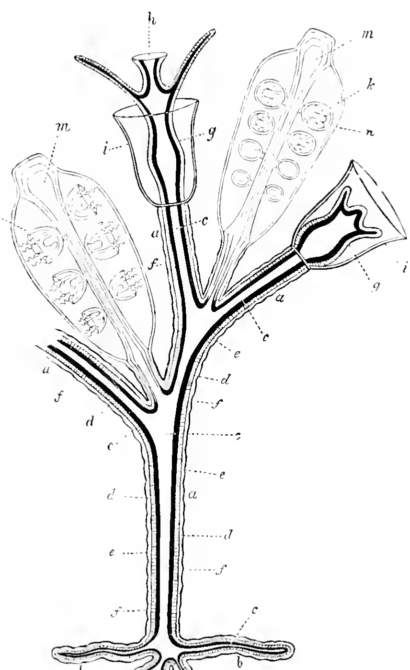

I. *Imaginary generalised Diagram of a Gymnoblastic Hydroid.*—*a, a, a, a.*—Hydrocaulus. *b, b.*—Hydrorhiza. } Hydrophyton. *c, c, c.*—Somatic cavity. *d, d, d.*—Endoderm of hydrophyton. *e, e, e.*—Ectoderm of hydrophyton. } Cœnosarc. *f, f, f.*—Perisarc. *g.*—Hydranth extended. *g'.*—Hydranth contracted. *h, h.*—Hypostome bearing the mouth at its extremity. *k.*—Sacciform gonophore (sporosac) springing from the hydrocaulus. *k'.*—Sporosac springing from a blastostyle. In *k, k'*, the spadix is seen to occupy the axis of the sporosac, and round the spadix are developed the generative elements. *l.*—Medusiform gonophore (planoblast). A manubrium occupies its axis, and in the walls of this the generative elements are directly developed. *m.*—Blastostyle.

II. *Imaginary generalised Diagram of a Calyptoblastic Hydroid.*— The letters *a* to *h* indicate the same parts as in I. *i, i.*—Hydrotheca. *k.*—Sporosac springing from a blastostyle, with the generative elements developed round a spadix which occupies the axis of the sporosac. *l.*—Planoblast springing from a blastostyle. *m, m.*—Blastostyle. *n.*—Gonangium.

TERMS APPLICABLE TO THE HYDROID COLONY IN GENERAL.

Hydrosoma (ὕδρα, hydra, mythological monster; σῶμα, body). The entire hydroid colony.

Ectoderm (ἐκτός, outside; δέρμα, skin). The more external of the two organized layers of which the body of every hydroid is composed. (Diagrams I and II, *e, e, e.*)

Endoderm (ἔνδον, within; δέρμα, skin). The more internal of the two organized layers of which the body of every hydroid is composed. (Diagrams I and II, *d, d, d.*)

Perisarc (περὶ, around; σάρξ, flesh). The unorganized chitinous excretion by which the soft parts are to a greater or less extent invested. (Diagrams I and II, *f, f, f.*)

Zooids (ζῶον, animal; εἶδος, form). The more or less independent products of non-sexual reproduction; the members more or less individualized of which the hydroid colony is composed. (Diagrams I and II, *g, g′, k, k′, l, m.*)

Trophosome (τροφή, nourishment; σῶμα, body). The entire assemblage of zooids with their common connecting basis, destined for the nutrition of the colony.

Gonosome (γόνος, offspring; σῶμα, body). The entire assemblage of zooids destined for the sexual reproduction of the colony.

Thread-cells. Peculiar bodies consisting of a containing capsule and contained filament destined for urtication, and universally present as a histological element of the ectoderm. (Fig. 52, page 118.)

Palpocils (*palpo*, I feel; *cilium*, an eyelash). Microscopic, hair-like, non-vibratile processes of the ectoderm, probably organs of touch. (Fig. 48, page 112.)

Heteromorphism (ἕτερος, diverse; μορφή, form). Diversity of form among the component zooids of the colony.

Homomorphism (ὅμοιος, similar; μορφή, form). Similarity of form among the component zooids of the colony.

Polymerism (πολύς, many; μέρος, part). Simple multiplicity of the component zooids of the colony.

TERMS APPLICABLE TO THE TROPHOSOME.

Hydranth (ὕδρα, hydra; ἄνθος, flower). The proper nutritive zooid, or that part of it which carries the mouth and proper digestive cavity. (Diagrams I and II, *g, g′.*)

Hypostome (ὑπὸ, under; στόμα, mouth). The distal prolongation of the hydranth, which carries the mouth on its summit. (Diagrams I and II, *h.*)

Hydrotheca (ὕδρα, hydra; θήκη, receptacle). The cup-like chitinous receptacle which protects the hydranth in the calyptoblastic genera. (Diagram II, *i, i.*)

Hydrophyton (ὕδρα, hydra; φυτόν, plant). The common basis of the trophosome by which its zooids are connected into a single colony. (Diagrams I and II, *a, a, a, a, b, b.*)

Hydrorhiza (ὕδρα, hydra; ῥίζα, root). The proximal end of the hydrophyton by which the colony fixes itself to other bodies. (Diagrams I and II, *b*, *b*, *b*, *b*.)

Hydrocaulus (ὕδρα, hydra; καυλός, stem). All that portion of the hydrophyton which intervenes between the hydrorhiza and the hydranth. (Diagrams I and II, *a*, *a*, *a*, *a*.)

Cœnosarc (κοινός, common; σάρξ, flesh). The common organized fleshy portion of the hydrophyton; the living bond by which the zooids are organically united to one another. (Diagrams I and II, *d*, *d*, *d*, *e*, *e*, *e*.)

Nematophores (νῆμα, thread; φορέω, I carry). Peculiar bodies developed in certain genera from definite points of the trophosome (and of the corbulæ in the genus *Aglaophenia*), and consisting of a chitinous receptacle with sarcode contents in which thread-cells are usually immersed. They are characteristic of the family of the *Plumularidæ*. (Figs. 50 and 51, pages 116 and 117.)

TERMS APPLICABLE TO THE GONOSOME.

Gonophore (γόνος, offspring; φορέω, I bear). The ultimate generative zooid which gives origin directly to the generative elements, ova or spermatozoa. (Diagrams I, *k*, *k′*, *l*, and II, *k*.)

Sporosac (σπορά, sexual product, offspring; σακός, a sack). A sack-shaped gonophore destitute of obvious umbrella. (Diagrams I, *k*, *k′*, and II, *k*.)

Planoblast (πλάνος, wandering; βλάστη, a bud). A generative bud with a structure fitting it for a free locomotive life when detached from the hydrosome. (Diagrams I and II, *l*.)

Gonocheme (γόνος, offspring; ὄχημα, chariot). A medusiform planoblast which gives origin directly to the generative elements. (Diagram I, *l*.)

Blastocheme (βλάστη, bud; ὄχημα, chariot). A medusiform planoblast which gives origin to the generative elements, not directly, but through the medium of special sexual buds which are developed from it. (Diagram II, *l*, and Figs. 9 and 10, page 35.)

Blastostyle (βλάστη, bud; στύλος, column). A columniform zooid destined to give origin to generative buds. (Diagrams I and II, *m*, *m*, *m*.)

Perigonium (περί, around; γόνος, offspring). The walls of a sporosac by which the generative elements are confined, and in which, when fully developed, three laminæ may be demonstrated. (Fig. 7, page 32.)

Ectotheca (ἐκτός, outside; θήκη, sheath). The most external of the three laminæ of the perigonium. (Fig. 7, *c*, page 32.)

Mesotheca (μέσος, middle; θήκη, sheath). The middle one of the three laminæ of the perigonium. (Fig. 15B, *b*, page 44.)

Endotheca (ἔνδον, within; θήκη, sheath). The most internal of the three laminæ of the perigonium. (Fig. 7, *b*, page 32.)

Spadix (σπάδιξ, the fruit-shoot of a palm tree, a term used by botanists for a form of inflorescence). The hollow body which projects from the floor of the sporosac into its cavity, and round which the generative elements are developed. (Diagrams I and II, *k*, *k′*, and Fig. 7, *a*, page 32.)

Umbrella. The gelatinous bell of a medusiform planoblast. (Diagrams I and II, *l*, and Fig. 8, *c*, page 33.)

Manubrium (*manubrium*, handle). The axial portion which, in a medusiform planoblast, hangs from the summit of the umbrella, carrying the mouth at its extremity. (Diagram I, *l*, and Fig. 8, page 33.)

Atrium (*atrium*, a hall). An enlargement of the somatic cavity which occurs in many medusæ. It is situated at the base of the manubrium, and from it the radiating canals proceed. (Fig. 17, page 46.)

Codonostome (κώδων, bell; στόμα, mouth). The orifice of the umbrella through which its cavity communicates with the external water. (Fig. 8, page 33.)

Velum (*velum*, a veil). The membranous perforated diaphragm which stretches transversely across the codonostome. (Fig. 8, *h*, page 33.)

Ocellus (diminutive of *oculus*, eye). A heap of pigment-cells accompanied or not by a refracting body, and forming a coloured spot on definite points of the umbrella-margin in certain planoblasts. (Fig. 56, *g*, page 139.)

Lithocyst (λίθος, stone; κύστις, bladder). A sack-like body containing concretions, developed on definite points of the umbrella-margin in certain planoblasts. (Figs. 57, *c*, and 58, *h*, pages 140 and 141.)

Phanerocodonic (φανερὸς, manifest; κώδων, bell). The condition of a gonophore when it possesses a developed umbrella. (Diagram I, *l*.)

Adelocodonic (ἄδηλος, not manifest; κώδων, bell). The condition of a gonophore when no developed umbrella is present. (Diagram I, *k*, *k'*, and II, *k*.)

Gonangium (γόνος, offspring; αγγειον, vessel). An external chitinous receptacle within which, in the calyptoblastic genera, the sporosacs or planoblasts are developed. (Diagram II, *n*.)

Gubernaculum (*gubernaculum*, rudder, director). A common sack-like membrane which surrounds the generative buds within the gonangium, and aids in directing them or their contents towards the orifice of the gonangium. (Figs 18, *d*, and 19, *d*, page 48.)

Acrocyst (ἄκρος, on the top; κύστις, bladder). An external sac which in certain hydroids is formed upon the summit of the gonangium, where it constitutes a receptacle in which the ova pass through some of the earlier stages of their development. (Figs. 21 and 22, page 50.)

Meconidium (diminutive from μήκων, a poppy). Peculiar sporosacs, somewhat resembling a poppy capsule in form, and borne upon the summit of the gonangium in the genus *Gonothyræa*. (Fig. 28, page 57.)

Corbulæ (*corbula*, a basket). Basket-shaped receptacles which enclose groups of gonangia in certain plumularian hydroids. (Fig. 30, page 60.)

Planula (a diminutive noun, suggested by a supposed resemblance to a *Planaria*). The locomotive infusorium-like embryo into which the egg of most hydroids becomes directly developed. (Fig. 39, κ, page 86.)

Actinula (a diminutive noun found from ἀκτίς, a ray). The locomotive polypoid embryo into which, in certain genera, the egg becomes directly developed. (Plate XXI, fig. 6, Plate XXIII, fig. 16, &c.)

TERMS APPLICABLE TO CERTAIN CONDITIONS OF THE HYDROSOMA.— NAMES OF LEADING SYSTEMATIC GROUPS.

Gymnoblastic (γυμνός, naked; βλάστη, bud). The condition of a hydroid when no external protective receptacle (hydrotheca or gonangium) invests either nutritive or generative buds. GYMNOBLASTEA, the name of one of the sub-orders of HYDROIDA. (Diagram I, and the various plates illustrating the present Monograph.)

Calyptoblastic (καλυπτός, covered; βλάστη, bud). The condition of a hydroid when an external protective receptacle (hydrotheca or gonangium) invests either the nutritive or generative buds. CALYPTOBLASTEA, the name of one of the sub-orders of HYDROIDA. (Diagram II, and fig. 2, page 23.)

Eleutheroblastic (ἐλεύθερος, free; βλάστη, bud). The condition of a hydroid when the nutritive buds, instead of remaining permanently attached, become free and enjoy an independent existence. ELEUTHEROBLASTEA, the name of one of the sub-orders of HYDROIDA.

MONOPSEA (μόνος, single; ὄψις, appearance). The name of one of the sub-orders of the HYDROIDA, in which development from the egg takes place without the intervention of a hydriform trophosome.

RHABDOPHORA (ῥάβδος, rod; φορέω, I bear). The name of one of the sub-orders of the HYDROIDA. It corresponds to the extinct group of the Graptolites, in which a solid rod is developed in the walls of the chitinous perisarc.

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PART I.

THE

HYDROIDA IN GENERAL.

THE

HYDROIDA IN GENERAL.

PHYSIOGNOMY OF THE HYDROIDA.—DESIGN OF THE PRESENT MONOGRAPH.

Rooted in the transparent reservoirs which the retiring tide has left behind it in the rocky shore, or spreading over the fronds of the sea-weeds, or fringing the reef at low water with a mimic vegetation, or brought up by the dredge of the naturalist and the lines of the fisherman from the deeper regions of the sea, there may be obtained, on perhaps every coast and in every latitude, certain singular organisms which repeat with such unerring fidelity the forms of the vegetable kingdom that we can scarcely bring ourselves to believe that the hundred plant-like shapes which root themselves in that marvellous sea-garden, and stretch forth their branches, and unfold their buds, and spread abroad their starry flowers, have not the structure and the life as well as the form and the habit of the plant. And yet they are no plants, these strange plant-like dwellers in the sea, but genuine animals in all that constitutes the essence of animality.

When Marsigli, more than a century and a half ago, fished up from the Mediterranean Sea a piece of living coral, and for the first time in the history of science its branches were seen clustered with starry polypes, he believed that he had before him a blossoming plant; for in the branching stem which he had plucked from the rock where it had been rooted, and in its living bark and eight-petalled flowers he saw nothing but the evidence of vegetality, which surely proved that the great botanists of the day—Ray and Tournfort, and Cæsalpinus, and Bauhin, and Lobel, were right when they called corals plants, and assigned them to the Flora rather than to the Fauna of the sea. And so, also, the organisms with which the present monograph is to be occupied are no less plant-like than their relatives the corals, for they are rooted, and branch, and bud and blossom like them.

But more than this, the sea is filled with living and moving forms, floating bells of crystal, whose beauty no description can convey, whose multitude no thought can estimate. Unlike those animated flowers which root themselves to the sea-bed, these no less wonderful Medusæ, with functions higher and more varied, lead a life of freedom. They love the upper regions of the sea, and wherever over its wide surface the conditions suited to their welfare are to be found there will the towing-net encounter them. A thousand leagues away from land, where the ship lies motionless in the calm, there they are abroad in their unnumbered hosts; and where the gale is strong, and the wave breaks upon the rocky headland, there too they congregate and sport unharmed in the surf. And yet for days together the towing-net may sweep the sea without a trace of them, for they are sensitive to every changing mood of the atmosphere above them; they feel the gathering cloud and the summer shower; and when the sea freshens beneath the falling rain-drops, or the air rests upon its surface with influences unfavorable to their well-being, they sink into salter waters and find shelter in more genial depths.

But their life was not always one of freedom as it now is, for they once grew as buds upon those strange hydroids, which, with the life of the animal, root themselves to the sea-bed like a plant; they sprung forth from their sides, and drew their nourishment from the parent branch, and expanded and developed themselves until they became fitted for an independent existence, and then, full of a new and higher life, they broke away from their supporting stalk, active and energetic beings, unrivalled in the gracefulness of their motions and in the symmetry and beauty of their forms.

The true significance of all this budding and blossoming, of this imitation by the animal of the form and growth of the plant, lies at the foundation of a scientific knowledge of the HYDROIDA, and constitutes one of the most interesting and marvellous chapters in the morphology and physiology of animals.

It is my intention to devote the present work to an examination of the HYDROIDA in their general morphological and physiological relations as a great natural group; while to one large and important subdivision of this group, the *Tubularinæ*, a more special consideration will be given, and all the genera and species of which it is composed will be described in detail. Thus, a purely descriptive zoology of the *Tubularinæ* will be combined with a careful study of their structure and physiology, and of the structure and physiology of the entire order of the HYDROIDA, that more comprehensive group under which the *Tubularinæ* are immediately included.

When thus investigated, it will be found that the study of the HYDROIDA possesses an interest far beyond what we may at first be inclined to attribute to beings so simple in their structure and so apparently insignificant in the place allotted to them in the economy of nature, for we shall then learn that some of the most important facts in morphology and some of the highest laws in physiology find in them their expression and elucidation.

SYSTEMATIC POSITION.

The HYDROIDA of the present monograph include the *Hydrinæ*, *Tubularinæ*, *Campanularinæ*, and *Sertularinæ*, being so far exactly coextensive with the HYDROIDA of Johnston.[1] The group HYDROIDA, however, as here understood, necessarily embraces most of the so-called naked-eyed or gymnophthalmic Medusæ, for a large proportion of these are known to be the free generative

[1] George Johnston, 'A History of the British Zoophytes.' Second Edition, 1847.

zooids of the *Tubularinæ* and *Campanularinæ*, while those which have not yet been so traced—provided we have no reason to regard them as the free zooids of the *Siphonophora*—and even those which may be proved to be developed directly from the egg, cannot, in a philosophical system, be separated from the others.

I accept without hesitation the group Cœlenterata, with the characters assigned to it by Leuckart; and I further adopt the division of this group into two primary sections, with the names of *Actinozoa* and *Hydrozoa*, as proposed by Huxley. The following table will indicate the place of the Hydroida among the other members of the *Hydrozoa*:[1]

	Actinozoa.	
		Ctenophora.[2]
		Discophora.
Cœlenterata	Hydrozoa . . .	Lucernariæ.
		Hydroida.
		Siphonophora.

HISTORY OF THE PROGRESS OF OUR KNOWLEDGE OF THE HYDROIDA.

The history of the successive stages through which any important branch of human knowledge passes in its development from the first dawnings of its truths upon the mind to that more perfect phase which in the lapse of time it has attained, constitutes one of the most instructive subjects upon which the philosophic student can be engaged; and a history of this development, as it shows itself in the progress of our knowledge of the Hydroida may, therefore, with advantage precede that exposition of the present state of our knowledge of them which is the chief aim of the present work.

In order to avoid extending our historical sketch to an inconvenient length, the record of many important anatomical and physiological discoveries must be postponed to that part of the volume where these discoveries can be described with sufficient detail; and I shall here confine myself chiefly to the more important steps which have been made towards the determination of the systematic position of the Hydroida, and their recognition as a distinct group with the limits assigned to them in this monograph.

[1] I must for the present hesitate to include among the hydrozoal orders the tabulate and rugose corals. The hydrozoal affinities of these groups have been recently claimed for them by Agassiz as the result of an examination of living specimens of *Millepora alcicornis*, a tabulate coral, in which, if there be no error of observation, Agassiz has detected a true hydrozoal structure, while he believes himself supported by analogy in attributing this structure, not only to all the other genera of tabulate corals, whether living or extinct, but even to the entirely extinct group of *Rugosa*. (See his 'Cont. Nat. Hist. United States,' vol. iv.) The observations, however, on which this view has been based are plainly not yet as complete as could be desired for a determination so important, and even startling. Of the generative system more especially we are entirely ignorant. Under these circumstances I believe it will be safer to wait for such verification as may be expected from further researches.

[2] In adopting the more usual view, in accordance with which the *Ctenophora* are placed among the *Hydrozoa* rather than among the *Actinozoa*, as originally indicated by Leuckart, and more decidedly insisted on by Huxley, I believe myself borne out by a careful study of the structure of *Beroe*.

We have no evidence whatever to show that the Greek and Roman naturalists were acquainted with any member of the HYDROIDA. Aristotle and the naturalists of Greece and Rome who followed him had some knowledge of corals, sea-anemones, and steganophthalmic Medusæ; but this was very imperfect, while no mention is made by them of a single hydroid, and it is not until the eighteenth century that we find in the writings of naturalists anything beyond the most obscure indications of an acquaintance with the animals now included in the order HYDROIDA.

It was in the beginning of the eighteenth century that the fresh-water *Hydra* was discovered by Leeuwenhoeck, and its faculty of budding like a plant accurately described. Leeuwenhoeck communicated a notice of this discovery to the Royal Society of London in 1803.[1]

The first grand impulse, however, to the study of the Hydroida was given some years later by Trembley. Abraham Trembley was born in Geneva in 1700, and in 1743 was awarded the Copley medal by the Royal Society of London, of which he had been elected a Fellow. It was while residing at the Hague with his two pupils, the sons of the Count de Bentinck, that he obtained, in the pond at Sorgvliet, the country house of the count, the hydras which enabled him to make that remarkable series of observations on the reproductive powers of these animals which resulted in the discovery of phenomena hitherto unsuspected in the animal kingdom, and of the highest significance in physiology; for they established the fact that the animal organism may not only multiply itself by budding in the manner of a plant, as Leeuwenhoeck had already demonstrated, but that it may possess the power of enduring repeated subdivision, and may suffer with impunity the most extensive mutilations, the fragments of the divided *Hydra* not only recovering from the operation, but becoming endowed, after a time, with all the parts of which they had been deprived by the act of division.

The discoveries of Trembley were communicated to Réaumur, and recorded by him, in 1742, in the preface to the sixth volume of his 'History of Insects;'[2] and in 1744 an extended account of them was published by Trembley himself, in his celebrated treatise on 'Fresh-water Polypes.'[3] In this remarkable work the species of *Hydra* known to Trembley are described with copious details of their general structure and habits, and of the curious experiments to which he subjected them. The work consists of four memoirs, and is abundantly illustrated with figures of great beauty exhibiting the *Hydra* in various conditions and under various modes of treatment, all from the pencil and most of them from the graver of the celebrated Lyonet; while the quaint but expressive vignettes from another hand, which are placed at the heads of the four memoirs, and which represent various parts of the grounds of Sorgvliet, with the author and his two pupils engaged in the capture and observation of the Hydræ, give an additional charm to a work which must be regarded as the most important step yet made towards a scientific knowledge of the HYDROIDA.

The progress of discovery in the natural history of the HYDROIDA, however, is so intimately connected with various observations which had been about this period made on certain corals and other Actinozoa, that it is impossible to follow the one without some knowledge of the other.

The researches of Trembley were preceded by Peysonelle's demonstration of the true nature of the polypes of coral. The coral polypes were discovered towards the beginning of the last

[1] Ant. de Leeuwenhoeck in 'Phil. Trans.' for 1803.

[2] René-Antoine Ferchaud de Réaumur, 'Histoire des Insectes.' Paris, 1742.

[3] 'Mémoires pour servir à l'Histoire d'un genre de Polypes d'eau douce à bas en forme de Cornes.' Leyden, 1744.

century by the Count de Marsigli.[1] Marsigli, however, regarded them as the flowers of the coral, and saw in them a proof of the vegetable nature of the supposed sea-plant which bore them: and his discovery was at once received as a full confirmation of the views entertained by the leading botanists of the time, who all regarded the corals as genuine members of the vegetable kingdom.

Jean Antoine Peysonelle, however, during a residence at Marseilles and on the Mediterranean shores of Africa, and subsequently at Guadaloupe, applied himself to the study of living corals and madrepores, and soon became convinced that the coral flowers of Marsigli were truly animals closely allied to the *Actiniæ*, or "*Urticæ marinæ*," as they were called by the naturalists of that day.

Peysonelle's views were communicated by Réaumur to the Academy of Sciences in 1727, where they were received with discredit, and even contempt, Réaumur himself, who believed in the vegetable nature of coral, not even mentioning the name of the author whose communication he undertook to present, so that Peysonelle's discovery remained almost unknown until 1742, when he forwarded to the Royal Society of London a long memoir, which was published in abstract in the 'Philosophical Transactions' of that year.

The discoveries of Peysonelle, however, had arrested the attention of the celebrated botanist, Bernard de Jussieu, and, with the view of verifying them, he determined to visit the sea-coast of Normandy. Though the shores of Normandy afforded to Jussieu no true corals, he found there the nearly allied *Alcyonium*, which enabled him to confirm the views of Peysonelle. He at the same time convinced himself that the plant-like Flustras were truly animals; and, what has a more direct importance in its bearing upon the present history, he observed the polypites of *Tubularia indivisa*, and was thus enabled to refer this hydroid to the animal kingdom. The results of de Jussieu's visit to Normandy were published in the 'Mémoires de l'Académie' for 1742,[2] where he gives a figure of *Tubularia indivisa*, which in truthfulness and expression has never since been surpassed.

Réaumur, unable to resist the accumulated evidence of the animality of corals and hydroids, now fully accepted the views of Peysonelle, which he had some years before scarcely deemed worthy of a serious thought.

At this time Linnæus was carrying out those wonderful reforms in classification and nomenclature which were destined to exert an influence on the progress of natural history greater than anything which had been effected since the days of Aristotle, and which mark out the eighteenth century as the most significant in the history of the natural sciences.

The discoveries of Peysonelle, of Jussieu, and of Trembley, however, had not yet brought conviction to the great systematist, and in 1745 we find him, in a dissertation on the fossil corals of Sweden,[3] after contrasting the various opinions regarding the nature of coral in accordance with which it was assigned either to the mineral, the vegetable, or the animal kingdom, candidly confessing that he was unable to decide between these rival views.

[1] See Luigi Ferd. Marsigli, 'Histoire physique de la Mer.' Amsterdam, 1725. Translated, under the care of Boerhaave, from the original Italian edition of 1711.

[2] Bernard de Jussieu, "Examen de quelques productions Marines qui ont été mises au nombre des plantes, et qui sont l'ouvrage d'une sorte d'Insectes de Mer;" 'Mém. de l'Acad. Roy. des Sciences,' Paris, 1742, p. 392.

[3] Carolus Linnæus, 'De Coralliis Balticis.' Upsaliæ, 1745.

The only hydroid which, up to this time, had been examined in a living state with results of any value to science was the *Tubularia indivisa*, which, as already mentioned, had been studied by De Jussieu on the coast of Normandy ; a most important accession, however, to our knowledge of the HYDROIDA was now about to be made by the observations of Ellis.

John Ellis was a London merchant devoted to the study of natural history, which he pursued in the intervals of his mercantile labours, with an enthusiasm and a success which renders his name familiar to every student of the HYDROIDA. He was elected a Fellow of the Royal Society, and was awarded the Copley Medal in recognition of the esteem in which his researches were held by that body.

An examination of dried specimens of various hydroids had already led Ellis to suspect that these plant-like productions really belonged to the animal kingdom, and determined him to study them in a living state. With this view he repaired with his microscope to the Island of Sheppey, and some other parts of the south-eastern shores of England, accompanied by Mr. Brooking, a distinguished painter of sea-pieces, and by the celebrated botanical painter Ehret. He had there abundant opportunity of studying a great number of living hydroids, and soon convinced himself that "these apparent plants were ramified animals in their proper skins or cases." In this remarkable assertion we have the first philosophic expression of the true nature of the fixed plant-like hydroids, and thus was finally settled the animality of these organisms. The results of his observations were published in 1755, in a work[1] whose beautiful and accurate figures and admirable descriptions render it at this day indispensable to the student.

Nothing was now wanting to produce general conviction of the animality, not only of the true corals, but of all those flexible, plant-like productions whose external form had so long caused their real nature to be overlooked. Even Linnæus himself was at last convinced by the discoveries of Ellis, and now declared himself a believer in their genuine animality.

Besides the generally very expressive vernacular names employed by Ellis, his species are, in accordance with the usual practice of the day, indicated by short Latin descriptions rather than by systematic designations. Linnæus's grand invention of the binomial nomenclature was, however, making its way among systematists. The 'Systema Naturæ' had already passed through several editions, and in 1766 we find the various species of HYDROIDA then known enumerated by Pallas under their binary designations in his admirable 'Elenchus Zoophytorum.'[2] In this work the species are characterised by a precision which leaves little to be desired; a complete synonomy is prefixed to each, and in their arrangement the celebrated Prussian naturalist affords evidence of an insight into those affinities on which the more natural classifications of subsequent systematists have been based.

In the tenth fasciculus of his 'Spicilegia Zoologica,'[3] published in 1774, Pallas describes and

[1] John Ellis, '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. To which is added the description of a large Marine Polype taken near the North Pole by the Whale-fishers in the summer of 1753.' London, 1755.

[2] Petr. Sim. Pallas, 'Elenchus Zoophytorum sistens generum Adumbrationes generaliores et specierum cognitarum succinctas descriptiones cum selectis Auctorum synonymis.' Hagæ-Comit., 1766.

[3] Petr. Sim. Pallas, 'Spicilegia Zoologica quibus novæ imprimis obscuræ Animalium species iconibus, descript. atque commentariis illustrantur,' tom. i, fasc. i—x, Berolini, 1767—1774; tom. ii, fasc. xi—xiv, Berolini, 1776—1780.

figures two new hydroids. One of them is a *Coryne*, a genus which he adopts from a MS. of Gaertner; the other has no generic name assigned to it by Pallas; it can, however, be easily recognised as a *Clava*, a genus founded a few years afterwards by Gmelin for the *Hydra squamata* of Müller. Pallas's figures, however, though sufficient for identification, cannot be compared, either in beauty of execution or in truthfulness, to those of Trembley, Jussieu, or Ellis.

A much better figure of a *Clava* was given shortly afterwards by the Danish naturalist and traveller, Forskål, in his 'Icones Rerum Naturalium,'[1] where the species is named *Hydra multicornis*; and in the same work, besides two other tolerable figures of hydroid trophosomes, we find some very expressive and, indeed, up to that time, the only really recognisable ones of true hydroid Medusæ.

Among the means which tend most powerfully to advance the progress of the natural history sciences is an accurate and expressive iconography. The beautiful figures of Trembley and of Ellis hold in this respect the first rank. As we have already seen, Jussieu had given an admirable figure of *Tubularia indivisa*, and Forskål some very good ones of other hydroids, while some tolerable figures of a *Tubularia* and of some Sertularian and Campanularian hydroids had been published by Baster;[2] but hitherto no attempt had been made at the publication of coloured drawings. Between 1777 and 1780, however, were issued the first two fasciculi of the 'Zoologia Danica' of O. F. Müller,[3] which after Müller's death was continued with additions by Abildgard. It contains coloured figures of Scandinavian animals, mostly invertebrate, from the surrounding seas, and amongst them several hydroids. In the accuracy, beauty, and abundance of the figures, too much praise cannot be given to the 'Zoologia Danica,' which marks out an era in zoological iconography.

The posthumous work of Ellis and Solander,[4] published in 1786, contains many hundreds of figures, chiefly of corals, but having also among them several hydroids. Many of the figures contained in this work are masterpieces of iconography.

Esper also gives us a most laborious iconography, partly copied, partly original, consisting of coloured figures of corals, sponges, &c., as well as of numerous hydroids.[5] Where the hydroid figures are not copied from Ellis they are vastly inferior to those of the English naturalist.

The naturalists who during the eighteenth century contributed most to advance our knowledge of the HYDROIDA close with the name of Cavolini. Cavolini, like Ellis, studied the Hydroida in a living state. His investigations were made in the Bay of Naples, where he discovered many hydroids previously unknown, and determined many points of interest in their structure and physiology. He was the first to observe a Medusiform gonophore in connection

[1] 'Icones Rerum Naturalium quas in Itinere Orientali depingi curavit Petrus Forskål.' Copenhagen, 1776. The descriptions are contained in a separate volume, published in 1775.

[2] Jobi Basteri, 'Opuscula Subseciva.' Harlemi, 1762.

[3] Otho Fredericus Müller, 'Zoologiæ Danicæ seu Animalium Daniæ et Norvegiæ variorum et minus notorum Icones.' Hafniæ, 1777—1780.

[4] 'The Natural History of many curious and uncommon Zoophytes collected from various parts of the Globe, by the late John Ellis, F.R.S. Systematically arranged and described by the late Daniel Solander, M.D., F.R.S.' London, 1786.

[5] 'Die Pflansenthiere in Abbildungen nach der Natur mit Farben erleuchten nebst Beschreibungen,' von Eugenius Johann Cristoph Esper. Nuremberg, 1791—1797.

with the trophosome, and has described the radiating canals and the included ova of this body in his *Sertularia pennaria* (*Pennaria distycha*, Goldfuss), without, however, exactly comprehending its true significance or its relations to a free hydroid Medusa. He also insisted on the vegetality of the proper corallines or nullipores, which, on the establishment of the animality of corals, were carried with these into the animal kingdom. The results of his researches were published in 1785, in a work[1] full of valuable information, and illustrated with excellent figures of living hydroids, corals, and Polyzoa.

In the 'Elenchus Zoophytorum' of Pallas, published in 1766, all the known hydroid trophosomes were distributed among three genera—*Hydra*, *Tubularia*, and *Sertularia*. In the 'Spicilegia' Pallas adds the genus *Coryne* from Gaertner MS. Gmelin, in his edition of the 'Systema Naturæ,' 1788, while he overlooks the genus *Coryne*, adds the new genus *Clava*. Besides these different genera of hydroids, all characterised from their trophosomes, several true hydroid Medusæ had been at this date known and described; but they were all included along with steganophthalmic forms, and with *Siphonophora* and *Ctenophora*, under the common generic name of "Medusa," given to them by Linnæus.

The state of the natural history of the HYDROIDA at the date of the publication of the thirteenth edition of the 'Systema Naturæ' (Gmelin's) may thus be stated in a few words:—The animality of the HYDROIDA was fully acknowledged. Such species as were known by their trophosomes were distributed under five genera—*Hydra*, *Tubularia*, *Sertularia*, *Coryne*, and *Clava*, while such free gonophores as were known were thrown together with all the other free forms of *Hydrozoa* under the common name of *Medusa*.

The natural history of the HYDROIDA, which during the latter half of the eighteenth century had been thus steadily advancing in the hands of Trembley, Jussieu, Ellis, Pallas, Forskål, O. F. Müller, and Cavolini, was, with the commencement of the nineteenth century, destined to receive a fresh impulse.

The famous voyage of Peron and Lesueur[2] inaugurates the natural history labours of the nineteenth century. It was commenced in 1800, and in 1804 the voyagers returned laden with new and important facts for science. No expedition could have afforded better opportunities of studying the pelagic forms of invertebrate animals; and soon after their return Peron and Lesueur undertook a systematic description of the Medusæ which they had observed in the great seas which their ships had traversed, as well as of other species which they had studied in expeditions afterwards made to the coasts of Normandy and to the Mediterranean. In the two memoirs[3] in which they publish the results of their researches they propose an entirely new classification of the Medusæ. The old Linnean genus *Medusa* is broken up into numerous separate genera, and

[1] Filipo Cavolini, 'Memorie per servir alla storia de Polypi Marini.' Naples, 1785. Translated in 1813 into German by Sprengel.

[2] 'Voyage de Découvertes aux Terres Australes, fait par ordre du Gouvernement sur les corvettes "le Géographe," "le Naturaliste," et la goëlette "la Casuarina," pendant les années 1800 à 1804, rédigé par Peron et continué par M. Louis de Freycinet,' 2e édit. revue, corrigée, et augmentée, par M. de Freycinet. Paris, 1824, 1825.

[3] Peron et Lesueur, "Notions préliminaires sur les Méduses," 'Ann. du Muséum,' 1809, p. 218; and 'Tableau des Caractères génériques et spécifiques de toutes les Espèces de Méduses connues jusqu'à ce jour,' id., p. 325. The plates referred to all through the second memoir have, unfortunately, never been published.

many true hydroid Medusæ are described; but the authors had as yet failed to recognise the fundamental differences between the hydroid Medusæ and the proper *Discophora*.

In 1812 Cuvier published a sketch[1] of his celebrated arrangement of the animal kingdom, which he divides into four primary groups. To the last of these he assigns the name of "Animalia Zoophyta seu Radiata." The group *Radiata* of Cuvier thus includes all the HYDROIDA, but though more precise and definite than the "Vermes" of Linnæus, it is still a heterogeneous assemblage, and as it fails to recognise the distinction between grade of development and morphological plan, it necessarily contains forms which belong to very different types.

The beautiful researches of Savigny on the compound Ascidians were published in 1816,[2] and by proving that a large number of organisms which, under the common name of *Alcyonium*, had been hitherto associated with true cœlenterate forms, are in reality Ascidians, these researches must be regarded as an important step towards the final limitation of the primary groups of the animal kingdom.

For some time past a vast amount of material for the zoology of the invertebrate animals was being accumulated, and a period had now arrived when a systematic arrangement of the whole was loudly called for. It was in this state of things that a work destined to exert great influence on the study of the lower animals made its appearance. The second volume of the 'Histoire Naturelle des Animaux sans Vertèbres' of Lamarck[3] was published in 1816. In this celebrated work three new genera of hydroids are instituted from their trophosomes, namely, *Campanularia*, *Antennularia*, and *Plumularia*. Among Medusæ, however, Lamarck recognises only a portion of the genera established by Peron and Lesueur, and in thus attempting to simplify the classifications of his predecessors he falls behind the famous voyagers in the actual requirements of science.

While Lamarck was engaged in the preparation of his 'Animaux sans Vertèbres,' Lamouroux was occupied with the study of a set of flexible, plant-like organisms forming a heterogeneous group, which included not only most of the hydroid trophosomes then known, but also a large number of *Actinozoa* and *Polyzoa*, and even many indubitable plants; and in the same year with the publication of the second volume of Lamarck's work there appeared a natural history of these organisms by Lamouroux. Lamouroux[4] has here defined some good additional genera of hydroids characterised by their trophosomes; though some of them are identical with genera instituted by Lamarck under other names. The names given by Lamarck, however, have found more general acceptance with subsequent authors; and whatever doubt may be entertained regarding actual priority of publication, the zoologist of the present day will scarcely hesitate to give them the precedence, especially when it is remembered that Lamouroux had complete access to all Lamarck's specimens which had been deposited in the Museum of the Jardin des Plantes, and which had been already labelled with the names given to them by the illustrious author of the 'Histoire des Animaux sans Vertèbres.'

[1] G. Cuvier, "Sur un nouveau rapprochement à établir entre les classes qui composent le Règne Animal." 'Annales du Muséum,' 1812.

[2] Marie Jul. Cæsar Lelorgue de Savigny, 'Mémoires sur les Animaux sans Vertèbres,' part ii, Paris, 1816.

[3] J. Bapt. P. Ant. de Monnet Lamarck, 'Histoire Naturelle des Animaux sans Vertèbres,' 7 vols., Paris, 1815—1822.

[4] J. V. F. Lamouroux, 'Histoire des Polypiers Coralligènes flexible vulgairement nommés Zoophytes,' Caen, 1816.

Almost precisely at the same time appeared the first edition of the 'Règne Animal' of Cuvier.[1] The general division of the animal kingdom, of which, as we have already seen, a sketch had previously appeared, is here adopted and carried into detail. In his association of the free Hydrozoa into a distinct class under the name of Acalepha, Cuvier now takes an important step, though its value is deteriorated by the admission of Actinia into the same group. Independently of the advance which the natural history of the HYDROIDA has thus directly received, the great influence which Cuvier has exerted on the studies of the zoologist, by taking anatomical structure rather than external resemblance as the basis of classification, renders it impossible in the history of any department of zoology not to see in the publication of the 'Règne Animal' a well-marked era of development.

The voyage of Peron and Lesueur, which had such valuable results for zoology, was only the first of a long series of scientific expeditions which, fitted out under the auspices of various governments, brought back with them rich stores of materials, and mark out the first half of the present century as eminently the era of the naturalist voyager.

Between the years 1815 and 1826 two exploratory expeditions round the world were fitted out by the Russian Government.[2] They were entrusted to the command of Kotzebue, and were accompanied by Chamisso and Eschscholtz as naturalists. The expeditions afforded fine opportunities for the observation of pelagic forms of *Mollusca* and *Cœlenterata*, and are rendered memorable by Chamisso's famous discovery of the "alternation of generations" in *Salpa*—a discovery which was destined to exert great influence on the study of the HYDROIDA and the interpretation of their marvellous life-history.

The study of the cœlenterate animals observed during these voyages was specially undertaken by Eschscholtz, and after the return of the voyagers from their second expedition we find this philosophic naturalist publishing a general work on the Medusæ and allied forms[3]—a work by far the most important which had as yet appeared upon the animals of which it treats, and one which, even at the present day, the student is unable to dispense with.

It is here that, for the first time, we find the hydroid Medusæ, under the name of "Discophora cryptocarpa," separated as a distinct and well-defined group from the proper *Discophora*, to which Eschscholtz assigns the name of "Discophora phanerocarpa;" and though the characters on which this dismemberment was based were but imperfectly understood by Eschscholtz, and have since undergone considerable modifications, the conception of the hydroid Medusæ as a separate section is a step of primary importance, and could have been entertained only by one who was able to recognise the fundamental differences and appreciate the true affinities of the group among which these organisms had been hitherto indefinitely distributed.

Cuvier had already[4] recognised an essential difference of structure between the actinozoal and hydrozoal forms included in his group of "Polypes," when he pointed out the presence of a digestive sac, with differentiated walls in the former, and its absence in the latter; but the

[1] Geo. Leop. Chr. Fred. Dajob. Cuvier, '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.

[2] Otto v. Kotzebue, 'Voyage of Discovery into the South Sea and Behring's Straits, undertaken in 1815-18, in the ship "Rurick,"' London, 1821; and 'New Voyage round the World in 1823-26,' London, 1830.

[3] Joh. Friedr. Eschscholtz, 'System der Acalephen,' Berlin, 1829.

[4] 'Le Règne Animal,' 1817, tome iv, p. 79.

structure of most of the animals constituting the *Radiata* of Cuvier was still so very imperfectly known that this important character failed to receive its due weight in classification.

In 1828 it was brought out with greater distinctness and force by M. Milne-Edwards in an account of his zoological researches in the Chausey Isles[1]; but still the fixed plantlike hydroids continued to be associated with the true corals and *Polyzoa*, under the common name of "Polypi," for, notwithstanding the deep-lying difference which had been indicated by Cuvier, and more definitely insisted on by Milne-Edwards, between the hydrozoal and actinozoal types, yet its full value as a classificatory character still continued unappreciated. As Eschscholtz, however, had seen in the reproductive system of the medusæ a ground for their separation into two primary groups, so in the same year Professor Rapp, of Tubingen, proposed to divide the polypoid *cœlenterata* into two sections, also based upon the peculiarities of their reproductive system.[2] Observing that in the hydroid trophosome the ovigerous buds were produced externally, while in *Actinia* and the corals the reproductive organs projected into the interior of the body-cavity, he assumed this difference as a basis for the definition of two distinct groups, to which he gave the names of *Endoarii* and *Exoarii*. Though the real nature of the peculiarity on which this dismemberment of the fixed cœlenterata rests was, like that in accordance with which Eschscholtz had already based his subdivision of the Medusæ, scarcely comprehended by its author, the proposal of Rapp must, nevertheless, be regarded as an important step towards the determination of the systematic position of the Hydroida.

Among the results of Milne-Edwards's investigations carried on in the Chausey Isles, the most important was his demonstration of a type of structure in the *Flustræ*, entirely different from that of the cœlenterate animals with which they had been associated by his predecessors. A similar conclusion had been just arrived at by Grant,[3] but the British zoologist had not worked out the structure with that completeness which characterised the investigations of Edwards, who now showed[4] that the *Flustræ* were constructed on a plan in all essential points identical with that of the compound Ascidians, with whose organisation Savigny had already made us acquainted in his masterly memoirs.

Though M. Milne-Edwards had thus proved the existence of a true molluscoid type of structure in *Flustra*, no comprehensive name had yet been given to the group so characterised. While Grant and Edwards, however, were thus engaged in their anatomical examination of *Flustra*, J. V. Thompson, then residing on the coast of Cork Harbour, was occupied with a series of similar investigations, and, quite independently of any knowledge of the labours of Grant and Edwards, had determined not only the molluscoid structure of *Flustra*, but had in a very complete way demonstrated an entirely similar structure in other plant-like organisms hitherto associated with true cœlenterate forms. To the organisms thus characterised by this common type of structure Thompson, while fully recognising their relation to the Ascidians, gave, in 1830, the name of *Polyzoa*.[5]

[1] J. Victor Audouin and H. Milne-Edwards, "Résumé des Recherches sur les Animaux sans Vertèbres, faites aux Isles Chausey," 'Ann. des Sci. Nat.,' 1828.

[2] Wilhel. Rapp, 'Ueber die Polypen in Allgemeinen und die Actinien insbesondere,' Weimar, 1829.

[3] Robert E. Grant, "Observations on the Structure and Nature of Flustræ," 'Edinb. New Phil. Journ.,' vol. iii, 1827.

[4] Op. cit.

[5] John Vaughan Thompson, 'Zoological Researches and Illustrations,' Cork, 1830. The date is

In 1831[1] Ehrenberg employs the term *Bryozoa* in a sense exactly equivalent to that of Thompson's *Polyzoa*, and in 1833[2] we find him proposing a new classification of the heterogeneous and unscientific group of the "Polypi," by dividing them into the *Anthozoa*, which embraced the cœlenterate forms, and the *Bryozoa* to which all the molluscoid forms were referred.

In the same memoir Ehrenberg also forms a separate group for the fixed *Hydrozoa*, which, under the name of "Zoocoralia oligactinia," he separates from the *Actinozoa*. He further gives a synopsis of such genera and species as were then known, and makes some valuable reforms in the limitation and arrangement of the genera; but the most important point in which this memoir has advanced our knowledge of the HYDROIDA will be found in the ascription of an independent zooidal significance to the so-called "egg-capsules" of these animals, and the consequent determination of a distinct sexuality among the zooids which compose a hydroid colony. This capital discovery, whose true import, however, was but partially comprehended by Ehrenberg, has in the hands of subsequent investigators undergone further development, and must be viewed as the starting-point for all those more recent researches which have so largely contributed to bring about the philosophical views now entertained regarding the structure, physiology, and systematic position of the HYDROIDA.

In 1834 De Blainville published his 'Manuel d'Actinologie.'[3] The important reforms of Eschscholtz, Rapp, and Ehrenberg are not adopted by De Blainville; and the 'Manuel d'Actinologie,' except in so far as it constituted a useful work of reference and description for the student, cannot be regarded as in any way advancing the systematic arrangement, or aiding in a philosophic conception of the HYDROIDA.

The notes and drawings of Medusæ made by Mertens during his voyage round the world as naturalist to the Russian exploring ship "Seniavin," were, after Mertens' death, entrusted to Brandt, who has given us an account of them in two important memoirs. The first, published in 1833,[4] consists in a synopsis of the genera and species observed by Mertens, among which are several new genera of both hydroid Medusæ and Discophora proper; while in the second[5] he gives us a more detailed account of them, and now publishes the numerous and beautiful figures made by Mertens from the living animals. Brandt does not adopt Eschscholtz's division of the Medusæ, so that the hydroid Medusæ are here mixed up with the *Discophora* proper. He gives us detailed anatomical descriptions of the Medusæ, so far as their structure was at that time known; but the chief value of the labours of Mertens and Brandt will be found in their rendering us acquainted with new forms, and in their giving us the most beautiful and accurate figures of Medusæ which had been up to that time published.

not printed on the title-page, but it will be found on the paper wrapper in which the publication was originally issued.

[1] Chr. Gdfr. Ehrenberg, 'Symbolæ Physicæ,' iv, Berolini, 1831.

[2] Corallenthiere.

[3] Henri Marie Ducrotay de Blainville, 'Manuel d'Actinologie ou de Zoophytes,' Paris, 1834.

[4] J. F. Brandt, "Prodromus descriptionis Animalium ab H. Mertensio in Orbis Terrarum circumnavigatione observatorum." 'Recueil des Actes de la Séance publique de l'Académie Impériale des Sciences de St. Pétersbourg,' 1833-34.

[5] Ibid. "Ausführliche Beschreibung der von C. H. Mertens auf seiner Weltumsegelung beobachteten Schirmquallen," 'Mém. de l'Acad. Impér. des Sciences de St. Pétersbourg,' vi sér., Sci. Nat., tom. ii, Pétersbourg, 1838.

In 1838 Dr. Johnston published his 'History of British Zoophytes.'[1] The "zoophytes" of Johnston include not only the plant-like hydroids, but the *Actinozoa* and *Polyzoa*. He does not, however, confound the natural boundaries of these groups, and proposes for the hydroid forms the name of *Hydroida*, which thus coincides with the HYDROIDA of the present Monograph in all respects, except in the fact of its not including the hydroid Medusæ, whose relation to the plant-like trophosomes had not yet been definitely recognised.

Without the originality of Ellis's classical 'Essay,' Johnston's 'History of British Zoophytes' is still a work of great utility for the student. The descriptions of the species are very good, and are accompanied by a copious and valuable synonomy; and the figures, though mostly drawn from the dried hydrosome, and certainly not equal in artistic feeling to those of Ellis, are often excellent, and always of great use in aiding in the determination of the species. The value of the 'British Zoophytes,' however, lies in its character as a descriptive work, and with its publication we may date a new impulse to the study of the HYDROIDA, similar to that which nearly a century before, Ellis's 'Natural History of Corallines' had exercised in the same direction. In 1847 a second edition of the 'British Zoophytes' made its appearance. A great number of additional species are described in it, and many new plates are added to those which were contained in the first.

The observations of Cavolini[2] in the last century, and afterwards those of Wagner[3] and Loven,[4] had already made us acquainted with certain facts which show that the hydroid trophosome may give rise to buds presenting a close resemblance to Medusæ; while the beautiful researches of Sars had shown that among the *Discophora* phenomena occur which in many points resemble this budding of Medusæ among the HYDROIDA, and have an intimate relation with it.[5] The true significance of these observations, however, was but imperfectly appreciated when Steenstrup, in 1842, combining them with analogous ones in other groups of animals, correlated with great skill all the known facts, and generalised the phenomena under the name of "alternation of generations," an expression already employed by Chamisso when describing the gemmation and generation of *Salpa*.[6]

Though in the terms in which Steenstrup enunciates his law of alternation of generations a false conception of the phenomena may appear to be involved, it is evident that his own view of them is a correct one, and the modification which Steenstrup's expression of the law has since undergone can never deprive it of its value in opening up more philosophic views of the morphology of the invertebrate animals, and marking out a new era in their study.

[1] George Johnston, 'A History of the British Zoophytes,' Edinburgh, 1838.

[2] Op. cit., 1785.

[3] Rudolf Wagner, 'Neue im Adriatischen Meere gefundene Art von naektem Armpolypen,' Isis, 1833, iii, p. 256.

[4] S. L. Loven, "Beitrag zur Kenntniss der Gatungen *Campanularia* und *Syncoryne*," 'Müller's Archiv,' 1837.

[5] Martin Sars, 'Beskrivelser og Jagttagelser over nogle mærkelige eller nye i Havet ved den Bergenske Kyst levende Dyr,' &c., Bergen, 1835; and 'Ueber die Entwickelung der *Medusa aurita* und der *Cyanea capillata*,' in 'Wiegm. Arch.,' 1841.

[6] Joh. Japetus Steenstrup, 'Ueber den Generationswechsel oder die Fortpflanzung und Entwickelung durch abwechselnde Generationen, eine eigenthümliche Form der Brutpflege in den niedern Thierclassen. Uebers. von Lorenzen,' Kopenh., 1842. Also translated for the Ray Society, by Busk, London, 1845.

Nearly at the same time some beautiful additional observations were made by Dujardin,[1] who traced various known forms of free hydroid Medusæ to their fixed trophosomes, and had seen them produce eggs; from this epoch we may regard as definitely established the genetic relation between the free hydroid medusa and the fixed trophosome.

In 1843 two memoirs on the Campanularian and Tubularian Hydroids were presented by Van Beneden to the Royal Academy of Brussels.[2] The structure and gemmation of several species are described at length, and the memoirs are accompanied by very beautiful figures. He has seen and described with much detail the free medusoid gonophores, as well as the fixed sporosacs, but he mistakes the former for embryos destined by direct metamorphosis to become changed into the form of the polypoid trophosome. He founds the new genus, *Hydractinia*, for the *Alcyonium echinatum*, of Fleming, and calls attention to the polymorphism of the zooids in this interesting and remarkable hydroid.

The voyage of the French corvette, "La Coquille," under the command of Duperrey, during the years 1822—1825,[3] afforded to Lesson, who, along with Garnot, accompanied the expedition as naturalist, fine opportunities for the study of the Medusæ; and in 1843 we find him publishing, as a volume of the "Suites à Buffon," his 'Histoire Naturelle des Acalephes.'[4] Lesson's work contains a great mass of information, and shows that its author must have had a very extensive acquaintance with the Medusæ, and yet we cannot say that, beyond the description of some new forms, our knowledge of the HYDROIDA has received from him any advance. Indeed, he does not avail himself as he might of the discoveries of his predecessors, while in his classification the Hydroid medusæ are, as usual, mixed up with the *Discophora* proper.

Up to this point of our history it is plain that the systematic writers who came after Eschscholtz have fallen behind him in their appreciation of the Hydroid medusæ as a natural group; for though Eschscholtz misunderstood the peculiarities of organization on which he founded his "Discophora cryptocarpæ," this group is not the less a natural one, and the *cryptocarpæ* of Eschscholtz must be recognised in every system which would aim at expressing the true position and affinities of the various members of that large and heterogeneous assemblage of organisms which have been included under the common name of Medusæ.

It was not, indeed, until 1846 that the Eschscholtzian division of the Medusæ into two grand groups was distinctly accepted by any other naturalist. In this year, however, a paper was read before the British Association by Edward Forbes,[5] in which the author divides the Medusæ into two groups, corresponding with the *phanerocarpæ* and *cryptocarpæ* of Eschscholtz.

The erroneousness of Eschscholtz's interpretation of the characters on which he founded his subdivision had by this time become apparent, and Forbes accordingly, while admitting the value of the groups, bases them on other characters than those employed by Eschscholtz; for he finds in the condition of the marginal bodies and of the gastro-vascular canals points of structure

[1] Fél. Dujardin, "Observations sur un nouveau genre de Medusaires (*Cladonema*) provenant de la Métamorphose des Syncorynes," 'Ann. Sci. Nat.,' 2e sér., 1843.

[2] P. J. Van Beneden, 'Recherches sur l'Embryogenie des Tubulaires, et l'Histoire Naturelle des différents genres de cette famille qui habitent la côte d'Ostende,' Bruxelles, 1843.

[3] 'Voyage autour du Monde sur la Corvette la Coquille, pendant les Anneés 1822, 1823, 1824 et 1825, par M. L. J. Duperrey, capitaine de frégate, commandant l'expédition.'

[4] René Primevère Lesson, 'Histoire Naturelle des Zoophytes. Acalephes.' Paris, 1843.

[5] Edward Forbes, "On the Pulmograde Medusæ of the British Seas," 'Brit. Assoc. Rep.' for 1846.

by which the two divisions may be anatomically characterised. In 1848 Forbes's views were further developed in a beautiful monograph on the Naked-eyed Medusæ of the British seas,[1] in which every known British species of hydroid Medusa is described and illustrated by an original figure. In this work he distinguishes the two groups by the names of "Steganophthalmia," corresponding with the *Discophora phanerocarpa* of Eschscholtz, and "Gymnophthalmia," corresponding with his *Discophora cryptocarpa*. With Forbes's monograph we may date the definite acceptance of the hydroid Medusæ as a well-marked and legitimate group.

The *Radiata* of Cuvier, which, by the elimination of various groups originally included in it, had been gradually attaining to a form more in accordance with the requirements of a natural classification, was in 1847 subjected to an important revision by Leuckart,[2] who insisted on the necessity of attending to a remarkable type of structure, which was common to certain members of the *Radiata* as then accepted by zoologists, namely, the free communication of the general body-cavity with the external world through the mouth. He saw in this feature a character of great value by which, after the exclusion of the *Polyzoa*, the whole of the Cuvierian "polypi" and "acalepha" would require to be united into a distinct group apart from the *Echinodermata*. To the group thus constituted Leuckart gave the name of *Cœlenterata*; while soon after Huxley was led to adopt similar views, and, quite independently of Leuckart, proposed the construction of an exactly equivalent group, under the name of *Nematophora*, suggested by the universal presence of thread-cells in the tissues of the animals composing it.[3]

The relation between the fixed hydroid trophosomes and the free hydroid medusæ, which, as we have seen, had already become apparent, received about this time additional light from the researches of Dalyell,[4] an acute, laborious, and conscientious observer, though without that technical precision in his descriptions which indicates a special zoological training, and without much acquaintance with what had been already done by others. Dalyell has recorded many additional instances of the development of Medusæ from the hydroid trophosome; and the accumulation of such facts now began to exert an influence on the classification.

We accordingly find Carl Vogt in 1851 combining the fixed hydroids with the whole of the *Discophora* of Eschscholtz, in order to form a single group, to which he gives the name of *Hydromedusæ*.[5]

In 1853 we find Kölliker employing the name of *Hydromedusida*,[6] but restricting it to a group composed of the gymnophthalmic Medusæ of Forbes, the Siphonophorous genus *Velella*, and all the non-natatory hydroids, except *Hydra*, which he unites with the rest of the *Siphonophora* to form his group *Hydroidea*, while he confines the name *Discophora* to the *Steganophthalmia* of Forbes, or *Discophora phanerocarpa* of Eschscholtz.

These proper Hydrozoal groups are, along with the *Ctenophora*, united to the *Actinozoa*, in order to form his division *Radiata molluscoida*, which would thus constitute a great natural

[1] Edward Forbes, 'A Monograph of the British Naked-eyed Medusæ,' London, 1848. Published by the Ray Society.

[2] Hnr. Frey und Rud. Leuckart, 'Beiträge zur Kenntniss wirbelloser Thiere,' Braunschweig, 1847.

[3] Th. H. Huxley, "An Account of Researches into the Anatomy of the Hydrostatic Acalephæ," 'Brit. Assoc. Rep.' for 1851.

[4] Sir John Graham Dalyell, 'Rare and Remarkable Animals of Scotland,' London, 1847.

[5] Carl Vogt, 'Zoologische Briefe,' Frankfurt-a-M., 1851.

[6] Albert Kölliker, 'Die Schwimmpolypen oder Siphonophoren von Messina,' Leipsig, 1853.

group corresponding to the *Cœlenterata* of Leuckart, were it not that Kolliker unfortunately combines with the cœlenterate forms the *Polyzoa*, so as to form by the union of the two his *Radiata molluscoidea*.

The same year Leuckart[1] proposed to divide the whole of the *Cœlenterata* into three classes —the *Ctenophora* of Eschscholtz, composed of the Beroes and their allies; the "Medusæ" (Scheibenquallen), and the "Polypes," which last name he confines to the Actinozoal *Cœlenterata*. Under the "Medusæ" of this classification are comprised three orders—the *Discophora* proper, the *Hydroida* with their Medusæ, and the *Siphonophora*.

The union thus nearly simultaneously proposed by Kölliker and by Leuckart of the non-natatory forms of hydroids with the gymnophthalmic Medusæ so as to form a group distinct from that of the steganophthalmic Medusæ, is the first expression we have of a natural relation which all subsequent research has only tended to confirm.

In 1856 Leuckart published his Supplement to Van der Höven's 'Manual of Zoology.[2] In this valuable little work we find him distributing the gymnophthalmic Medusæ between two groups. Those which he believes to undergo a direct metamorphosis without the intervention of a hydroid trophosome are combined into one order, to which he gives the name of *Ceratostera*, from the rigid habit of their marginal tentacles; while those which are known to be produced as buds from a trophosome are associated with their trophosomes, and with other fixed hydroids in which the gonophore never assumes the form of a free medusa, so as to constitute his order *Hydroidea*.

In the same year Huxley[3] proposed to divide the group *Cœlenterata* into two classes, which he names *Hydrozoa* and *Actinozoa*. Instead of assigning to the *Ctenophora* the value of a distinct class, he regards them as *Actinozoa*, thus bringing them into immediate relation with *Actinia*.

In 1857 Gegenbaur published a very valuable paper on the Medusæ,[4] in which he describes and figures many new forms of *Gymnophthalmia*, the subordinate groups of which he revises and limits more in accordance with the natural affinities of the animals than had been hitherto attempted. He adopts the Eschscholtzian subdivision; but instead of basing it on the characters assumed by Eschscholtz, or on those proposed by Forbes, he finds the grounds of the subdivision in the presence or absence of the membranous diaphragm which extends horizontally inwards from the margin of the umbella, and which Forbes had already designated by the name of "Velum." In accordance with this view Gegenbaur divides the Medusæ into the *Acraspeda*, or those in which no velum is developed, and which correspond to the *Steganophthalmia* of Forbes, and the *Craspedota*, or those which are provided with a velum, and which correspond to the *Gymnophthalmia* of Forbes.

In 1858 McCrady published an important paper on the "Gymnophthalmic Medusæ,"[5] in which many new forms are described and figured. Instead, however, of limiting his group *Gymnophthalmia* within the bounds of that to which Forbes had already assigned this name, he extends

[1] Rud. Leuckart, 'Zoologische Untersuchungen.' Erstes Heft. Giessen, 1853.

[2] Rud. Leuckart, 'Nachträge und Berichtigungen zu dem ersten Bande von J. Van der Höven's Handbuch der Zoologie,' Leipsig, 1856.

[3] Thomas Henry Huxley, "Lectures on General Natural History," in 'Medical Times' for 1856.

[4] Carl Gegenbaur, "Versuch eines Systemes der Medusen," 'Zeitsch. für Wissensch Zoologie,' 1857.

[5] J. McCrady, the *Gymnophthalmata* of Charleston Harbour, 'Proc. of the Elliott Society of Natural History,' Charleston, 1858.

it by uniting with the medusoid form which constitutes the *Gymnophthalmia* of Forbes, not only the polypoid forms of hydroids, but also the *Siphonophora*. The *Gymnophthalmia* of M'Crady thus correspond to the *Hydromedusida* and *Hydroidea* of Kölliker united.

In a small treatise on the alternation of generations among the hydroids,[1] Gegenbaur had already contributed some valuable observations to our knowledge of the generative phenomena and life-history of the HYDROIDA; while, as we have seen, he had also made the so-called naked-eyed Medusæ a subject of careful systematic study. In his 'Outlines of Comparative Anatomy,' published in 1859,[2] he retains his divisions of *Acraspeda* and *Craspedota*, uniting them into a single order, *Medusida*, while he combines the various non-natatory hydroid colonies into another order under the name of *Hydroida*.

In 1859 Huxley gave us a monographic treatise on the *Siphonophora* observed during the circumnavigatory voyage of H.M.S. "Rattlesnake."[3] The "Rattlesnake" was fitted out in 1846, under the command of Captain Owen Stanley, for the purpose of surveying the channel lying within the great barrier reef which extends along the east coast of Australia, and for the exploration of the neighbouring seas; and the expedition was accompanied by Mr. Huxley as assistant-surgeon. Owing to the refusal of the Admiralty, on the return of the expedition, to furnish the means of publication, the results of Huxley's observations remained unpublished, until, after many fruitless attempts to obtain the aid of Government, and many years of vexatious delay, the Ray Society undertook the task of publication. In this valuable work the *Siphonophora* are described under the designation of *Oceanic Hydrozoa*. The special part of the treatise is preceded by a general introduction, which abounds in original and philosophic views of the morphology of the HYDROIDA and of their relation to the other groups of *Hydrozoa*; and the author proposes a new and comprehensive terminology, much of which has been adopted in the present Monograph. In his systematic arrangement of the *Hydrozoa*; he does not venture to unite into a single group with the polypoid phases of the HYDROIDA those hydroid Medusæ which have not been proved to proceed from a polypoid trophosome, but prefers to arrange them as a distinct order of *Hydrozoa* under the name of *Medusidæ*, attaching, however, only a provisional significance to the group thus constituted.

Between 1860 and 1862 there appeared the third and fourth volumes of Agassiz's 'Contributions to the Natural History of the United States.'[4] These volumes are devoted to the *Hydrozoa*, which are treated of under the designation of Acalephæ. We learn from the preface to the first volume that the author has been assisted by Prof. H. J. Clark, to whom the microscopical researches which form so valuable a portion of the work are mainly due. Many new genera and species of hydroids are described, and their trophosomes as well as gonosomes represented in elaborate and beautiful figures drawn from the living animal, while the number and beauty of the drawings expressing anatomical and embryological details give to

[1] Carl Gegenbaur, 'Zur Lehre vom Generationswechsel und der Fortpflanzung bei Medusen und Polypen,' Wurzburg, 1854.

[2] Carl Gegenbaur, 'Grundzüge der Vergleichenden Anatomie,' Leipzig, 1859.

[3] Thomas Henry Huxley, 'The Oceanic Hydrozoa; a Description of the Calycophoridæ and Physophoridæ observed during the Voyage of H. M. S. "Rattlesnake," in the years 1846-50.' London, printed for the Ray Society, 1859.

[4] Louis Agassiz, 'Contributions to the Natural History of the United States of America,' Boston, 1857—62.

this work a special value, and place it among the most important contributions we possess to the natural history of the HYDROIDA.

Agassiz here divides his "Acalephæ" into three orders, *Ctenophora*, *Discophora*, and *Hydroida*, which last embraces the *Gymnophthalmia* of Forbes, the admitted polypoid forms of *Hydrozoa*, and the *Siphonophora* and *Lucernariæ*; and he also, contrary to the universally entertained opinion of previous naturalists, maintains that the corals constituting the still living group of the *Tabulata*, and those forming the entirely extinct groups of the *Tubulosa* and *Rugosa*, have a true hydroid structure, and that they must accordingly be removed from the *Actinozoa*, with which they had been hitherto associated, and take their place among the genuine HYDROIDA.

It will be seen that Agassiz here follows Kölliker, Leuckart, and M'Crady in uniting the polypoid forms of *Hydrozoa* with the gymnophthalmic Medusæ as elements in a group equivalent in value with that of the *Discophora*, a name which he employs in the limited sense adopted by Kölliker to indicate the *Discophora phanerocarpa* of Eschscholtz.

In 1861 Greene published his excellent little Manual of the Cœlenterata,[1] a work which gives us in a condensed form a very complete view of the structure, development, and relations of the various members of this group. He adopts the name of *Hydrozoa* in the sense in which it was limited by Huxley, while he combines the gymnophthalmic Medusæ into a distinct order from which the polypoid forms are excluded, and thereby as, I believe, fails to express the true relations of these organisms.

Though Greene's Manual lays no claim to originality, it discusses in a philosophic spirit various questions bearing on the subject with which it is occupied, and constitutes one of the most valuable aids to the general study of the *Cœlenterata* which can be placed in the hands of the student.

In the first volume of the 'Manual of Zoology,' by Peters, Carus, and Gerstaecker,[2] published in 1863, J. Victor Carus gives us among other articles an excellent one on the *Cœlenterata*. The *Hydromedusæ* which form his third order of *Cœlenterata* are here divided into the *Siphonophora* and *Hydroidea*, the latter embracing both the free gymnophthalmic Medusæ and the polypoid colonies. The article contains an account of the leading anatomical and embryological features of the HYDROIDA; and the subordinate groups under which the author believes that they ought to be distributed are characterised. It also contains a very useful synopsis with diagnoses of all the genera of hydroids.

Observations on both the hydriform and medusiform elements of the HYDROIDA had been thus for several years accumulating, and the time had already come when it seemed possible to assign to the free hydroid Medusa its proper place in a comprehensive system of the HYDROIDA. The importance of uniting the two elements in the definitions of genera had been already recognised by M'Crady, Agassiz, and Victor Carus; but notwithstanding the prominence which these authors, and especially Agassiz, had given to the medusiform buds, it did not seem that a thoroughly natural distribution of the HYDROIDA under legitimately limited genera had yet been effected, and this belief led me in 1864 to attempt a revision of the older genera of all tubularian and campanularian hydroids whose hydriform element was known.[3]

[1] Joseph Reay Greene, 'A Manual of the Sub-kingdom Cœlenterata,' London, 1861.

[2] Wilh. C. H. Peters, Jul. Victor Carus, und C. E. Adolph Gerstaecker, 'Handbuch der Zoologie,' Leipzig, 1863.

[3] Allman, 'On the Construction and Limitation of Genera among the Hydroida.' 'Ann. and Mag. of Nat. Hist.' for May, 1864.

In the diagnoses of the genera I regarded the reproductive zooid, whether fixed or free, of as much importance as the nutritive, and the resulting classification, in so far as it applies to the subject of the present Monograph, is, with such modifications as further investigations rendered necessary, that which I have here adopted.

At this period the *Æginidæ* constituted a group of Medusæ whose structure was but imperfectly understood, and whose systematic position and affinities had given rise to much discussion. In 1865, however, Ernst Haeckel published some very valuable observations[1] which no longer leave any doubt that these Medusæ possess a true hydroid structure, by which they become associated with the ordinary hydroid or gymnophthalmic Medusæ; while he still further made the remarkable discovery that *Cunina*, a typical Æginidan, is produced as a bud from *Geryonia*, a medusa of an entirely different form, and one whose true hydroid affinities had never been doubted.

In the same year, Alexander Agassiz published his illustrated Catalogue of the North American Hydrozoa contained in the Museum of Comparative Zoology at Harvard College.[2] In this work, besides other hydrozoal groups, a large number of hydroid Medusæ, occasionally accompanied by their trophosomes, and including many new forms, are described and illustrated by very expressive woodcuts. The views of Prof. Louis Agassiz on almost all that concerns nomenclature, generic groups, and systematic position and affinities are throughout adopted by his son; but whether these views be in all points accepted or not, we cannot but regard the work of Alexander Agassiz as tending in no small degree to advance to our knowledge of the zoology of the HYDROIDA.

In 1866, while the present sheets were passing through the press, M. Van Beneden published in the 'Memoirs of the Royal Academy of Belgium' a treatise on the Natural History of the *Cœlenterata* of the Belgian Coast, a group for which he uses the general name of "polypes."[3]

The greater part of the work is devoted to the HYDROIDA; it is illustrated by many beautiful plates, and is one of the most elaborate treatises which has been hitherto published on these animals. M. Van Beneden describes and figures not only a considerable number of the fixed forms, but also many free medusiform gonophores; and the work must be regarded as a valuable contribution to the iconography and descriptive natural history of the Hydroida, though the author's opinions on many points, more especially such as concern the synonomy and determination of species, cannot receive our assent, and will be discussed in another part of the present Monograph.

While the natural history of the HYDROIDA was thus gradually advancing towards perfection in all that appertains to descriptive Zoology and systematic arrangement, the anatomists were developing it from a structural and embryological point of view. The introduction of the achro-

[1] Ernst Haeckel, 'Ueber eine neue Form des Generationswechsels bei den Medusen, und über die Verwandeschaft der Geryoniden und Aegmiden Monatsbericht der Könige Akad. der Wiss. zu Berlin,' 2 Feb., 1865. Translated in the 'Ann. of Nat. Hist.' for Jan. 1865.

Id., 'Beiträge zur Naturgeschichte der Hydromedusen,' Leipzig, 1865.

[2] 'Illustrated Catalogue of the Museum of Comparative Zoology at Harvard College.' No. II. "North American Acalephæ." By Alex. Agassiz. Cambridge, U.S., 1865.

[3] P. J. Van Beneden, "Recherches sur la Faune littorale de Belgique.—Polypes." 'Mém. de l'Acad. Roy. de Belg.,' tome xxxvi. Published also in a separate form.

matic microscope had already placed in their hands a new and powerful instrument of investigation, and discoveries in the anatomy and physiology of the lower animals had begun to accumulate with a rapidity hitherto unprecedented. We have already referred to the important light which the microscope in the hands of Ehrenberg, Sars, Dalyell, Steenstrup, Dujardin, Leuckart, and Gegenbaur had thrown upon the mutual relations and life-history of these animals, and we have seen the influence it has thus had on their classification, while within the last twelve years the microscopical investigation of the HYDROIDA has been pursued with an assiduity greater than at any former period, and has yielded the results which might have been expected from the numerous able observers who have been engaged in it. To give, however, in the present historical sketch even an imperfect analysis of the various discoveries by which recent anatomical research has enriched our knowledge of the HYDROIDA, would be impossible without extending our introductory pages far beyond the limits within which it is expedient to confine them, and the reader must accordingly be referred for an account of such discoveries to the parts of this work where they will be specially considered.

The steps which in the history just sketched have exerted the greatest influence in determining the boundaries and systematic position of the HYDROIDA, in the sense in which this group is limited in the present Monograph, would seem to be the following :—

1. The discoveries of Trembley in the anatomy and physiology of *Hydra*.

2. The researches of Ellis among the marine forms, which resulted in the complete establishment of the animality of the fixed plant-like HYDROIDA—results to which the observations of Peysonelle and De Jussieu had led the way.

3. The establishment of the *Radiata* by Cuvier as one of the four primary divisions of the animal kingdom.

4. The recognition by Eschscholtz of two types of form among the Medusæ, and his consequent subdivision of these organisms into the *Phanerocarpa* and *Cryptocarpa*.

5. The recognition by Cuvier, Milne-Edwards, and Rapp, of the difference of structure which separates the actinozoal from the hydrozoal forms of the so-called "Polypi."

6. The determination by Ehrenberg of the sexuality of the HYDROIDA.

7. The discovery of a genetic relation between certain free gymnophthalmic Medusæ and the fixed Hydroids, by Loven, Sars, Dalyell, Dujardin, and others, and the correlation of this with analogous phenomena by Steenstrup.

8. The gradual rectification of the *Radiata* of Cuvier by the successive elimination of the Nullipores, Worms, *Infusoria*, *Rhizopoda*, and *Polyzoa*.

9. The further analysis by Leuckart of the amended *Radiata*, resulting in his establishment of the group *Cœlenterata*.

10. The union by Kölliker and Leuckart of certain free gymnophthalmic Medusæ with the fixed HYDROIDA, so as to constitute a single group equivalent in value with that of the *Discophora* or steganophthalmic Medusæ.

MORPHOLOGY OF THE HYDROIDA—TERMINOLOGY.

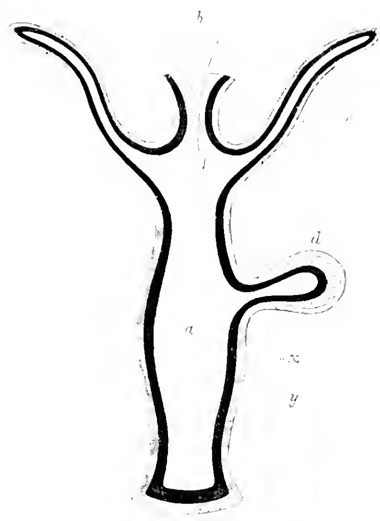
I. The Hydrosoma in general.

1. *Generalised conception of a Hydroid.*

We shall best bring this part of our subject before the mind, if we first endeavour to conceive of hydroid organisation freed from all non-essential complication.

Let us, then, imagine an open sac (woodcut, fig. 1), whose walls consist of a double membrane (*x*, *y*), and whose orifice (*b*) is surrounded by a circle of tubular tentacles (*c*) formed by cæcal offsets from its cavity. Let us further suppose that there projects from some part of the walls of this sac another sac (*d*), also composed of a double membrane. To the morphological conception thus acquired, let us add the physiological one which we obtain by regarding the walls as endowed with irritability; and as a further physiological element in our ideal picture, let us imagine that while the former sac subserves the function of a digestive cavity, the latter, which has been emitted as an external bud from its side, is destined to give origin to generative elements which are formed between the two membranes which constitute its walls; and we shall then have as general an idea, morphological and physiological, as it is possible to form of a hydroid.

Fig. 1.



Diagramatic section of a Hydroid.

a, Body cavity; *b*, orifice serving for ingestion and egestion; *c*, tentacle; *x*, outer membrane of body walls (ectoderm); *y*, inner membrane of body-walls (endoderm); *d*, generative sac, containing eggs. The endoderm is throughout indicated by a darker shading than that of the ectoderm.

The hydroid organism, however, which we have thus reduced to its simplest expression, admits of much and varied complication, while the actual forms which we meet with in nature present a beautifully graduated series, in which the law of specialisation is expressed with a distinctness and significance in the highest degree instructive, and whose study possesses a peculiar interest in leading us to those wider generalisations in which other groups of the *Hydrozoa* may be included, and by which we are enabled to assert a morphological unity of the whole.

2. *General Structure—Ectoderm and Endoderm.*

Every hydroid is composed of two membranes, an outer or *ectoderm* (woodcut, fig. 1, *x*), and an inner or *endoderm* (*y*), the ectoderm having its free surface in direct relation with the medium in which the animal lives, while the free surface of the endoderm is turned inwards, and forms the boundary of the gastric cavity and of all its prolongations through the organism. A similar composition may be demonstrated not only in all the rest of the *Hydrozoa*, but in the whole group of the *Cœlenterata*. For the important generalisation which thus asserts the composition of every cœlenterate animal out of two membranes—a generalisation which forms the basis of the whole morphology of the *Cœlenterata*—we are indebted to Prof. Huxley, who first enunciated it as a great anatomical truth.[1]

Another character which the Hydroida possess in common with the entire group of Cœlenterata is the presence of the peculiar bodies known as *thread-cells*. These bodies, which will be afterwards more particularly examined, are developed in the ectoderm, where they are frequently aggregated in definite groups very characteristic of the species.

3. *Composite character of the Hydroida—Trophosome, and Gonosome.*

The Hydroida, wherever our knowledge of them is sufficiently complete to justify us in arriving at any well-founded conclusion regarding the entire life of the individual are all, with only a single apparent exception, composite animals at some one period of their existence, each consisting then of an assemblage or colony of zooids,[2] in organic union with one another (woodcut, fig. 2). The colony thus formed constitutes the "hydrosoma" of Huxley.

It will be shown in the sequel that, except in the solitary—and, perhaps, after all, only

[1] Huxley, "On the Anatomy and Affinities of the Medusæ," 'Phil. Trans.,' 1849.

[2] For the introduction of the very convenient term "zooid" into the language of zoology, we are indebted to Prof. Huxley, who, in defining the "individual" as "the total result of the development of a single ovum," proposed to designate by the term zooid all more or less independent forms which may be included as elements in this total result. (See Huxley, "Observations on *Salpa*," &c., in 'Phil. Trans.,' 1851; "Lecture on Animal Individuality," 'Ann. Nat. Hist.,' June, 1852; and his review of J. Müller's "Researches on the Development of the Echinodermata," in 'Ann. Nat. Hist.,' July, 1851. See also Carpenter, 'Principles of Gen. and Comp. Physiology,' 1851, p. 906, and 'Brit. and For. Med.-Chir. Rev.' for Jan. 1848 and Oct. 1849, where the same idea is clearly supported, Dr. Carpenter using the expression "a generation" for all that intervenes between one act of true or sexual generation and another.

The distinction between a "zooid" and an "organ" is not always easy, and may indeed sometimes appear to be arbitrary. I believe, however, that we may define a zooid as *a more or less individualised animal organism, which may or may not be capable of independent existence, and which constitutes one of a series whose members are related to each other by some form of non-sexual reproduction, and morphologically repeat one another either actually or homologically.* In this sense not only are the free medusiform buds of the *Hydroida* true zooids, but we must also regard as such the fixed hydranths and those fixed gonophores which never attain a developed medusiform structure, as well as the simple generative sacs which are developed on the radiating canals of *Obelia*, *Thaumantias*, &c. (see p. 35).

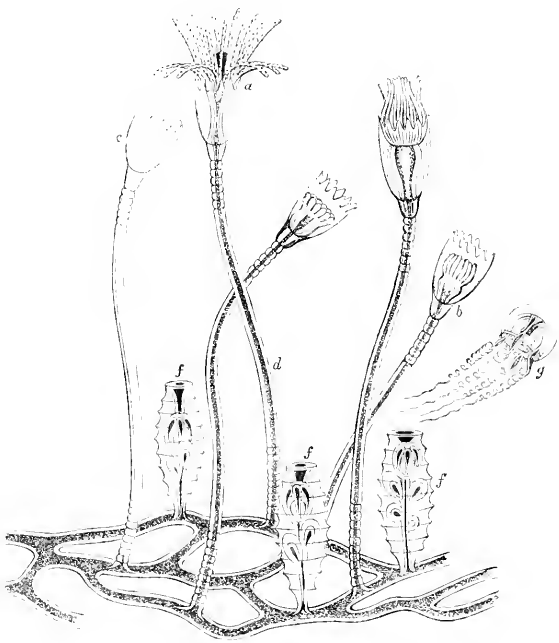
On the other hand, from the above definition are necessarily excluded all mere *organs*, however capable they may be for a longer or shorter period of self-maintenance, such, for example, as the *Hectocotylus* of the Hectocotylus-forming *Cephalopoda*.

Many zooids may combine to form the true *zoological Individual*—the logical element of the *species*.

apparently exceptional—case here referred to, and which will be afterwards more particularly described, those which have been adduced as affording exceptions to this phenomenon are in every instance based upon incomplete observations; that they may or may not be confirmed when opportunities of more extended observation shall have been afforded; and that accordingly, in the present state of our knowledge, we are not justified in accepting them.

The associated zooids are always of two kinds. In one (*a*, *b*), the zooid is destitute of all power of true or sexual generation, and has as its proper function the general nutrition of the colony. The other group of zooids (*f*, *g*) has nothing to do with the general nutrition of the colony; it has as its proper function true generation, and the zooids which compose it give origin to the generative elements—ova or spermatozoa—either directly or after having first developed a special sexual bud. For the whole assemblage of the former, or nutritive zooids, with their common connecting basis, I propose the name of *trophosome*, while I shall designate the entire association of generative zooids by the name of *gonosome*. Every hydroid, therefore, with whose life-history we are acquainted consists essentially—with the solitary exception already alluded to—of a trophosome destined for the preservation of the individual, and of a gonosome for the perpetuation of the species.

Fig. 2.



Hydrosoma of *Campanularia Johnstoni*.

a, *b*, *c*, *d*, *e*, Various portions of the trophosome; *f*, *f*, *f*, *g*, of the gonosome. *a*, Hydranth expanded; *b*, hydranth contracted; *c*, empty hydrotheca; *d*, free portion of hydrophyton (hydrocaulus); *e*, adherent portion of hydrophyton (hydrorhiza); *f*, *f*, *f*, gonangia, containing generative buds, which in this genus are blastochemes; *g*, a blastocheme just after its escape from the gonangium.

4. *Orientation.*

The attached extremity of the fixed hydrosoma, or its equivalent in the free one, is described by Huxley as the *proximal* end; that which is placed diametrically *opposite* to this is the *distal* end. In the present Monograph I shall employ the terms proximal and distal in the sense thus proposed. Beyond these two aspects none other can be definitely distinguished in the HYDROIDA. The determination of a right and a left side is impossible, for though an apparent bilateralism occasionally occurs, as, for example, in the planoblasts of *Corymorpha* (Pl. XIX), and in those of *Gemmellaria* (Pl. VII) and *Dicoryne* (Pl. VIII); these conditions must be regarded rather in the light of an arrest or retardation of the development which in the vast majority of cases results in the symmetrical disposition of the parts radially round a common axis.

II. MORPHOLOGY OF THE TROPHOSOME.

1. *Hydranths.*

Two distinct portions enter into the composition of the trophosome, namely, the hydranths and the hydrophyton.

The proper nutritive zooids (woodcut, fig. 2, *a*, *b*) which constitute the essential part of the trophosome of the Hydroida have been usually known in common with the zooids of the *Actinozoa*, or proper coral-animals, by the name of "polypes." It will be more convenient, however, to restrict this term to the *Actinozoa*, to which Réaumur originally applied it, borrowing the word from Aristotle, who used it, not for cœlenterate animals at all, but for the cuttle-fishes; while for the alimentary zooids of the HYDROIDA I shall in the present work employ the term *hydranth*.[1]

The hydranth consists essentially of a digestive sac opening at one end by a mouth. Behind the mouth are situated tubular offsets from the sac; these are known as *tentacula*. The mouth itself is borne on the summit of a more or less distinctly developed proboscis-like extension of the sac, and to this the name of *hypostome* may be given.

The hydranth is developed on some part of the hydrophyton, which usually forms for it a hollow, stem-like support (*d*), on whose summit or sides it is carried, and with whose cavity its own is directly continuous.

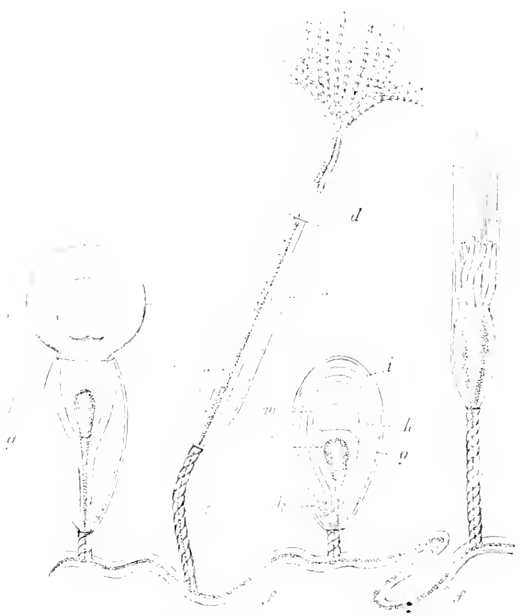
The form of the hydranth varies. It may be flask-shaped, or fusiform, or nearly cylindrical; but is in every case more or less mutable, constantly changing its shape as the result of various states of contraction. The hypostome may pass imperceptibly into the body of the hydranth (*Hydra*, *Perigonimus*), or it may be strongly differentiated from it, and it then usually presents a trumpet-like form, though frequently acquiring at the same time increased contractility and

[1] Huxley uses in the same sense the term *polypite*, and in former publications of my own I followed him in the employment of this word. As, however, a virtually identical term (polypide) is in use for the exsertile and retractile portion of a polyzoon, an objection similar to that which renders inexpedient the use of the word polype may be urged against the employment of polypite in the terminology of the Hydroida.

mutability of outline (*Eudendrium*, *Campanularia*, woodcuts figs. 2 and 13). The tentacles vary in form, number, and arrangement in the different species, and thus afford excellent characters for the purposes of classification. Their axial tube may be continued throughout (*Hydra*), or it may be more or less obliterated (*Coryne*, *Campanularia*). They are usually simple filiform processes, as in *Hydra*, *Clava*, *Hydractinia*, *Campanularia*, &c.; but in some cases their extremity presents a knob-like enlargement, as in *Coryne*, when they are said to be "capitate." Their number may be as low as two (*Lar*), or it may amount to more than 100 (*Corymorpha nutans*). They may be arranged in a single circlet (*Campanularia*),[1] or in two (*Vorticlava*), or in several (*Stauridium*), or they may be scattered over the body of the hydranth (*Coryne*), or may be partly verticillate, partly scattered (*Pennaria*). Finally, they may be all of one kind (filiform, as in *Clava*, capitate, as in *Coryne*), or the same hydranth may carry both filiform and capitate tentacles (*Stauridium*).

In a great number of hydroids the hydranth is destitute of any external protection (*Tubularia*, *Coryne*, &c.). In others, however, there exists a cup-shaped receptacle, within which

FIG. 3.



Portion of the Hydrosoma of *Calycella syringa*, showing the operculate hydrothecæ &c.

a, *a*. The hydranth extended; *b*, *b*, hydranth retracted: *c*, hydrotheca; *d*, operculum open for the exit of the hydranth; *d'*, operculum closed after the retraction of the hydranth; *e*, *e*, hydrocaulus; *f*, hydrorhiza; *g*, gonangium with its contents previous to the escape of ovum; *g'*, gonangium after the passage of the ovum into an acrocyst; *h*, walls of sporosac; *i*, gubernacular sac; *k*, remains of blastostyle; *m*, ovum still contained within the sporosac; *n*, acrocyst: *o*, ovum after its escape into the acrocyst; *p*, empty sporosac, still enclosing the spadix.

[1] A single circlet may be absolutely simple or it may result from the close approximation of two or more verticillate series of tentacles.

it may be partially or totally withdrawn, and from which it may again spontaneously extend itself (*Campanularia*, *Sertularia*, &c.). To this receptacle, which is characteristic of a large section of the Hydroida, the name of *hydrotheca* has been given by Huxley.

The hydrotheca is formed of a chitinous membrane continuous below with the perisarc or common chitinous investment of the hydrophyton, to be presently described. Its margin may be quite even, or it may be divided into minute teeth (woodcut, fig. 2); the cup may be permanently open (woodcut, fig. 2), or it may be provided with a kind of operculum formed of triangular segments, united, as by a hinge, to the margin, and capable of completely closing over the cup when the hydranth is retracted (woodcut, fig. 3). Sometimes the operculum consists of a flexible membranous continuation of the cup-margin, and then, during the retracted state of the hydranth, falls together in loose folds.

In a few hydroids (*Bimeria*, Pl. XII, fig. 1) the chitinous perisarc is continued from the hydrophyton for a greater or less distance over the hydranth, which it closely invests without forming anything like a free hydrotheca. In others (various species of *Bougainvillia*, Pl. IX and X) the perisarc continued over the hydranth invests it so loosely that in extreme contraction the hydranth seems to be withdrawn into a cup; but this apparent cup has nothing of the permanent form or rigid texture of a true hydrotheca, and is always thrown into more or less distinctly marked transverse folds or rugæ by the contraction of the hydranth.

2. *Hydrophyton.*

The term *hydrophyton* is used to designate the common basis by which the various zooids of the hydrosoma, or general colony, are kept in union with one another.

Cœnosarc and Perisarc.—The hydrophyton consists mainly of a fleshy tubular basis, composed, like all the zooids which it supports, of an ectoderm and an endoderm. I shall designate this fleshy and only essential portion of the hydrophyton by the name of *cœnosarc*.

In every member of the Hydroida, however, with whose trophosome we are acquainted, excepting only the fresh-water *Hydra*, and possibly also *Nemopsis* and *Acaulis*, whose trophosomes, like that of *Hydra*, are stated—though without sufficient evidence—to be free, the ectoderm excretes from its outer surface an unorganised pellicle, chemically identical with chitine, and forming an external tubular investment for the soft organised ectoderm.[1] This unorganised excretion, which must be placed in a totally different category from that of the ectoderm and endoderm, I shall designate as the *perisarc*. In some cases it is confined to the hydrophyton; in others it extends, not only over the entire hydrophyton, but is continued for a greater or less extent, and in a more or less modified form, over the various zooids of the colony. In the *Sertularinæ* and *Campanularinæ* it forms the cup-like receptacles or *hydrothecæ* already described, into which the hydranths are retractile; as well as peculiar receptacles—the *gonangia* (woodcuts, fig. 2, *f*, and fig. 3, *g*)—destined for the protection of the sexual buds. It varies greatly in thickness, from a tough investment, in which numerous layers of deposition can be detected, to a delicate, scarcely recognisable pellicle, and is invariably absent from those zooids (fig. 2, *g*) which have detached themselves from the colony in order to lead an independent life in the open sea. In the adult *Hydractinia* and *Podocoryne* it presents the very exceptional condition of not only investing the

[1] If future observations should confirm the view entertained by Agassiz, as to the hydroid nature of the tabulate and rugose corals, we shall then have examples of calcareous as well as chitinous skeletons among the Hydroida.

ectoderm, but being itself overlaid by a soft naked expansion of the cœnosarc, for which it thus forms an internal framework, recalling the sclerobasic corallum of certain *Actinozoa*.

Hydrorhiza and Hydrocaulus.—In almost every case the general colony, or hydrosoma, is attached to some foreign body, such as rocks, shells of mollusca and crustacea, sea-weeds, floating timber, &c., to which it is fixed by some part of its surface (woodcuts, fig. 2, *e*, and fig. 3, *f*). In many cases this is effected by a definite organ of attachment, as in the fresh-water *Hydra*, where, by means of a disc-like expansion of the end diametrically opposite to the mouth, the animal can attach itself to the stems and leaves of aquatic plants, from which it can again spontaneously free itself; or, as in a great number of marine HYDROIDA, in whose young state a disc occupying a similar position (Pl. XIII, figs. 12—16) also becomes an organ of fixation, differing, however, from the corresponding organ in *Hydra* by its not admitting of spontaneous detachment, and by its being usually replaced, as the animal grows older, by adherent tubular offsets, or *stolons*, given off from the same part. For the definite organ of fixation the term *hydrorhiza*, as suggested by Huxley, may be employed; while for the whole of that portion of the hydrophyton which intervenes between the hydrorhiza and the hydranth (woodcuts, fig. 2, *d*, and fig. 3, *e*) it will also be very useful, especially in descriptive zoology, to have a distinct name, and that of *hydrocaulus* may therefore be conveniently used to designate it.

In many cases, however, all trace of a definite hydrorhiza disappears as the animal grows old, and continues to complicate itself by the formation of new buds and branches; and we then find fixation effected by some part of the general surface of the hydrosoma, as in certain creeping Campanularians, &c., in which a greater or less extent of the hydrocaulus itself becomes the medium of attachment. Sometimes it is the hydrocaulus which is suppressed, and the hydranth will then be sessile on the hydrorhiza, as in *Hydractinia* (Pl. XV).

It is occasionally very uncertain whether the part which fixes the hydrosoma ought to be regarded as a true hydrorhiza or as an adherent hydrocaulus. Most usually, however, some peculiarity of structure or of form will justify a decision. Thus, in the *Campanularia* represented in woodcut, fig. 2, the tendency of the adherent portion to form a network of inosculating branches, so very different from anything exhibited by the free stems, will fully entitle us to regard this adherent network as a true hydrorhiza, and to place it in a category distinct from that of the free hydrocaulus.

Again, it is by no means always easy to say where the hydranth ends and where the hydrocaulus begins. In by far the majority of cases the distinction is easy enough, as in the whole of the calyptoblastic hydroids, and in *Tubularia*, *Corymorpha*, and many others among the gymnoblastic genera, in all of which the line of demarcation is indicated by a marked change of form, and frequently of structure. In some other cases among the *Gymnoblastea*, however, the hydranth passes so imperceptibly into the hydrophyton that it is difficult to say how much we ought to give to the one, and how much to the other.

The limit of the perisarc, or common chitinous investment, will often help us in this. Thus in *Clava* (Pl. I), where the hydranth possesses a very much elongated form, one might easily be led to regard as hydrocaulus what is really part of the hydranth. Here, however, if we consider the whole of the naked portion of the trophosome as belonging to the hydranths, we shall have a distinct though rudimental hydrocaulus in the very short, narrow tubes, invested by a perisarc, which arise from the upper surface of the hydrorhiza, but which have usually been overlooked in the description of this genus. It must, however, be admitted that there are cases among the gymnoblastic hydroids in which the boundary can scarcely be regarded as otherwise than arbitrary.

Besides the fresh-water *Hydra*, two cases have been described in which the entire hydrosoma occurs in a free state. This very exceptional condition is stated to exist in two North American genera, *Nemopsis* and *Acaulis*, whose trophosomes have been found floating free in the open sea. *Acaulis*, however, is described as becoming attached at a later period of its life.[1]

In most cases the hydrophyton becomes developed into a ramified, tree-like growth (*Eudendrium ramosum*, *Bougainvillia ramosa*, *Laomedea dicholoma*, &c.). In other cases it consists of a creeping adherent, usually ramified stolon, with simple free tubes sent off from it at intervals (certain species of *Clava*, *Campanularia*, &c.); while sometimes, as in *Hydractinia* and *Podocoryne*, it forms a continuous stratum, spreading over the surface of some foreign body which the hydroid has selected for its abode.

Nematophores.—In hydroids belonging to the family of *Plumularidæ* certain very remarkable appendages are developed at definite and constant points from the hydrophyton. They have been named *nematophores* by Busk;[2] and though the part they perform in the economy of the hydroid cannot be regarded as strictly determined, they may be here described more appropriately than anywhere else. They consist each of a cup-like receptacle containing a sarcode mass, which can extend itself from the cup in the form of simple or branching processes, and again completely withdraw itself, so as in every respect to resemble the pseudopodial prolongations of a rhizopod. There is usually a cluster of thread-cells immersed in the sarcode.[3]

The receptacle is formed of a chitinous membrane like that of the hydrothecæ, and may either consist of a single chamber (*Aglaophenia pluma*) or its cavity may be divided by a transverse diaphragm into a distal and a proximal chamber, which freely communicate with one another through an orifice in the diaphragm (*Antennularia*).

The nematophores may be attached to the hydrosoma by a broad base, or be adnate to it for a greater or less extent (*Aglaophenia*), or they may taper away to a fine point of attachment at their proximal ends (*Antennularia*).

In *Aglaophenia pluma* there is a nematophore always situated immediately in front of each hydrotheca. It is here adnate to the walls of the hydrotheca, with whose cavity that of its own receptacle communicates by means of a common lateral aperture, through which the sarcode prolongations of the nematophore can freely pass into the interior of the hydrotheca.

In the singular Campanularian genus *Ophiodes* Mr. Hincks has described certain appendages which take the place of the nematophores in the nematophore-bearing genera.[4] They consist of very extensile tentacula-like bodies, which are carried both upon the hydrocaulus and the hydrorhiza. They terminate at their distal extremity in a spherical capitulum loaded with thread-

[1] See M'Crady's account of *Nemopsis*, in Proc. Elliot, 'Soc. of Nat. Hist.' vol. i; and Stimpson on *Acaulis*, in his 'Fauna of Grand Manon,' published in the Smithsonian Contributions. These floating trophosomes, however, are probably only the detached hydranths of fixed forms, while the statement that *Acaulis* becomes subsequently attached is almost certainly founded on an error.

[2] Busk, 'Hunterian Lectures' (MS.), delivered at the Royal College of Surgeons, London, 1857.

[3] Figures of nematophores are given below in the section which treats of the physiology of the Hydroida.

[4] T. Hincks on *Ophiodes*, in 'Ann. Nat. Hist.' for Nov., 1866.

cells and are surrounded at their base by a chitinous sheath. During the life of the hydroid they may be seen to be in a state of great activity, stretching themselves out and twisting about in every direction.

III. Morphology of the Gonosome.

1. *General view of the Gonosome.*

The zooids which compose the gonosome may remain permanently attached to the rest of the hydrosome, or they may become free and lead henceforth an independent existence in the open sea. It will be found very convenient to have a common term to express all these free zooids of the gonosome, and I accordingly propose for them the name of *planoblast*.[1] With one rare exception, they are all in the form of the so-called gymnophthalmic medusæ.

Under the planoblasts, however, must be included certain comparatively rare instances in which the medusiform zooid, though having its natatory organ well developed, remains, from some unknown cause, attached to the trophosome, and attains to sexual maturity without ever actually becoming free. It is capable, however, when accidentally detached, of swimming by the systole and diastole of a true natatory umbrella, and cannot, therefore, be placed in a different category from that of the essentially free planoblast.

The gonophore is the *ultimate generative zooid,*—that on which devolves the duty of giving immediate origin to the generative elements which are always produced from it between its own ectoderm and endoderm without the intervention of any other zooid. It is the only essential part of the gonosome, being never absent. It may remain attached during its whole lifetime, or it may sooner or later separate itself from the rest of the hydrosome, and thus become a free generative bud or planoblast. It presents either the form of a "gymnophthalmic medusa" or else that of a zooid in which the form of the medusa is more or less disguised, or its parts more or less suppressed, but which can nevertheless be always referred by an easy comparison to the essential type of the medusa.

The planoblasts may either be the direct producers of the generative elements, and are then true gonophores, or may never produce the generative elements directly, but only through the intervention of another bud which is developed from them. For this latter form of planoblast, which is thus, strictly speaking, non-sexual, and which, notwithstanding its resemblance to a gonophore, should be carefully distinguished from it, I have given the name of *blastocheme*; while the proper sexual medusiform planoblast may be designated by the term *gonocheme*.

Among the fixed zooids of the gonosome there is very frequently one which, like the blastocheme, takes only a subordinate part in the generative function, being, like it, destined for the production of other generative buds which are developed from some part of its surface, and which may be either gonophores or blastochemes. It is never medusiform, but may be regarded as a peculiarly modified hydranth, having its alimentary function suppressed. It is referred to in the present work under the name of *blastostyle*.

The gonophore is always borne as a bud, either directly upon some part of the trophosome, or upon a blastostyle, or upon a blastocheme. While it is constructed essentially on the plan of a gymnophthalmic medusa, it varies greatly in the degree of completeness in which this plan is expressed in it. It may be referred to one or other of two principal types, based respectively on

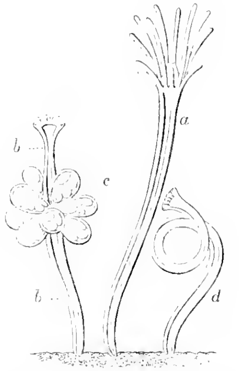
[1] "Wandering buds"—πλανομαι and βλαστός.

the greater or less approach to the completely formed medusa. The peculiar condition by which one of these types is characterised may be termed *phanerocodonic*, while that which distinguishes the other may be designated as *adelocodonic*—conditions, however, which, it must be borne in mind, pass into one another by numerous gradations.

The phanerocodonic condition is found in those gonophores (Pl. X, &c., and woodcut, fig. 8) which present an obvious medusa-form, and which are distinguished by having a well-developed umbrella, provided with the wide aperture, or *codonostome*, which characterises the complete medusa; the umbrella, except in one remarkable form—that presented by *Clavatella*, Hincks (woodcut, fig. 5), and *Eleutheria*, Quatrefages—being eminently contractile, and fitted for natation. The adelocodonic condition is found in the bodies to which I have elsewhere given the name of *sporosac*; these bodies (Pl. I, &c., and woodcuts, fig. 4, *c*, and fig. 7) have either no umbrella, or, if this be present, it is in an incompletely developed state, never provided with a wide, open codonostome, and quite incapable of acting as a locomotive organ.

The phanerocodonic gonophores, in by far the greater number of instances, detach themselves from the hydrosoma after they have attained a certain degree of maturity, and lead henceforth an independent existence, during which they increase in size, often develop new parts, and sooner or later give origin to ova or spermatozoa.

Fig. 4.



Group of zooids from a colony of *Hydractinia echinata*, taken from near the margin of the colony.

a, alimentary hydranth; *bb*, blastostyle; *c*, gonophores which have been produced as buds from the blastostyle, and are filled with ova; *d*, spiral hydranth, developed close to the margin of the colony. The alimentary and spiral hydranths are connected to one another and to the blastostyle by a common basal expansion or cœnosarc.

In some cases, however, they develope and discharge their reproductive elements while still attached, and then wither away, without ever becoming free, notwithstanding their well-developed contractile umbrella apparently fitting them for an independent natatory existence. If an observation of Agassiz be not really made on two different species instead of one, as he himself believes, it would seem that this condition is dependent, in one case at least, on the season of the year; for he informs us that he found the gonophores of *Coryne mirabilis*, Agass., in the earlier months of the year, detach themselves from the trophosome and swim away as gymnophthalmic medusæ before the development in them of ova or spermatozoa; while, somewhat later, he has seen the gonophores attain to sexual maturity, without ever becoming free.[1] It is possible, however, that the two conditions here described by Agassiz belong to two quite different species.

The free phanerocodonic gonophore is in one rare form (woodcut, fig. 5) ambulatory: in all others it is natatory; locomotion being effected by alternate systole and diastole of the umbrella. In the ambulatory form the umbrella is incapable of evident systolic and diastolic movements, and locomotion is performed by marginal tentacles peculiarly modified for creeping over solid bodies. This very exceptional form has been met with only in *Clavatella*, whose trophosome has been

[1] Agassiz, 'Contributions to the Nat. Hist. of the United States,' vol. iv, p. 189.

[2] The gonophores of the siphonophorous group *Calycophoridæ* properly come under the designation of phanerocodonic, though they may never become free, and though we find them departing from the typical form of the gymnopthalmic medusæ by the non-development of the marginal appendages of the umbrella.

discovered by Hincks, and in the nearly allied *Eleutheria* of De Quatrefages, whose trophosome has not yet been detected.

While all the leading features of a gymnophthalmic medusa are thus at once obvious in the phanerocodonic gonophore, the adelocodonic gonophores, on the other hand, present the medusoid structure only in a disguised or undeveloped condition. They have the form of sacs, and, except in a single known instance, the whole gonophore remains permanently attached to the hydrosoma, giving rise within it to the generative elements, which, after attaining a certain degree of maturity, are ultimately discharged from its cavity. The single exception is afforded by the

Fig. 5.

Ambulatory Medusa of *Clavatella prolifera*.

Fig. 6.

Free locomotive sporosac of *Dicoryne*. The figure represents two aspects of the female sporosac when swimming in the open sea, and viewed in planes at right angles to one another.

genus *Dicoryne*, Allm. (woodcut, fig. 6), in which, before discharging its generative products, the gonophore liberates itself from its external investment or ectotheca, and thus, becoming a free planoblast, swims about actively by the aid of vibratile cilia.

The following tabular view will exhibit at a glance the various parts which may occur in a hydroid gonosome:

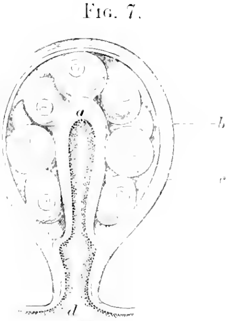
Gonosome.	Zooids directly sexual (*Gonophores*)	Adelocodonic or sacciform (*Sporosacs*)	fixed. natatory.	
		Phanerocodonic or medusiform (*Gonochemes*).	natatory. ambulatory.	*Planoblasts.*
	Zooids not directly sexual, but giving origin to sexual buds.	Medusiform (*Blastochemes*)	natatory.	
		Styliform (*Blastostyles*)	fixed.	

Whether the gonosome remains during its whole lifetime connected with the trophosome, or detaches itself as one or more independent zooids, it is manifest that it constitutes an essential element in the character of the species, and the study of no one species of hydroid can be regarded as complete unless it embrace both trophosome and gonosome. Since, however, in many cases we are acquainted with only the free gonophore, or the free blastocheme, not having yet discovered the trophosome to which it belongs, while in other cases the trophosome alone is known to us, we have been in the habit of treating such instances without regard to the missing zooids, and as if they afforded examples of independent species; but it must never be forgotten that the data on which we thus assign to them the rank of determinate species, or genera, are insufficient for the purposes of a philosophic system: such genera and species must be regarded as purely provisional; for the zoologist is no more justified in accepting such incomplete characters as sufficient for the accurate determination of his hydroid, than would the botanist be in regarding the flower alone on the one hand, or the root, stem, and leaves alone, on the other, as affording characters sufficient for the definition of any flowering plant whose exact determination he would attempt.

The gonosome is that part of the hydroid which presents the most marked variation among the different members of the group, and it is here that we find most distinctly manifested those beautiful gradations of form which, by throwing light not only on one another, but on forms belonging to other groups of the *Hydrozoa*, possess for the morphological student a profound significance. It will therefore be necessary to enter into a more detailed examination of the gonosome in its various modifications among the HYDROIDA.

2. *The Adelocodonic Gonophore* (*Sporosac*).

FIG. 7.



Adelocodonic gonophore of *Hydractinia echinata.*

a, Spadix surrounded by the ova, the whole enveloped by the perigonium, which here consists of *b*, endotheca, and *c*, ectotheca, the mesotheca being absent; *d*, communication of the cavity of the spadix with that of the blastostyle.

The adelocodonic gonophore (woodcut, fig. 7) is a sac-like body, which presents the following parts:

1. An internal hollow process, the *spadix* (*a*), which occupies the axis, and whose cavity is in communication with the general somatic cavity of the hydrosome.

2. The generative elements, *ova* or *spermatozoa*, which are developed round the spadix.

3. A sac (*perigonium*) which surrounds the generative elements, and retains them in their place. This sac may be simple or its walls may present two or even three layers, in which last case it will consist of (1) an internal layer (*endotheca*), which lies immediately on the generative elements; (2) a middle layer (*mesotheca*); and (3) an external layer (*ectotheca*). The mesotheca, moreover, may have a system of canals developed in it.

Of the adelocodonic gonophore we have examples in such forms as the so-called generative sacs of *Clava, Hydractinia, Eudendrium,* &c.

3. *The Phanerocodonic Gonophore* (*Gonocheme. Sexual Medusa*).

The phanerocodonic gonophore (woodcuts, figs. 8 and 17) is bell-shaped, and in its most developed form presents the following parts:

1. A central tubular body, the *manubrium* (*a*), which carries a mouth (*i*) at one extremity.

2. The generative elements (*b*), which are developed between the inner and outer membranes (endoderm and ectoderm), which compose the walls of the manubrium.

3. A contractile bell, *umbrella* (fig. 8, *c*), from the summit of whose concavity the manubrium is suspended, and in whose walls is always developed a system of canals (*gastrovascular*), consisting of —1. A set of equidistant longitudinal canals (*d d*), mostly four in number, which radiate from the base of the manubrium, into which or into a special cavity (*atrium*, fig. 17) which often exists at its base—they open at their origin; and 2, of a circular canal (*e*) which surrounds the *codonostome*, or orifice of the bell, and receives the distal extremities of the radiating canals.

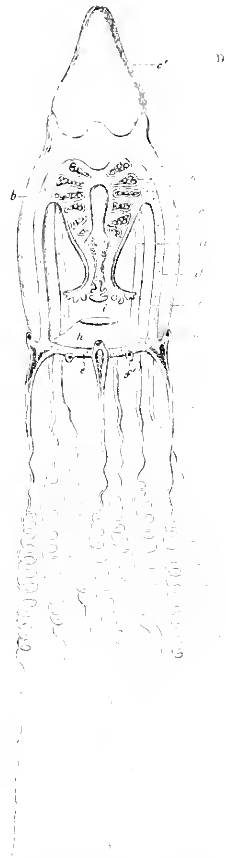
4. Contractile *tentacula* (*f*), which spring from the margin of the umbrella, and often carry at their bases definite accumulations of pigment-granules (fig. 8, *g*, and fig. 17, *e*) named *ocelli*.

5. A membranous extension, *velum* (*h*), of the margin of the umbrella over the codonostome where it forms a thin, muscular diaphragm, perforated in the centre by a circular opening of greater or less diameter.

The body composed of the various parts now enumerated constitutes one form of the so-called "gymnophthalmic medusa,"[1] and in its young state is usually invested by an external protective membrane, the *ectotheca*, the homologue of the external layer of the perigonium in the sporosac.

Of the form of medusa presented by the phanerocodonic gonophore we have examples in the types described by authors under the names of *Sarsia*, *Steenstrupia*, *Oceania*, &c.[2]

FIG. 8.



Oceania coronata, Allm. (provisionally), a medusa of unknown trophosome, as an example of a phanerocodonic gonophore.

a, Manubrium; *b*, generative elements (ova) developed between endoderm and ectoderm of manubrium; *c*, umbrella; *c'*, peculiar development of the solid tissue of the umbrella, which occurs in the present species; *dd*, radiating gastrovascular canals; *e*, circular gastrovascular canal; *f*, marginal tentacles; *f'*, rudimental marginal tentacles; *g*, ocellus; *i*, mouth surrounded by its four fimbriated lips.

4. *The Blastostyle.*

The blastostyle, as has been already said, must be regarded as a hydranth whose alimentary functions have become suppressed, and which, though not, properly speaking, sexual itself, is entirely destined for the production of sexual buds or gonophores, either directly or through the medium of a non-sexual bud, the blastocheme. A good idea of this form of zooid may be obtained from the so-called "fertile polypes" of *Hydractinia echinata* (Pl. XV, and woodcut, fig. 4, *b b*). These are bodies of a cylindrical shape, which are scattered among the alimentary hydranths, and which in all respects they resemble except in the

[1] Another form is presented by the blastocheme described below.

[2] The structure above described is that of the phanerocodonic gonophore in its most completely

fact that the tentacles are entirely suppressed, their place being taken by small clusters of thread-cells, and that the mouth, if not wholly obliterated, is reduced to a very minute perforation, which probably never subserves the function of ingestion. Near the distal extremity of these bodies the gonophores (*c*) are borne as a dense cluster of buds.

In the whole of the *Campanularian* and *Sertularian* hydroids the blastostyle, with its buds, is enclosed in an external chitinous capsule, the *gonangium* (woodcut, fig. 2, *f*), which is never present in the *Tubularinæ*. The gonangium is of very definite form for each species, and affords good characters for diagnosis.

Though it is necessary to distinguish the blastostyles from the hydranths, it cannot be overlooked that they may pass into them by certain transitions. Agassiz[1] describes a mouth in the blastostyles of the *Hydractinia polyclina* of the North American coast, but as the tentacles are entirely suppressed, it is doubtful whether the orifice which here exists can be regarded as destined for the ingestion of nutriment. In certain *Eudendria* the hydranths which carry the gonophores grouped round their base present a perfectly developed form while the gonophores are young; but as these continue to grow, the hydranths which carry them frequentiy become atrophied, losing their tentacles and mouth; and by the time the gonophores have attained to maturity the hydranths have assumed the condition of blastostyles. Again, among the *Sertularinæ* we find in *Halecium halecinum* (woodcut, fig. 29) the female blastostyle developing from its summit a pair of perfect hydranths with tentacles and mouth, and with their digestive cavity in communication with that of the blastostyle; but I know of no more instructive demonstration of the relation between blastostyle and hydranth than what is afforded by the female gonangium and its contents in *Sertularia rosacea*, *S. tamarisca*, and *S. fallax*. In these hydroids (woodcuts, fig. 23—26) the blastostyle develops from its summit a set of peculiarly formed tentacles, which, after becoming invested with a perisarc, continuous with the chitinous walls of the gonangium arch, over the summit of the gonangium, so as to form the walls of a special chamber, which constitutes a marsupial receptacle, in which the ova, after their discharge from the gonangium proper, may undergo further development. These, however, are all exceptional cases, and do not render less valid the association of the blastostyle with the gonosome rather than with the trophosome, while they are important as showing the homological identity between the hydranth and the blastostyle.

Notwithstanding the transitions which may be thus traced between the hydranth and the blastostyle, we must carefully avoid the confounding of a true blastostyle, whose characteristic form and suppression of nutritive function show themselves *before* the appearance of the generative buds, and those pseudo-blastostyles which are caused by the exhaustive action of the generative buds on an ordinary hydranth.

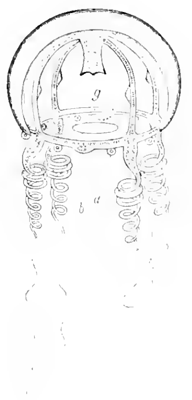
developed form. Such complete differentiation, however, is not always attained even in the HYDROIDA, while among the SIPHONOPHORA a hydrozoal group possessing the closest relations with the HYDROIDA, the margin of the gonocalyx or umbrella of the medusiform gonophore in the *Calycophoridæ* carries neither tentacles, ocelli, nor lithocysts, and the manubrium develops, at least usually, no mouth upon its extremity.

[1] Agassiz, 'Contrib. to the Nat. Hist. of the United States,' vol. iv, p. 230.

5. *The Blastocheme (non-sexual Medusa).*

It has been already stated that the blastocheme presents, like the phanerodoconic gonophore, the form of a completely developed gymnophthalmic medusa. It differs, however, from the gonophore, not only in never producing generative elements directly, and in being thus, properly

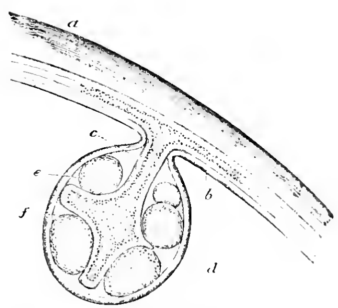
FIG. 9.



Medusa of *Campanularia Johnstoni*, shortly after liberation from the gonangium, illustrating the peculiarities of the blastocheme.

a, Lithocyst; *b*, incipient tentacle; *g*, incipient sporosac, formed as a bud upon the radiating canal.

FIG. 10.



Sexual zooid (sporosac budding from a radiating canal in the blastocheme of *Obelia geniculata*.

a, Portion of the umbrella, and *b*, radiating canal of the blastocheme; *c*, spadix of sporosac; *d*, perigonium consisting here of a single membrane; *e*, ovum with germinal vesicle and spot; *f*, ovum with numerous germinal spots in the germinal vesicle.

speaking, non-sexual, but also in certain points of structure; for it is almost universally characterised by the absence of ocelli, and by the presence of peculiar capsules called *lithocysts*, which are attached to the margin of the umbrella, and enclose one or more transparent refractile corpuscles.[1]

[1] An exceptional condition in this respect is presented by a few medusæ referable to the type of the blastocheme. *Thaumantias*, as limited by Gegenbaur, has ocelli instead of lithocysts, and the same is the case, according to Agassiz, in *Staurophora*, Brandt, and in *Laodicea*, Lesson; while in *Melicertum*, Oken, there are neither lithocysts nor ocelli.

In *Tiaropsis diademata*, Agas., a well-defined pigment spot has been described by Agassiz as existing in the base of the lythocyst, a statement which I can confirm by my own observations on a species of *Tiaropsis* captured in the Firth of Forth. As will be afterwards seen, however, I do not regard the pigment spot of *Tiaropsis* as representing a true ocellus. According to Strethill Wright, a medusa, which has been described by him under the name of *Goodsirea* ('Edin. N. Phil. Journ.,' July, 1859), is a true gonocheme, and yet it has lithocysts instead of ocelli. As to *Oceania octona*, Fleming, and *O. turrita*, Forbes—medusæ belonging to the type of the gonocheme—the statement of Forbes, that they have a lithocyst imbedded in the base of the tentacle, is founded on an error of interpretation

While it is itself non-sexual, the blastocheme always gives origin to special sexual buds, or gonophores, which are borne upon some part of the radiating canals.

As characteristic examples of the blastocheme, we may adduce the planoblasts of *Campanularia Johnstoni* (woodcuts, fig. 2, *g*, and fig. 9)—which are medusiform zooids referable to the deep-belled section of Gegenbaur's genus *Eucope*—and those of *Laomedea dichotoma* and *L. geniculata* (woodcut, fig. 10) of authors—medusæ referable to Peron's type of *Obelia*. In none of these are sexual elements ever directly developed, but instead of the direct formation of ova and spermatozoa, there is produced a new zooid, which no longer presents the complete medusal type, but is formed upon the plan of the adelocodonic gonophore. This zooid (woodcuts, fig. 9, *g*, and fig. 10) springs as a bud from the radiating canals of the medusa, and is constructed upon precisely the same plan as that which we meet with in the gonophore of *Clava* or *Hydractinia*, except that the perigonium would seem to be simple. It has an axile spadix (woodcut, fig. 10, *c*), whose cavity is in direct communication with that of the radiating canal (*b*) from which it springs. Immediately investing the spadix are the generative elements (*e*, *f*) ova or spermatozoa; while these are themselves surrounded and confined by a true perigonium (*d*), which becomes at last ruptured for the liberation of its contents.

The zooidal nature of these buds is nowhere more distinct than in the genus *Aglaura*, Pér., a form not yet traced to a polypoid trophosome. Here the generative elements are produced in eight sac-like processes which surround the base of the manubrium, which is itself borne on the extremity of a stalk dependent from the summit of the umbrella. These sacs are undoubtedly true buds, and are entirely homologous with the gonophores of *Clava;* and it is plain that they are developed from the proximal extremities of the radiating canals, just where these canals pass off from the manubrium in order to run along the sides of its stalk before reaching the umbrella.[1]

In some blastochemes the sexual bud extends over a greater length of the radiating canal, and presents, in consequence, a less defined and individualised appearance than in the instances just mentioned, so as to lead one at first to hesitate as to the propriety of regarding it as a true zooid. Such, for example, is its character in the medusæ referable to the types of *Thaumantias*, *Tima*, and *Melicerta*, in all of which, while the generative buds are situated as in *Obelia*, on the radiating canals, they occupy with their extended base so much of the canal as to be readily mistaken for mere organs—ovaries or spermaries. Notwithstanding this, however, they are constructed upon essentially the same plan as the others, and offer no exception to the view here taken.

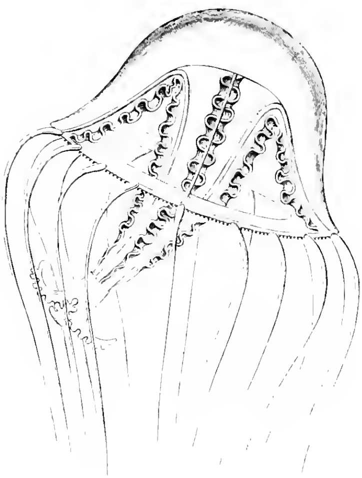
In *Tima*, indeed (woodcut, fig. 11), we have an extreme case of this extension of the base of the generative buds, which here present themselves in the form of four long, flattened, sinuous frill-like bands, each attached by one edge along the whole length of a radiating canal. When a section is made from the free to the attached edge of this band (woodcut, fig. 12), the generative elements

while the view of the structure of *Slabberia*, Forbes, which would make this medusa to be a blastocheme, having ocelli instead of lithocysts, is also, as will be shown below, based on an error. Though it is thus very rare to find a blastocheme without lithocysts, the absence of ocelli in the gonocheme is quite common.

[1] See Leuckart's description of *Aglaura Péronii* ('Wiegmann's Archiv,' 1856, Erster Band, S. 10). Leuckart recognises in the generative sacs of *Aglaura* the significance of true zooids, though he refrains from extending this view to the generative sacs of other medusæ.

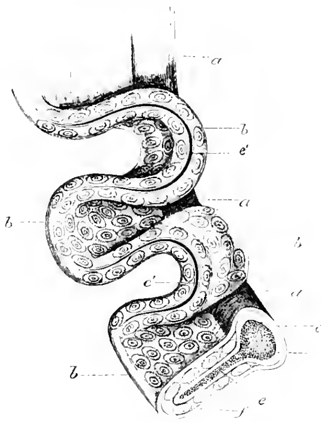
are seen to be disposed upon each side of a hollow longitudinal septum (*e*). This septum consists of a diverticulum of the endoderm of the radiating canal; it admits into its interior the fluid which circulates in the radiating canal, and is plainly homologous with a laterally extended and flattened spadix; while the generative elements are externally confined by an ectodermal covering, which is in the same way the homologue of the perigonium in an ordinary sporosac, but here flattened out like the spadix, in accordance with the ribbon-shaped form of the gonophore.

Fig. 11.



Medusa (*Tima Bairdii*), a blastocheme of unknown trophosome, showing the convoluted and ribbon-shaped sporosacs along the course of the radiating canals.

Fig. 12.



Portion of the ribbon-shaped sporosac, much enlarged in a female specimen of *Tima Bairdii*.
a, *a*, *a*, radiating canal; *b*, *b*, *b*, sporosac; *c*, ectoderm; *d*, endoderm; *e*, cavity of the spadix; *e'*, *e'*, distal edge of the spadix, seen through the ectodermal layer; *f*, ova.

The blastocheme is thus essentially a free non-sexual medusa, which, like the blastostyle, gives origin to sexual buds, but which, unlike the blastostyle, is endowed with the locomotive powers of a medusa, so that it carries those buds from place to place by the contractions of an umbrella.

In the account here given of the blastocheme, I have confined this term to such medusæ as develop distinct sexual buds upon the gastro-vascular canals. In some of those medusæ, however, in which the sexual elements are produced in the walls of the manubrium, we find the portions of the walls which give origin to the ova or spermatozoa more or less differentiated from the general walls of the manubrium, and presenting a lobulated appearance, which might easily lead to the belief that the manubrium emitted from its sides true sexual buds. I am not, however, prepared to place any of these cases in the same category with the blastocheme.

The condition alluded to is especially well marked in the medusa of *Cladonema* and of *Bougainvillia*, and in certain forms of *Oceania*, in the sense in which this group has been restricted by Forbes and Gegenbaur, and generally accepted by the German zoologists; and an opportunity of studying an undescribed medusa of this type (woodcut, fig. 8), which I obtained abundantly in the autumn of 1865, on the west coast of Scotland, has plainly shown that the generative lobes of the manubrium cannot be regarded as true zooids. The generative elements are here simply produced between the endoderm and ectoderm of the manubrium, and the lobes are nothing more than a puckered or sacculated condition of the walls in those parts where the ova or spermatozoa originate. I do not, however, deny the possibility of the manubrium as well as of the gastrovascular canals giving origin to true buds, to which the development of the sexual elements may be confined; when this has been shown to be the case, the medusa presenting it must take its place among the blastochemes.

Whether the medusæ referable to the type of *Geryonia* and its allied forms ought to be regarded as blastochemes is as yet uncertain, though my own opinion is in favour of so viewing them. The parts which in these medusæ give origin to the generative elements have been described as leaf-like expansions of the radiating canals. Haeckel's observations have led him to deny to them the significance of true zooids,[1] while he sees in them nothing more than mere lateral expansions of the canal, a portion of whose epithelium becomes here differentiated into ova or spermatozoa. This question as regards the *Geryonidæ* is, as we shall afterwards see, one of considerable importance. Having had no opportunity of examining for myself specimens of these medusæ, I can bring no direct personal observations to bear upon it; but the account given by Haeckel, who has so admirably worked out the structure and history of the *Geryonidæ*, does not appear, as I shall afterwards show, to necessitate the conclusion to which he arrives, or to be inconsistent with the zooidal nature of the reproductive pouches. Further observations, however, instituted for the express determination of this point will be needed before we can regard the question as thoroughly cleared up.

6. *Homological parallelism between Sporosac and Medusa.*

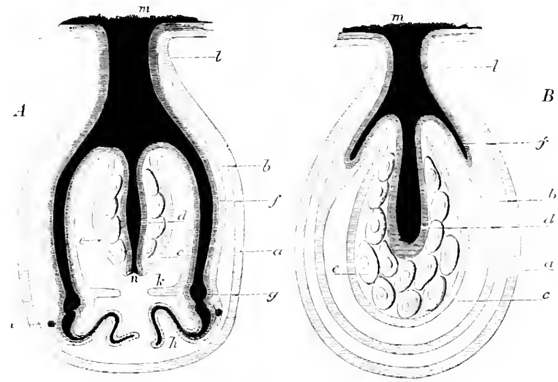
While it will be found very convenient to insist upon the differences pointed out above between the adelocodonic gonophore on the one hand, and the phanerocodonic gonophore and blastocheme on the other, it must not be supposed that these two forms are constructed upon plans widely different from one another. We find, on the contrary, that the most exact parallelism admits of being demonstrated between them; for though they may at first sight appear very different, it can nevertheless be shown that the closed generative sac of a *Clava* or a *Hydractinia* is an easily understood modification of a medusa.[2]

[1] Haeckel, 'Die Familie der Rüsselquellen,' Vorwort, viii.

[2] It is now many years since I endeavoured to demonstrate that the so-called "ovarian vesicles" of the *Tubularinæ*, and the fixed sacs contained within the gonangium of the *Sertularinæ* and *Campanularinæ*, are in all cases strictly homologous with the free medusa, that they possess a true medusal structure in a more or less degraded or disguised condition. ("On the Anatomy and Physiology of *Cordylophora*," 'Phil. Trans.,' June, 1853.)

In comparing the two classes of bodies with the view of determining their homological relations, their composition out of the two membranes ectoderm and endoderm must be carefully kept in mind.

Fig. 13.



Diagrammatic sections of phanerocodonic and adelocodonic gonophores.
A, Phanerocodonic, and B, adelocodonic gonophore.
a, Ectotheca; *b*, mesotheca or umbrella; *c*, endotheca, or ectodermal layer of manubrium; *d*, spadix, or axile tube of manubrium; *e*, ova; *f*, radiating gastrovascular canals; *g*, circular gastrovascular canal seen in transverse section; *h*, marginal tentacle; *i*, ocellus in bulbous base of tentacle; *k*, velum; *l*, peduncle of gonophore; *m*, general cavity of cœnosarc; *n*, mouth of medusa.
In both sections the endoderm is distinguished from the ectoderm by giving it a darker shade.

Commencing with the central parts of a hydroid medusa, and comparing these with the central parts of a sporosac, we shall find that in the medusa (woodcut, fig. 13, *A*) we have a manubrium in the form of a more or less elongated tubular body occupying its axis. The walls of the manubrium are composed of two layers, an internal or endodermal layer (*d*) and an external or ectodermal (*c*); and in all phanerocodonic gonophores or hydroid medusæ of the sexual type, these two layers become ultimately more or less separated from one another by the development of the generative elements (*e*) between them.

In the sporosac or adelocodonic gonophore also (*B*) we have a double-walled tubular body, between whose two walls the generative elements are developed exactly as in the medusa; but while in the medusa this body is in almost every case perforated by a terminal mouth, in the sporosac it is completely closed, so that it assumes, by the increasing volume of the generative elements, the appearance of a sac, filled with ova or spermatozoa, and having a cæcal diverticulum (spadix) plunged into the middle of the mass. This cæcal diverticulum (*d*) is plainly the equivalent of the endodermal portion of the manubrium in the medusa, while the wall (perigonium) of the sac represents more or less completely the structures which in the medusa lie external to the generative elements.

When the perigonium presents its highest degree of development it consists as we have already seen of three layers. Of these the inner (*c*) (endotheca) is the equivalent of the ectodermal layer of the manubrium in the medusa; the middle layer (*b*) (mesotheca) corresponds to the umbrella, and like it may have a system of canals (*f*) more or less completely developed in it, and may even present a rudimental codonostome, while the most external layer (*a*) (ectotheca) corresponds to a similar external layer frequently present in the young medusa bud.

It would seem that in no case is a velum or its homologue developed in the adelocodonic gonophore, even though the representative of the umbrella should possess as in *Tubularia* a rudimental codonostome, while the marginal tentacles of the medusa are, except in the "meconidium" (see below, p. 57), also without their representative in this form of gonophore; for the tentacula-like tubercles which crown the summit of the sporosac of some of the *Tubularidæ* (*Tubularia larynx*, for instance, Pl. XXI) are of an entirely different significance, being merely processes of the ectotheca.

7. *Homological parallelism between Hydranth and Medusa.*

While we have been thus enabled to trace a close parallelism between the medusa and the sporosac, another comparison of great interest in this inquiry suggests itself, that, namely, between the medusa and the hydranth. Now there can be little difficulty in finding in the distal portion of the hydranth the homologue of the manubrium of the medusa;[1] but the equivalents of the umbrella and gastrovascular canals of the medusa are not at first sight so obvious. I believe, nevertheless, that these are not totally unrepresented in the hydranth. It will be kept in mind that the tentacula of the hydranth are merely tubular radiating prolongations of the digestive cavity, though with the cavity of the tube usually more or less obliterated by the peculiar condition of the endoderm, and that for some distance from their origin they are necessarily included in the thickness of the body-walls of the hydranth, where they consist merely of radiating canals extending through these walls and lined by a layer of endoderm. Now this included portion I regard as the true representative of the radiating canals of the medusa; and if we were to imagine the ectoderm of the hydranth in a *Eudendrium* or *Campanularia* to acquire unusual thickness in a zone corresponding in position to the roots of the tentacles, we should have a disc-like extension of the

[1] Huxley ('Oceanic Hydrozoa') strongly insists on this relation, and is so impressed with the closeness of the homology between manubrium and hydranth, that he uses the same term, "polypite," for both.

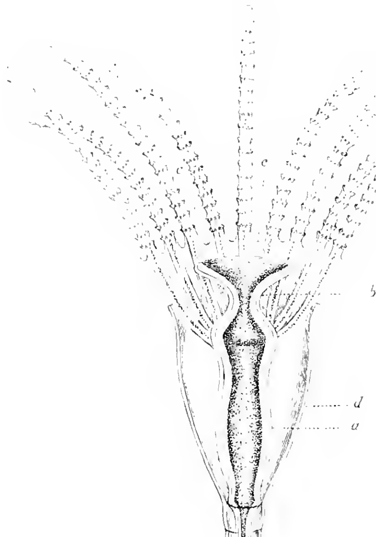
Agassiz (op. cit., vol. iv, p. 226) has witnessed the very simple adelocodonic gonophore in male specimens of his *Rhizogeton fusiformis*, instead of withering away after the discharge of its contents, elongate itself, develop tentacles, and become transformed into a hydranth. I have myself, on one occasion, seen an analogous phenomenon in the female gonophore of *Cordylophora lacustris*, in which, after the discharge of the ova, the spadix had become elongated through the ruptured chitinous investment of the original gonophore, had developed an ectoderm, thrown out tentacles from its summit, and become metamorphosed into an ordinary hydranth. In the case of *Cordylophora* the transformation is confined to the spadix, while, according to Agassiz, the entire gonophore of *Rhizogeton* takes part in the metamorphosis.

I believe that in both cases the phenomenon is an abnormal one; it certainly is so in *Cordylophora*, for, in the ordinary conditions to which this hydroid is exposed, no metamorphosis of the kind takes place.

ectoderm traversed in a radiating direction by tubular extensions of the endoderm which lines the body-cavity of the hydranth, and this disc would only need to become still further expanded in order to show itself as an unmistakable umbrella, with radiating gastrovascular canals, while the hypostome or proboscidiform extension of the body, which in these genera advances far in front of the base of the tentacles, would resemble in all essential points the manubrium of the medusa.

Now, the commencement of such an expansion is evident in the hydranth of many *Campanularidæ*, while in certain species, as *Laomedea flexuosa* and *Campanulina acuminata*, the ectoderm of the body is actually extended as a thin disc for a considerable distance in the plane of the tentacles, which acquire in consequence the appearance of being connected at their bases by an intervening web (woodcut, fig. 14).

FIG. 14.



Longitudinal section through the hydranth and hydrotheca of *Laomedea flexuosa*, showing the web-like membrane by which the bases of the tentacles are connected to one another.

a, Body of hydranth; *b*, hypostome, carrying the mouth on its summit; *c*, *c*, intertentacular web; *d*, hydrotheca.

While the portion of the tentacles included in the thickness of the body-wall of the hydranth will thus be the equivalent of the radiating canals of the medusa, their free portion is plainly homologous with the free tentacles, which in the medusa hang from the margin of the umbrella at the points corresponding to the entrance of the radiating into the circular canal, and which must be regarded as strictly the continuation of the radiating canals beyond their apparent termination in the circular canal. The tentacles, which in many medusæ spring from the intervening spaces upon the margin of the umbrella, and are therefore not directly continuous with the radiating canals, make their appearance probably in all cases later than the others, and are frequently less developed. These inter-radial tentacles must be placed in the same category with the lithocysts as simple marginal appendages, to be carefully distinguished from the primary tentacles, and, like the lithocysts, have no representative in the hydranth.

It cannot be urged, as an argument against this view, that the circular canal of the medusa is not represented in the hydranth; for the absence of a developed umbrella in the hydranth necessarily brings with it the absence of this canal; and it is for the same reason that velum, lithocysts, and secondary tentacles, are also absent. Neither can it be said that those cases in which the tentacles of the hydranth are not arranged in a single verticil, but are repeated regularly or irregularly in different planes upon the body, are inconsistent with the homological relations here insisted on; for such cases can be regarded only as special modifications of the more typical plan which has directly suggested our comparison.

Huxley, believing the difference in structure and development between the locomotive disc of the gymnophthalmic and that of the steganophthalmic medusæ to be so great as to place them in different categories, would confine the term "umbrella" to the disc of the *steganophthalmata*, and would designate that of the *gymnophthalmata* by the terms "nectocalyx" and "gonocalyx." I was at first disposed to adopt the same view; but an investigation of the mode in which this part makes its appearance in the gymnophthalmic forms has convinced me that the development is essentially the same in both cases, and that, notwithstanding some marked structural differences, there is sufficient unity between the two to render it more convenient to speak of them under the same term as strictly homologous organs. In both cases they are formed by an outgrowth of the walls of the polypoid manubrium, and the fact that the steganophthalmic medusa is produced by successive transverse divisions of a "scyphostoma," while the gymnophthalmic medusa is formed as a lateral bud from a hydrosome, is no valid argument against this approximation; for every segment of the "scyphostoma" is strictly comparable to the bud of the hydroid, and developes its umbrella by an outgrowth from its sides in quite the same way.

A very instructive example, which strikingly bears out the comparison I have here attempted to make between the hydranth and the medusa, is afforded by the remarkable locomotive zooid which forms the gonophore of *Dicoryne*. This little zooid (woodcut, fig. 6) is essentially a free medusa, reduced to the condition of an ova-bearing or spermatozoa-bearing manubrium, from whose base two free tentacula in form and relations like those of a hydranth are developed. Now, there is here no umbrella, locomotion being affected by the action of cilia; but it is evident that we have only to imagine the ectoderm of the manubrium projected as a disc, in the way already supposed, in the horizontal plane passing through the base of the two tentacles so as to include the basal portion of these tentacles in its thickness, in order to have an umbrella with two radiating canals added to the manubrium.

But development, as we shall afterwards see, entirely coincides with anatomy in pointing to the same conclusion; and it is only necessary to trace the formation of the umbrella and radiating canals in the budding medusa, in order to become convinced that their origin is essentially that here insisted on); while the interesting observations of Johannes Müller on the development of *Æginopsis*, and of M'Crady on that of *Cunina*—observations which will be specially referred to below—show that in these genera the umbrella grows out as a horizontal disc from the walls of a free polypoid manubrium, which bears a close resemblance to the generative zooid of *Dicoryne*. It would appear, however, from the observations of Fritz Müller,[1] and of Haeckel,[2] that in certain geryonidan medusæ the umbrella is formed by the excavation of a solid spherical embryo; but it must be noted that neither of these observers had seen their embryo medusæ at a period anterior to the commencement of the developing umbrella.

The parallelism which I have thus endeavoured to demonstrate may be expressed in the following scheme:

Phanerocodonic Gonophore and Blastocheme. (Medusa.)	Adelocodonic Gonophore. (Sporosac.)	Hydranth.
Ectotheca	Ectotheca . . .	0
Umbrella	Mesotheca . . .	Web-like membrane uniting the bases of the tentacles in *Laomedea flexuosa*, &c.
Gastrovascular canals	Canals of Mesotheca .	Base of tentacles extending through the thickness of the body walls, and through the web-like membrane.
Ectoderm of manubrium	Endotheca . .	Ectoderm of hypostome.
Endoderm of manubrium	Walls of spadix . .	Endoderm of hypostome.
Manubrium	Spadix + endotheca .	Hypostome.
Primary or radial marginal tentacula .	Primary tentacula in the meconidium.	Free portion of tentacula.
Secondary or interradial marginal tentacula.	Secondary tentacula in the meconidium.	0
Ocelli and lithocysts	0	0
Velum	0	0
Generative elements in gonocheme . .	Generative elements .	0

8. *Further modifications of the Gonosome.*

Besides the great leading differences already described, many others of a more subordinate kind are met with. The adelocodonic gonophore in particular exhibits many special modifications, and presents us with a regular series of gradations in complexity, which throw much light on its morphology.

The simplest form is probably that which we meet with in the female gonophores of the freshwater *Hydra*. Here there would seem to be no differentiation of an ectotheca, while the

[1] 'Wiegm. Archiv,' 1859, p. 310.

[2] 'Die Familie der Russelquallen (Geryonidæ),' 1866.

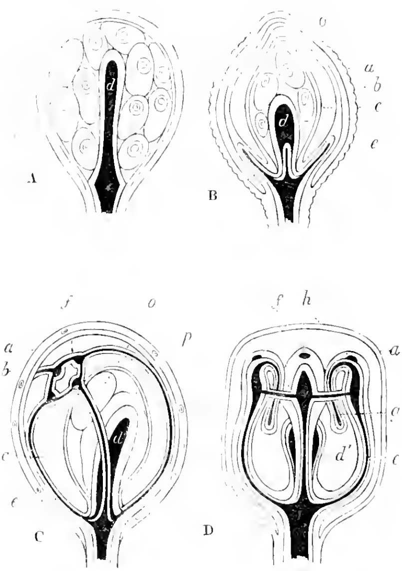
spadix itself remains in a rudimental condition, being scarcely elevated above the base of the gonophore, whose whole cavity becomes at an early period occupied by the ovarian mass.

An advance over this condition is seen in the sexual bud which is borne by that form of medusa described above, under the name of "blastocheme." Here we have the ultimate sexual bud quite destitute of ectotheca, and reduced to the condition of spadix and endotheca separated from one another by the intervening generative elements (fig. 10, p. 35).

In *Clava*, *Hydractinia*, &c., we have a still further advance in complexity. The gonophore has here the form of a simple closed sac, whose axis is occupied by a cylindrical or club-shaped spadix, round which the generative elements are clustered (woodcut, fig. 15, *A*). Careful examination, however, will show that the walls of the sac consist of two membranes, an outer or ectotheca and an inner or endotheca. The mesotheca is entirely absent.

In *Garveia nutans*, I have found a mesotheca to be distinctly demonstrable; but it is closed at the summit, and destitute of circular canal, while four short radiating canals may be seen in its walls extending from the base of the spadix for about a third of the height of the sac (woodcut, fig. 15, *B*).

FIG. 15.



Types of Gonophores.

A, *Hydractinia echinata*. B, *Garveia nutans*. C, *Tubularia indivisa*. D, *Syncoryne eximia*.
a, ectotheca; *b*, mesotheca; *c*, endotheca; *d*, spadix; *d'*, manubrium; *e*, radiating gastrovascular canals; *f*, circular gastrovascular canal; *g*, marginal tentacles; *h*, ocelli; *o*, ova; *p*, ovarian plasma in *Tubularia*.

In *Tubularia indivisa* the mesotheca presents the highest degree of development which it attains in any adelocodonic gonophore, if we except the peculiar body described below under the name of "meconidium." It is perforated at its summit, and the perforation is surrounded by a distinct circular canal, which receives four radiating canals, which open into it by small bulbous expanions (woodcut, fig. 15, *C*). We thus find almost entirely the conditions of a medusa —a medusa, however, which never divests itself of its ectotheca, and accordingly never becomes free, while the spadix remains as a simple cæcal diverticulum, and the codonostome is reduced to a mere perforation of the mesotheca, this last exhibiting but the faintest traces of contractility, and being quite incapable of acting as a locomotive umbrella.

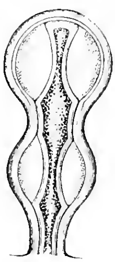
From the sporosac of *Tubularia indivisa* it is thus but a single step to the true phanerocodonic gonophore, such as we find in *Corymorpha nutans*, or *Syncoryne eximia*, where the mesotheca assumes the condition of a contractile locomotive umbrella, with a well-developed codonostome and velum, and, the manubrium now becoming perforated by a mouth, the gonophore is no longer dependent on the trophosome for its nutrition, but can become free and lead an independent life in the open sea (woodcut, fig. 15, *D*).

The typical and ordinary condition of the spadix is that of a hollow cylindrical or clavate body, occupying the axis of the adelocodonic gonophore. Occasionally, however, it departs from this condition and becomes more or less branched, as in *Cordylophora lacustris* (Pl. III), *Plumularia pinnata*, *Laomedea calicu1ata*, &c.

The gastrovascular canals in the adelocodonic gonophore may, as we have already seen, be either entirely suppressed or present the condition of simple, short, blind tubes, radiating from the base of the gonophore, or be continued from this point as fully developed radiating canals to the distal extremity of the gonophore, where they become united by a circular canal. In certain free medusæ (*Willia*, *Cladonema*—Pl. XVII) the radiating canals subdivide before reaching the circular canal.

The usual condition of the adelocodonic gonophore is that of a simple, more or less spherical or oval sac. In *Eudendrium*, however, the male gonophores present the form of a simple sac only at first; for by the time that their contents have approached maturity, new spermatogenous tissue becomes apparent between the endoderm and ectoderm of their supporting peduncles, and these two membranes thus become separated from one another so as to form a second sac immediately below the first, while a third may in the same way be formed below the second, the gonophore thus acquiring the peculiar moniliform or polythalamic conformation characteristic of this genus (woodcut, fig. 16). It will be at once apparent that the separate chambers presented by this peculiar form must not be regarded as so many distinct gonophores; the whole moniliform series ought rather to be viewed as a simple adelocodonic gonophore, in which the perigonium is not uniformly separated from the spadix by the intervention of the spermatogenous tissue, but remains at intervals permanently adherent to it. Among the planoblasts an entirely analogous phenomenon occurs in a *Sarsia*-like medusa of unknown trophosome, which I captured in the towing-net on the south-west coast of Ireland (woodcut, fig. 17). In this the manubrium, which is extraordinarily extensile, and can be projected to a great length beyond the umbrella, was enlarged at distinct intervals by the development of the generative elements between its ectoderm and endoderm. The specimen captured was a male, and the manubrium, when extended, presented, by the mode in which the spermatogenous tissue was developed in its walls, five elongated cylindrical enlargements, separated from one another by long thin intervening portions, in which the ectoderm and endoderm of the manubrium continued in direct contact with one another, no generative elements being there developed. The spermatogenous mass which occupied the free end of the manubrium was divided into two by a shallow strangulation. The peculiar mode in which the generative elements are developed in the manubrium of *Dipurena*, a nearly allied genus described by M'Crady,[1] would seem to afford an example of an analogous phenomenon.

FIG. 16.



Male gonophore of *Eudendrium*, showing the development of the spermatogenous tissue at intervals between the ectoderm and endoderm.

FIG. 17.

Medusa (*Sarsia strangulata*, Allm., provisionally) of unknown trophosome.

a, very extensile manubrium opening at its proximal end into a special cavity, the atrium; *b*, *b*, *b*, male elements developed at intervals between the ectoderm and endoderm of the manubrium; *c*, ocellus.

The gonophore may be borne upon a distinct peduncle, which may be simple (*Syncoryne eximia*, &c.) or branched (*Tubularia indivisa*, *Corymorpha nutans*, &c.), each branch then bearing a gonophore on its summit; or the peduncle may be obsolete, and the gonophore become sessile (*Laomedea flexuosa*, &c.)

The gonophores, whether phanerocodonic or adelocodonic, may be destitute of any further

[1] M'Crady, op. cit., p. 135.

covering, and will then, while still forming part of the hydrosoma, have their surface in immediate contact with the surrounding water (*Syncoryne*, *Clava*, *Hydractinia*, &c.)

In other cases the blastostyle, with the gonophores which bud from it, may be surrounded by a close case or capsule, formed by a layer of ectoderm with an external chitinous investment (*Campanularia* and *Sertularia*) (woodcut, fig. 2, *f*). I have elsewhere designated this capsule by the name of "*gonangium*."[1] The blastostyle extends through the axis of the gonangium as a cylindrical column, bearing the gonophores as buds upon its sides, and generally expanded at its summit into a conical plug or disc, by which the gonangium is here closed.

In some cases the contents of the gonangium escape, when mature, by the simple rupture of the summit (*Plumularia*, &c.). In others, however, the summit is separated as a distinct lid, which is then either cast off at once (*Sertularia pumila*, &c.), or it remains movably attached by one spot of its edge, as by a hinge, to the margin of the aperture thus formed in the summit of the gonangium (*Sertularia operculata*, *Antennularia antennina*).

In every instance where a gonangium exists the hydranths also are protected by a hydrotheca, while the absence of a gonangium is always associated with the absence of a hydrotheca. The difference thus involved in the presence or absence of these parts corresponds to two primary sections of the HYDROIDA, and I have distinguished all hydroids which possess a gonangium and hydrotheca by the name of CALYPTOBLASTIC, while the GYMNOBLASTIC hydroids are those which—with the exception of the freshwater Hydras which constitute a separate section—are destitute of these protective coverings.

In by far the greater number of cases the blastostyle in the calyptoblastic genera carries numerous buds, which are either sporosacs or blastochemes, and which always increase in maturity as they recede from the base and approach the summit of the gonangium (woodcuts, fig. 2, *f*, and figs. 18 and 19). In some cases, however, the blastostyle bears but a single bud; and then it often happens that this enlarges to such an extent as to fill nearly the entire cavity of the gonangium, the blastostyle being pushed aside out of the axis, and becoming often partially absorbed, so as to render it difficult to demonstrate its existence[2] (woodcut, fig. 3, *k*).

It usually happens that a fleshy membrane abounding in thread-cells may be seen passing over the whole of the generative buds while still attached to the blastostyle within the gonangium (woodcuts, figs. 18, *d* and 19, *d*). It closely confines them as in a common sac, and is probably an internal layer which has separated from the original formative ectoderm on whose outer surface the gonangium had been excreted. It performs an important office in the economy of the hydroid by confirming the generative buds and guiding them or their contents towards the orifice of the gonangium. I shall refer to it under the name of *gubernaculum*.

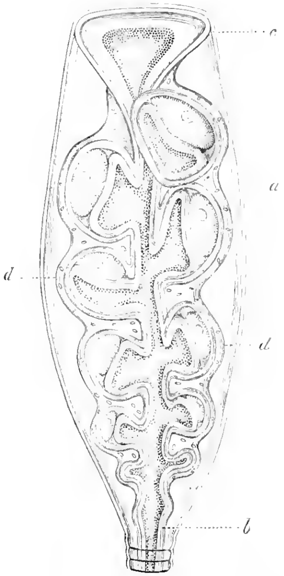
Sometimes the blastostyle, though in the very young state quite simple, soon breaks up, from a common point near the base, into several distinct tubes, which again unite in the

[1] "On the Structure and Terminology of the Reproductive System in the Corynidæ and Sertulariadæ," 'Ann. Nat. Hist.,' July, 1860.

[2] The difference presented by the gonangia, according as they contain numerous gonophores or only a single one, is regarded by Gegenbaur ('Generationswechsel,' p. 38) as of sufficient importance to induce him to distinguish the gonangia into "polymeric" and "monomeric." I am not disposed however, to give much weight to this difference, the number of gonophores which a gonangium may contain varying with particular conditions of development.

common cavity of the plug-like summit. This has been shown by Agassiz to be the case in his *Laomedea* (*Clytia*) *poterium*, and I have myself seen it in a nearly allied species from the east

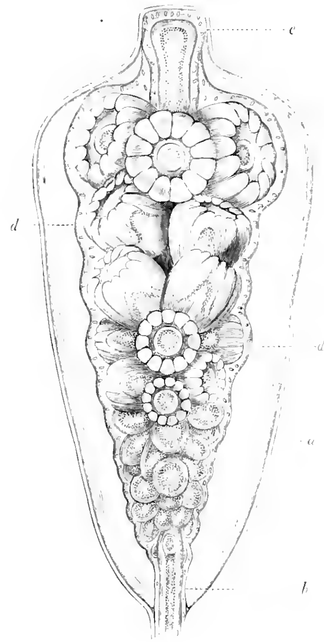
FIG. 18.



Gonangium, with its contents from *Laomedea flexuosa*.

a, Gonangium; *b*, blastostyle, carrying gonosacs, which increase in maturing from below upwards; each containing a single ovum in which the germinal vesicle and germinal spot are conspicuous; *c*, opercular summit of blastostyle; *d*, common investing membrane of the contents of the gonangium.

FIG. 19.



Gonangium, with its contents, from *Obelia geniculata*.

a, Gonangium; *b*, blastostyle loaded with medusæ (blastochemes), which increase in maturing from below upwards; *c*, opercular summit of blastostyle; *d*, *d*, common membrane, investing and confining the medusæ.

coast of Scotland (woodcut, fig. 20). It is entirely analogous to the breaking up of the cœnosarc which will be described below as occurring in the stem of *Antennularia*.

In most cases the gonophore discharges its generative elements directly into the surrounding water. In the females of some calyptoblastic species, however, the ova, instead of escaping directly from the gonophore into the water or the cavity of the gonangium, are retained for some time in a peculiar receptacle, where they undergo further development, and which is supported upon the summit of the gonangium, and lies entirely external to its cavity (woodcuts, figs. 3, *n*, 21 and 22). It will be found convenient to employ a special term for this receptacle, which confers upon the gonosomes in which it occurs a very characteristic feature. I have already designated it by the name of "*acrocyst*.[1]" It may be seen in *Sertularia pumila*, *S. cupressina*, *S. polyzonias*, *Calycella syringa*, *Calycella lacerata*, &c., and would seem to be in every instance confined to the female.

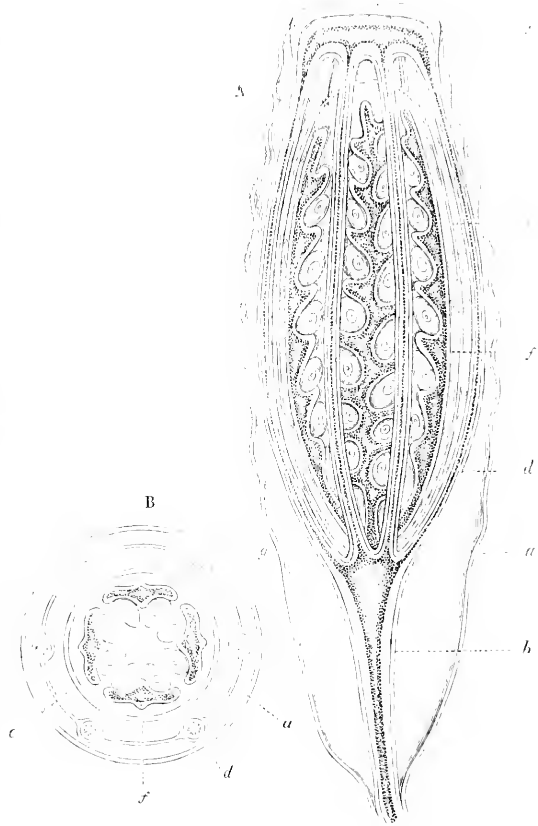
[1] 'Proc. Roy. Soc. Edin.,' 1858.

There is some difficulty in determining the exact morphology of the acrocyst. In its usual form it seems to consist of a simple extension of the endotheca of the gonophore, protruded as a hernia-like sac through the summit of the gonangium, when the whole becomes surrounded by a thick gelatinous-looking envelope, which is excreted from the outer surface of the sac, and which shows no appearance of true structure, though distinct zones of deposition may occasionally be observed in it.

In *Calycella lacerata* the spadix itself, as was first shown by Dr. S. Wright, is, with the surrounding endotheca and ova, carried upwards upon the blastostyle, by whose elongation these various parts are protruded from the summit of the gonangium, and the endotheca thus becomes a true acrocyst and excretes from its outer side the usual thick gelatinous investment (woodcut, fig. 22). The peculiarity of the acrocyst in this case is found in the presence within it of the spadix, which, however, is depressed by the enlarging ova, and forced back into the bottom of the sac.

In the interior of the acrocyst the ova pass through certain stages of their development, and ultimately escape as free ciliated embryos by the rupture of its walls.

Fig. 20.



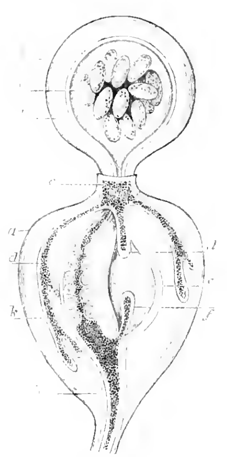
Gonangium, with its contents, from *Laomedea repens*, Allm., showing the compound blastostyle.

A, General view; B, plan of transverse section. *a*, gonangium; *b*, lower portion of blastostyle continuing simple; *c*, opercular summit of blastostyle; *d*, separate tubular branches into which the blastostyle has become divided; *e*, the endotheca, *f*, ramifications of spadix; *g*, an ectodermal membrane, connecting the divisions of the blastostyle with one another.

From the observations of Strethill Wright it would appear that in *Wrightia* (*Atractylis*) *arenosa*, a gymnoblastic species, the ova escape, by the rupture of the sporosac, into a gelatinous mass which is a secretion from the outer surface of the summit of the sporosac, to which it remains adherent, and that in this gelatinous nidus they become converted into planulæ, and then escape into the surrounding water. It is plain, however, that the simple gelatinous secretion which thus affords a protective nidus for the developing ova cannot be confounded with a true acrocyst, which is found only in the calyptoblastic hydroids.

In the cases above described the acrocyst is destitute of any further covering, and has its walls with their gelatinous investment freely exposed to the surrounding water. In *Sertularia rosacea*, *S. fallax* and *S. tamarisca*, however, an additional covering is provided for the acrocyst, and there is thus formed a curious and complicated receptacle, in which the ova, as in a sort of

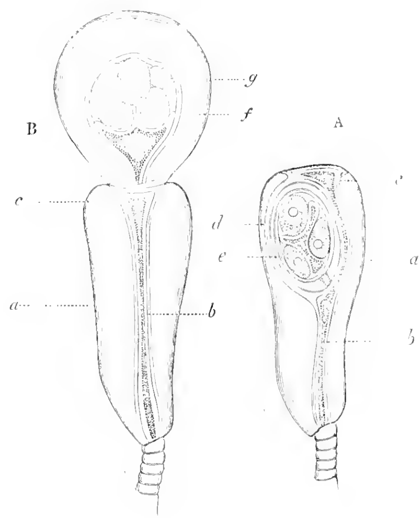
FIG. 21.



Female gonangium, with acrocyst of *Sertularia pumila*.

a, gonangium; *b*, blastostyle; *c*, opercular summit of blastostyle; *d d*, cæcal offsets from the summit of the blastotyle; *e*, gonophore after having discharged its contents into the acrocyst; *f*, spadix; *g*, proper sac of acrocyst; *h*, external gelatinous investment of acrocyst; *i*, ova contained in acrocyst; *k*, young ova in blastostyle.

FIG. 22.



Female gonangium with acrocyst of *Calycella lacerata*.

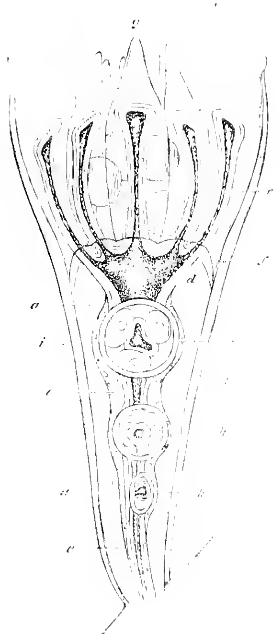
A, Young gonangium, with its contents before the formation of the acrocyst. B, older gonangium, bearing an acrocyst.

a, gonangium; *b*, blastostyle; *c*, opercular summit of blastostyle; *d*, membrane passing over the gonosac while still confined within the gonangium; *e*, gonosac still within the gonangium, and containing ova which surround a lobed spadix; *f*, proper membrane of acrocyst; its gelatinous investment. Within the acrocyst are seen ova already somewhat advanced in development, and the spadix depressed towards the bottom of the sac by their enlargement.

marsupium, pass through certain early stages of their development, previously to being discharged into the surrounding water.

The nature and morphology of this receptacle in *Sertularia rosacea* (woodcut, fig. 23) will be best understood by tracing its development. The young female gonangium (woodcut, fig. 25) is a conical body, with eight slightly projecting longitudinal ridges, and with the broad end of the cone constituting the distal end or summit of the gonangium. A blastostyle occupies its axis, having upon its sides, one over the other, the young budding gonophores, and expanding at its summit into a broad thick disc, which closes, as with a plug, the free end of the gonangium. Upon the outer side of this disc a thin chitinous investment is excreted, becoming continuous at

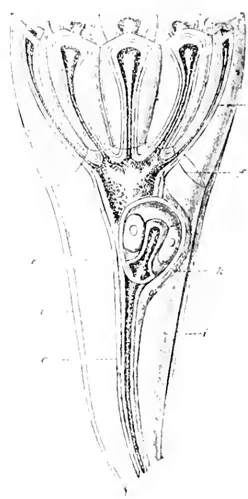
Fig. 23.



Mature female gonangium with marsupial chamber in *Sertularia rosacea*.

a, *a*, Cavity of the proper gonangium; *c*, *c*, blastostyle; *d*, opercular summit of blastostyle; *e*, one of the eye's radiating arms which are given off from the summit of the blastostyle, marked by a chitinous sheath *f*, which is prolonged from the walls of the gonangium; the arms are seen surrounding the marsupial chamber, which contains ova advancing towards the condition of planulæ; *g*, the six shorter spines which crown the marsupium; *h*, the two longer lateral spines; *i*, *i*, the two lateral ridges of the gonangium, which are continued into the longer spines; *k*, *k*, *k*, gonophores in various stages of development, all surrounded by the gubernacular membrane.

Fig. 24.



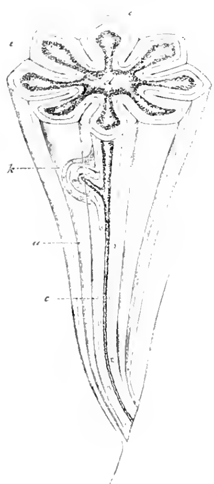
Young female gonangium of *Sertularia rosacea*, showing the formation of the marsupial chamber.

a, Cavity of the proper gonangium; *c*, blastostyle; *e*, radiating arms prolonged from the opercular summit of the blastostyle; *f*, chitinous sheath of arms; *i*, *i*, lateral ridge of gonangium; *k*, gonophore surrounded by its gubernacular membrane.

the edge of the disc with the chitinous walls of the gonangium, while in the centre of the disc the chitinous investment is deficient, leaving here the summit of the blastostyle naked.

The edge of the disc soon becomes produced into eight thick symmetrically radiating lobes (*e*, *e*) which gradually elongate themselves, carrying with them a continuation of the chitinous excretion which forms a wide tube around each; and now bending upwards, in the form of eight arms with enlarged extremities, they remind one of the disposition of the petals in a flower and present altogether an appearance of great elegance (woodcut, fig. 24, *e*). These eight radiating arms are composed of ectoderm and endoderm, and have their axis occupied by a tubular cavity, which communicates with that of the blastostyle. As the arms continue to elongate, we find them next with their free extremities bending towards one another, until finally (woodcut, fig. 23), they completely enclose a space, which becomes entirely shut in by the lateral coalescence of the wide chitinous tubes with which the radiating processes are each invested.

FIG. 25.



Very young female gonangium of *Sertularia rosacea*.

a, Cavity of the gonangium; *c*, blastostyle; *d*, opercular summit of blastostyle; *e*, radiating lobes from summit of blastostyle, about to be prolonged into arms; *k*, young gonophore.

In the mean time the eight longitudinal ribs of the gonangium continue themselves upon the radiating arms, and ultimately extend beyond their extremities as free pointed processes (*g*, *h*). Two of them, however, situated opposite to one another, greatly surpass the others in size, and mainly contribute to the peculiar and characteristic form of the gonangium. Into the marsupial chamber thus formed the ova make their way, enclosed apparently in a proper acrocyst.

A very similar condition is presented by *Sertularia fallax*. Here, however, the summit of the blastostyle is prolonged into four instead of eight lobes; but the subsequent history of these is in all essential points the same as in *Sertularia rosacea*.

If we compare the structures now described with an ordinary hyrandth, we shall have no difficulty in recognising an exact parallelism; for the tubular processes which are developed from the summit of the blastostyle may be regarded as homologous with the tentacles of a hydranth. They have, however, undergone a special modification, by which they become subservient to an entirely different function from that of the tentacles of the hydranth; for, no mouth being developed on the blastostyle, they are no longer prehensile organs administering to the alimentation of the colony, but, like the blastostyle itself, have assigned to them functions appertaining to reproduction rather than nutrition, and are destined to circumscribe a cavity for the retention and development of the ova.

The ova would seem to continue in the marsupial cavity until they have acquired the condition of ciliated embryos.

The modification of marsupial receptacle which occurs in *Sertularia tamarisca* is also very interesting. The female gonangia (woodcut, fig. 26 B) are here of an oval form for about the proximal half of their length, and then become trihedral, with the sides diverging upwards, while the whole is terminated by a three-sided pyramid. The sides of the pyramid are cut into two or three short teeth along their edges, and each of their basal angles is prolonged into a short spine.

The trihedral portion, with its pyramidal summit, is formed of three leaflets (*g*, *g′*, *g″*) which merely touch one another by their edges, without adhering, so that they may be easily pushed aside from one another by the dissecting needle, or by the embryo during its escape.

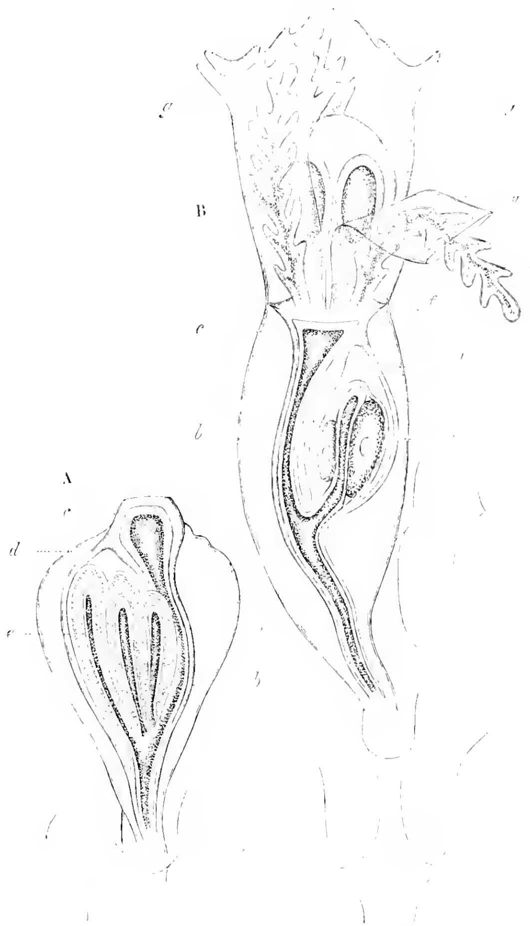
On laying open the gonangium the oval or proximal portion of it is seen to be occupied by a blastostyle (*b*), which gives origin to one or more gonophores. It terminates upwards by closing round the distal extremity of the blastostyle, where it forms a ring (*f*) with tooth-like processes, by which the extremity of the blastostyle is encircled. This oval portion constitutes the gonangium proper, and is the only part developed in the male (fig. 26 A).

From the summit of the blastostyle three tentacula-like processes (*h*) are given off. They constitute ramified cæcal offsets of the cavity of the blastostyle, and are composed of an ectodermal and an endodermal layer. Immediately after their origin from the blastostyle they enter the terminal leaflets, and now lie between the two laminæ of which these leaflets are composed.

The leaflets, with their contained cæcal offsets from the blastostyle, surround a membranous sac (*i*) which is borne on the summit of the oval portion, or proper gonangium, and contains one or two ova, which are usually in an advanced stage of development. Each ovum is immediately invested by a delicate structureless sac (*k*), which is continued by a neck-like prolongation to the summit of the blastostyle.[1]

The homological relations

Fig. 26.



Male and female gonangia of *Sertularia tamarisca*.

A, Male gonangium; B, female, with its marsupial chamber.

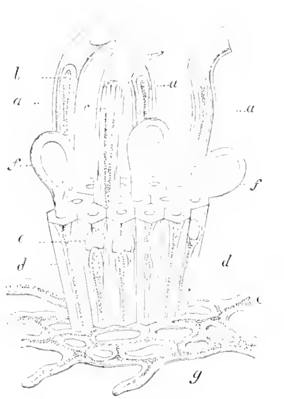
a, Proper gonangium, *b*, blastostyle with *c*, its opercular summit; *d*, gubernaculum; *e*, gonophores, having the spadix surrounded by the spermatozoa in the male and by the ova in the female; *f*, chitinous roof of the gonangium proper in the female, perforated by a central denticulated aperture; *g*, *g'*, *g''*, the three leaflets, forming the walls of the marsupial chamber, and each containing within it a ramified cæcal process, *h*, from the summit of the blastostyle; *g'* is cut across and depressed; *i*, acrocystal sac; *k*, ovum, included in a special sac.

[1] The account here given of the marsupial receptacle of *Sertularia tamarisca* differs in some

between the marsupial receptacles of *Sertularia rosacea* and *Sertularia fallax* on the one hand, and *Sertularia tamarisca* on the other, are at once apparent, and are very interesting. The ramified tubes of *S. tamarisca* are manifestly the representatives of the simple tubes in *S. rosacea* and *S. fallax;* while the three broad chitinous leaflets within which the ramified tubes are contained are homologous with the hollow chitinous processes of the gonangium, which in *S. rosacea* and *S. fallax* enclose the simple tubes, and subsequently coalesce to form with their prominent ridges and spines an external capsule-like covering for the sac, into which, as in *S. tamarisca,* the ova are expelled from the gonangium proper.

The structures just described in *Sertularia rosacea, S. fallax,* and *S. tamarisca* will, I think, enable us to explain a peculiar feature observed in *S. pumila,* and probably some other species. In *S. pumila* the blastostyle of both male and female gonangia gives off from its enlarged opercular summit several more or less ramified cæcal tubular processes (woodcut, fig. 21, *d, d*), which, instead of developing themselves externally, are found entirely within the gonangium, where they hang freely from the summit of the blastostyle. Their walls are composed both of endoderm and ectoderm, and their cavity communicates with that of the blastostyle, so that the peculiar coloured corpuscles which circulate within the cavity of the blastostyle are freely admitted into the cæcal tubes, where they may occasionally be seen in active motion. The tubes can be most satisfactorily examined in the younger gonangia. In the older ones they will frequently be found to have contracted adhesions to the gonangium, to have become atrophied, and, finally, even to have disappeared.

FIG. 27.



A portion of the hydrosoma of *Coppinia arcta.*

a, a, a, Hydrothecæ; *b,* a hydranth retracted and destitute of tentacles; *c,* a hydranth retracted and with its tentacles present; *d, d,* basal encrusting portion formed by the juxtaposition and adhesion of tubular gonangia; *e,* sporosac, enclosing a solitary ovum; *f, f,* acrocysts, enclosing the ovum in a more advanced stage of development; *g,* retiform stolon, forming the hydrorhiza.

I believe that these tubes are the exact equivalents of those which in *Sertularia tamarisca* and *S. rosacea* are given off from the same part of the blastostyle, but where, instead of growing into the cavity of the gonangium, they are developed in an outward direction, and assist in the formation of the peculiar receptacle which surrounds the acrocyst in those species.[1]

Among the most remarkable modifications of the trophosome is that of *Coppinia arcta* (woodcut, fig. 27). In this singular hydroid the hydrothecæ and gonangia spring directly from a creeping retiform hydrorhiza, while the gonangia, which are very numerous, become closely adherent to one another by their sides, so as to form with the proximal portion of the hydrothecæ and with the hydrorhiza a continuous encrusting basis spreading over the surface to which the

respects from my original description of the same part ('Brit. Assoc. Report on HYDROIDA'), subsequent more favorable examinations having caused certain modifications of my former views.

[1] It is evidently the tubes here described to which Agassiz ('Nat. Hist. U. S.,' vol. iv, p. 329, pl. xxxii, figs. 10, 10a) refers as occurring in a North American hydroid which he regards as identical with the *Sertularia pumila* of the European coasts. He views them, however, as simply representing the fleshy bands which may frequently be seen in the trophosome of the Hydroida, extending from the outer

hydroid had attached itself. Each gonangium in the female contains a single sporosac with a single ovum; and this ovum, after a time, becomes extra-capsular in order to undergo within an acrocyst some of the earlier stages of its development.[1]

But there is, perhaps, no modification of the gonosome more interesting than that which we meet with in *Gonothyræa Lovéni*, Allm., and at least one other allied species. In this calyptoblastic hydroid there are borne upon the summit of the gonangium, and altogether external to its cavity, certain very peculiar gonophores, which convey the impression of small, fixed, imperfectly developed medusæ (woodcut, fig. 28). It was to these extracapsular gonophores

surface of the cœnosarc to the inner surface of the chitinous periderm, and which these tubes certainly resemble when they become more or less atrophied and adherent to the walls of the gonangium. They are also described and figured by Lindström in a paper "On the Development of *Sertularia pumila*" ('Oefversigt af Köngl. Vetenskap-Akademiens Förhandlingar,' 1855).

[1] As the nature of *Coppinia arcta* has been hitherto very imperfectly understood a more detailed description of it may here be given.

The hydrosoma forms small sponge-like masses on the stems of the larger hydroids, and is especially abundant on *Sertularia abietina* and *Plumularia falcata* from deep water.

Even on a superficial inspection it may be seen to consist of two distinct portions. Of these, one constitutes a continuous encrusting base, and the other consists of curved cylindrical tubes which project from the free surface of the base. In each of these tubes is contained an exsertile and retractile hydranth. The tubes are thus true hydrothecæ. The hydranths are conspicuous by their fine lemon-yellow colour, and are furnished with a verticil of filiform tentacles disposed round the base of a short conical hypostome. They are, however, often imperfect and apparently destitute of mouth and tentacles.

The encrusting base which forms the most remarkable part of the hydroid has never yet been correctly described.

The hydrothecal tubes can be traced through it to its attached surface, while vertical and transverse sections show that the rest of the crust is mainly composed of vertical chitinous tubes rendered polygonal by mutual pressure. They adhere to one another by their sides, and each, as had been long ago shown by Dalyell, opens on the free surface of the crust by a small circular aperture.

These tubes are true gonangia; within each is a solitary sporosac which seems to have originally budded from a blastostyle, which soon, however, becomes suppressed by the growing sporosac. A sufficiently obvious spadix may be recognised in the sporosac which contains a single large lemon-yellow ovum, in whose earlier stages there may be seen a distinct germinal vesicle, while the place of the germinal spot is taken by numerous clear spherical bodies which disappear in a few seconds after the ovum is pressed out of the sporosac and exposed to the action of the surrounding water.

Segmentation commences while the ovum is still within the gonangium, and the ovum becomes thereby converted into a mass so plastic that it allows of its being forced through the small aperture in the summit of the gonangium. In its exit it carries out with it a hernial extension of the attenuated walls of the sporosac, which thus form for it an acrocyst in which it is still for some time confined. It ultimately, by the rupture of the acrocyst, escapes as a planula into the surrounding water. The planula and its development into a hydranth enclosed in a chitinous tube have already been observed by Dalyell.

Both hydrothecæ and gonangia spring from an adherent retiform hydrorhiza without the intervention of a hydrocaulus.

A knowledge of the structure of *Coppinia* will enable us to give a more correct generic that Lovén long ago[1] called attention when he supported and developed the doctrine, just then announced by Ehrenberg, of the sexuality of the HYDROIDA—a doctrine which, though in its mode of statement not absolutely correct, was yet full of significance.

The bodies (*g*, *g'*) in question are nearly spherical sacs, and occur in both the male and female colonies. In their walls may be demonstrated an ectotheca, mesotheca, and endotheca. The generative elements are formed within the endotheca, and surround a well-developed spadix. The endotheca, however, is generally of short duration, becoming absorbed or ruptured under the increasing volume of its contents. In the female four very distinct radiating canals may frequently be seen; these spring from the base of the spadix, and thence run in the walls of the mesotheca towards the opposite end of the sac. In many cases, however, I was unable to detect any trace of these canals, and could never find them in the male. We should, however, be scarcely justified in asserting that in such cases they are altogether absent; for it is quite possible that emptiness or some other peculiar condition at the time of observation may have caused them to escape detection—a supposition which receives confirmation from the fact that, even in cases where they are obvious, they become obliterated under slight pressure.

At the summit of the sac the mesotheca is perforated by a circular aperture, round which its walls appear to be thickened, and seem to contain here a circular canal in which the radiating canals terminate; at least, the presence of a line of coloured granules at this place affords an indication of the existence of such a canal. The ectotheca, which is loaded with thread-cells, is also perforated by an aperture corresponding to that of the mesotheca; and the gonophore is crowned by a circle of short tentacles, which seem to originate from the thickened margin of the perforation in the summit of the mesotheca.

These tentacles possess, like the marginal tentacles of a true medusa, considerable contractility. They may frequently be seen of very different lengths in different gonophores of the same colony; and this, which is really the result of different degrees of contraction, may be easily taken for different degrees of development, the tentacles being especially sluggish in the acts of extension and contraction. Their length, when fully extended in the female gonophore, will equal about half the diameter of the gonophore. While under external irritation, they will slowly contract to a third of their original length, and will then show themselves as a little stellate crown on the summit of the gonophore, reminding us of the sessile stigma in the pistil

diagnosis than was possible so long as we were ignorant of the true nature of this curious hydroid, and the following may be taken as expressing the essential characters of the genus:

COPPINIA, Hassall.

Trophosome.—Hydrocaulus absent; hydrothecæ tubiform, springing from an adherent retiform hydrorhiza.

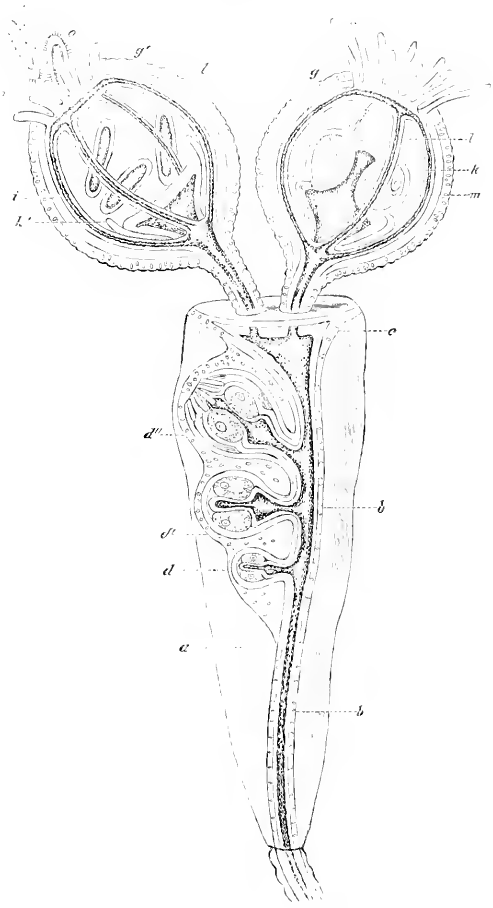
Hydranths with a single verticil of filiform tentacles.

Gonosome.—Gonosphores adelocodonic; gonangia tubiform, sessile on the hydrorhiza, and forming, by the close approximation of their sides, a continuous incrusting mass surrounding the bases of the hydrothecæ which project from it at intervals.

[1] Lovén, "Beiträge zur Kenntniss der Gattungen *Campanularia* und *Syncoryne*," 'Wiegm. Arch., 1837. Lovén names the hydroid in which he witnessed the extracapsular gonophores *Campanularia geniculata*, which is certainly a wrong determination of the species. See "Notes on the Hydroida," 'Ann. Nat. Hist.' for August, 1859.

of a poppy. They vary in number; I have counted in the female from eight to sixteen or twenty. They are composed of ectoderm and endoderm, the ectoderm containing thread-cells, and the endoderm presenting the usual septate appearance. They are less numerous and less developed in the male than in the female.

Fig. 28.



Gonangium with Meconidia of *Gonothyræa Lovéni* (female).

a, Cavity of gonangium; *b*, *b*, blastostyle, with *e*, its opercular summit; *d*, *d'*, *d''*, gonophores in various stages of maturity still within the gonangium, all surrounded by the gubernacular membrane; in *d''* the tentacles are seen already formed and lying back on the walls of the gonophore; *g*, *g'*, meconidia, *g'* being more advanced than *g*; *i*, mesotheca, external to which may be seen the ectotheca loaded with thread-cells; *k*, endotheca; *k'*, remains of endotheca in the more advanced meconidium; *l*, radiating canals, united by the circular canal, *n*; *m*, ovum with germinal vesicle and spot; *o*, *o*, embryos, escaping in the form of ciliated planulæ.

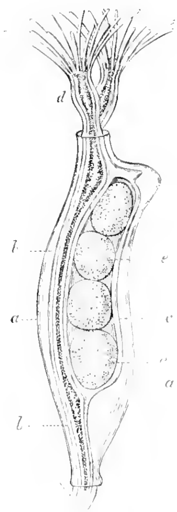
The contents of the sacs are, as in an ordinary gonophore, either ova or spermatozoa, and the sexes are invariably found separated on distinct colonies. The ova, while contained within them, pass through the various stages of development up to that of ciliated embryos, in which state, as has been already shown by Lovén, they are discharged into the surrounding water through the orifice in the summit.

If we follow the development of these extracapsular gonophores, we shall find, as, indeed, Lovén had already pointed out, that they are originally produced within the gonangium where they originate, exactly like intracapsular gonophores, as buds from the blastostyle. By the growth of the blastostyle the gonophores are carried upwards with it, in the order of their maturity—the oldest ones, while within the gonangium, being always nearest the summit of the blastostyle; but instead of discharging their contents and then withering away on their arrival at the orifice of the gonangium, as in ordinary adelocodonic forms, they are here carried out through the orifice, become truly extracapsular, and in this state undergo, with their contents, further development, while the growing blastostyle always keeps its extremity truncated on a level with the summit of the gonangium, whose orifice it continues to close by a plug-like expansion, which at the same time affords a support for the gonophores after they have become extracapsular. Two or three of these extracapsular gonophores, in different stages of development, may be usually seen, borne each by a short peduncle upon the opercular summit of the blastostyle, with whose cavity that of their spadix freely communicates through the tubular axis of the peduncle.

While the gonophore is still contained within the gonangium, the mesotheca has become developed in it, and in the more advanced ones (*d''*) the rudimental tentacles may be seen thrown back in their walls in the form of a little star.

That the bodies now described belong to the class of adelocodonic rather than to that of phanerocodonic gonophores must, I think, be admitted. In all essential points, except in the presence of entacles developed from the mesotheca, they agree with the gonophores of *Tubularia indivisa*, which must certainly be classed among the adelocodonic forms, notwithstanding their possession of a well-developed mesotheca and gastrovascular canals. In both the aperture of the mesotheca is reduced to a mere perforation, and in neither is the mesotheca ever developed as a locomotive organ.

Fig. 29.



Gonangium with gonangial hydranths in *Halecium halecinum*.

a, *a*, Gonangium; *b*, *b*, blastostyle; *c*, gubernacular membrane, still confining the ova, *e*, *e*, which are here in an advanced stage of development, the proper gonophore having become absorbed after discharging its contents; *d*, gonangial hydranths.

It must also be borne in mind that, when planoblasts are produced in the *Campanularinæ*, they are in almost every instance blastochemes; in other words, they belong to the type in which the generative elements are produced, not directly, as in *Gonothyræa*, between the ectoderm and endoderm of the manubrium, but are formed in special zooids developed from some parts of the gastrovascular system; *Leptoscyphus tenuis*, Allm.,[1] affording the only known exception to this rule.

The extracapsular gonophores of *Gonothyræa Lovéni* are thus of no little interest in the morphology of the Hydroida, and it will be found convenient to speak of them under a special name. Their resemblance to a pomegranate, or perhaps still more obviously to a poppy-capsule, with its sessile stellate stigma, will instantly strike us; and it is this comparison which has suggested to me the name of *meconidium*,[2] by which I have elsewhere found it useful to designate them.

A very remarkable feature, which one is at first sight tempted to place in the same category with the formation of meconidia, but which is in reality of an entirely different significance, is presented by *Halecium halecinum*. In this hydroid there is borne upon the summit of the female gonangium, in a situation precisely similar to that of the meconidia of *Gonothyræa Lovéni*, a pair of hydriform bodies (woodcut, fig. 29 *d*). These bodies present no appreciable difference by which they may be distinguished from the ordinary hydranths of the trophosome. They are of an elongated oval form, with the mouth situated on the summit of a short conical hypostome, which is surrounded by a circle of filiform tentacles. They are always two in

[1] "Notes on the Hydroid Zoophytes," 'Ann. Nat. Hist.,' Nov., 1859.

[2] A diminutive noun, formed from μήκων, a poppy. "Notes on the Hydroid Zoophytes," 'Ann. Nat. Hist.,' August, 1859.

number, and diverge from a common point of attachment, while their wide gastric cavities, after contracting below, communicate here with one another and with the tubular cavity of the blastostyle.

I have never been able to discover any direct relation between these gonangial hydranths and the generative functions of the hydroid. The ova, so far as I can determine, seem to be produced in the usual way in a sporosac which springs from the blastostyle, and are then discharged into a chamber formed by the gubernacular sac (*c*), the sporosac itself entirely disappearing after the loss of its contents. In the sort of internal marsupium thus formed the ova pass through certain stages of their development before their ultimate liberation as planulæ through the summit of the gonangium, which takes place, probably, after the disappearance of the gonangial hydranths.

I may here mention a very singular body, whose exact significance I have never been able satisfactorily to determine, and which may be seen in the female gonangium of *Antennularia antennina*, where it is of frequent occurrence. It is always found floating free in the cavity of the gonangium, along with the ova which had escaped from the ruptured gonophores, and resembles an imperfectly developed medusa, with a large and apparently imperforate manubrium, but with its umbrella closed, and without any trace of gastrovascular canals, the walls of the umbrella being separated from the manubrium by a considerable space, which is filled with a clear fluid. It may be compared to a free sporosac; but it is much smaller than the ordinary sporosacs of the *Antennularia;* and I have never observed in it any trace of generative elements. It is possibly an undeveloped sporosac, produced, like the perfect sporosacs, as a bud from the blastostyle, and becoming separated at an early stage; but I can offer no decided opinion either as to its origin or its ultimate destination. It may be a parasite, though it is not easy to reconcile its peculiar structure with this view.

In almost every case the gonangium, when present in the Hydroida, is destitute of any further covering. In certain hydroids, however, belonging to the family of the *Plumularidæ*, the gonangia are developed in groups, and each group is contained in a common receptacle, which confers upon the hydroid in which it exists a very striking and characteristic feature. This receptacle must be carefully distinguished from a proper gonangium, with which, indeed, it has been confounded in various descriptive works on the HYDROIDA. It will therefore be very convenient to give it a special name, and I have already proposed for it the term *corbula*, suggested by its basket-like form.[1]

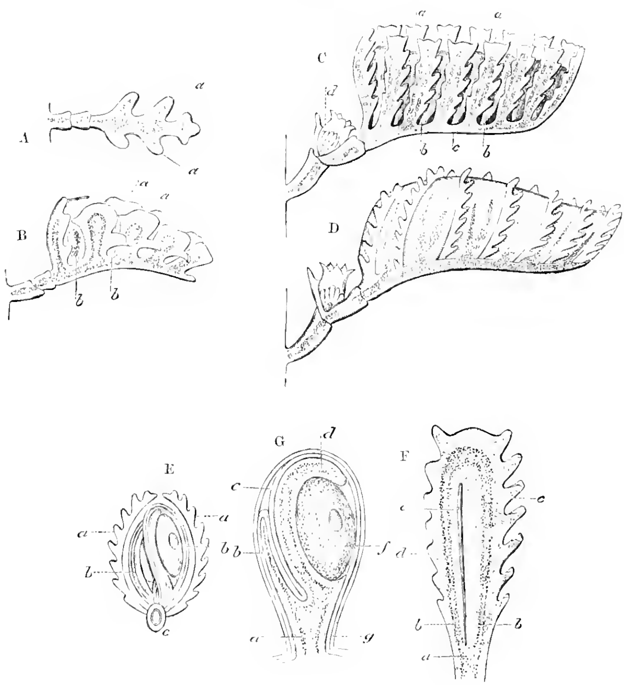
In *Aglaophenia pluma* the corbulæ (woodcut, fig. 30, D) may be plainly seen to be metamorphosed ramuli. The peculiar metamorphosis of a ramulus, which results in the formation of a corbula, consists here in the suppression of the hydrothecæ, accompanied by the development on each side of the ramulus of numerous oval, hollow, alternately placed leaflets; each leaflet consisting of a diverticulum from the cœnosarc of the ramulus, invested by a continuation of the general perisarc.

In the earliest stages of these leaflets (A, *a*) their edges are entire, but they soon become deeply serrated by the formation of hollow tooth-like processes, more especially upon the edge which is turned towards the distal extremity of the ramulus. Upon the proximal edge of the leaflet these processes usually remain in an imperfectly developed state, though they are occasionally equally

[1] 'Proc. Roy. Soc. Edin.,' 1858.

well developed on both edges. The processes which are thus developed on the edges of the leaflet are in all respects similar to the lateral nematophores of the trophosome (see p. 28). They are filled, like these, with soft granular protoplasm, in which is immersed a cluster of fusiform thread-cells, and which is in direct communication with the cœnosarc filling the cavity of the leaflet. They are also, like these, perforated at their extremity by an oblique aperture; but I have never seen the nematophores of the corbulæ emit, like those of the trophosome, pseudopodial prolongations of their contents.

Fig. 30.



Development of the Corbula in *Aglaophenia pluma.*

A, Very young corbula; B, corbula more advanced; C, corbula in a still more advanced stage; D, the mature corbula; E, transverse section of mature corbula, showing two gonangia, each containing a single gonophore. *a*, *a*, leaflets of corbula; *b*, *b*, gonangia; *c*, ramulus supporting the leaflets; *d*, a hydrotheca.

F, Separate leaflet from mature corbula. *a*, continuation of the somatic cavity into the leaflet, where it divides into two branches. *b b*; *c*, nematophores forming tooth-like processes on the distal edge of the leaflet; *d*, imperfectly developed tooth-like processes on the proximal edge; *e*, septum, dividing the cavity of the leaflet.

G, Gonangium from mature corbula. *a*, continuation of somatic cavity into gonangium; *b*, blastostyle, partially suppressed by the enlarging gonophore; *c*, gonophore; *d*, spadix; *f*, ovum; *g*, wall of gonangium.

As the young leaflet continues to grow, its cavity becomes partially divided by a chitinous septum (F *e*) which stretches across from the outer to the inner side, parallel to the axis of the leaflet, but always nearer to the proximal edge. At the free end of the leaflet the septum is incomplete; so that here the contents of the cavity at one side of the septum communicate with those upon the other side, both sides communicating at the base of the leaflet with the common cavity of the cœnosarc.

The leaflets, as they increase in size (B, C), direct themselves vertically from the upper surface of the ramulus, and those of one side arch over so as to approach those of the opposite. They are at first free, but they afterwards become intimately united at their edges, the nematophores continuing to project as tooth-like processes, and forming an elegant serrated ridge between every two leaflets. Ultimately the leaflets of one side coalesce with those of the other by their summits, and thus form a completely closed chamber (D).[1]

In the receptacle thus formed the gonangia are produced. They spring from the upper side of the metamorphosed ramulus, near the point where the leaflet leaves it, and represent the hydrothecæ which exist on an ordinary ramulus, and whose place they here take. They begin to be produced at an early stage of the corbula, and may be easily examined in the young corbula before it has become closed (B *b*, C *b*). The metamorphosed ramulus generally remains unchanged for a short distance from its origin, and may be here seen bearing one or two ordinary hydrothecæ.

About twelve gonangia are usually contained in each corbula. They are of a very simple type (G), of a regular oviform figure, and with their chitinous walls thin and delicate. Each gonangium seems to contain but a single sporosac, which soon comes to occupy almost its whole cavity. A long, nearly cylindrical spadix extends from the base to the summit of the sporosac, passing in the male through the axis of the mass of spermatogenous tissue, but in the female pushed to one side by the development of the large single ovum, which here occupies almost the whole remaining portion of the cavity of the sporosac.

There may appear some difficulty in deciding as to whether the corbula ought to be regarded as properly belonging to the trophosome or to the gonosome. The truth is, that it holds a place exactly intermediate between the two, and may in this respect be compared to the bracts in plants; for these are in the same way intermediate between the ordinary leaves and the proper floral verticils. As the bracts, however, are usually treated of in connection with the *inflorescence*, whose limitation they frequently determine, we shall, perhaps, here also find it convenient to speak of the corbula in connection with the gonosome rather than with the trophosome.[2]

[1] In some other species (*Aglaophenia myriophyllum*) the leaflets never coalesce, and the corbula remains permanently open.

[2] In a very ingenious paper, "On the Morphology of the Reproductive System in the Sertularian Zoophytes," by Professor E. Forbes ('Ann. of Nat. Hist.,' 1844, vol. xiv, p. 385), the author recognises in the corbulæ of *Aglaophenia pluma*, and some other allied species, their true significance as metamorphosed branches. He mistakes, however, the nature of the metamorphosis, while, in accordance with the prevailing view, he sees in the receptacles in question bodies in all respects corresponding to the proper gonangia of the other hydroids.

Forbes, moreover, extends his generalisation, applying it to the gonangia of the other Sertularians, which he believes must be all regarded as peculiarly metamorphosed branches, with metamorphosed and confluent hydrothecæ, exactly in the same way that the floral verticils in plants may be referred to verticillate, metamorphosed, and variously combined leaves. "The vesicle," he says, "is formed from a branch or pinna through an arrest of individual development, by shortening of the spiral axis, and, by a transformation of the stomachs (individuals) into an ovigerous placenta, the dermato-skeletons (or

As a general rule, there is no perceptible difference between the male and female colonies of the same species of hydroid, either in the trophosome or the gonosome, beyond what is, of course, presented by the generative elements themselves. In some cases, however, the difference is sufficiently well marked. Thus in *Sertularia tamarisca* the male and female gonangia (woodcut, fig. 26) differ strikingly from one another; for the male gonangia are compressed, somewhat obcordate receptacles, with a short terminal tubular aperture; while the female are oval for about the proximal half of their height, and then become trihedral with the sides diverging upwards, the whole being terminated by a three-sided pyramid whose edges are cut into two or three short teeth, and the basal angles prolonged into a short spine.[1]

So also in *Sertularia rosacea* a well-marked difference may be seen. The male gonangia are here of a conical form, curved near the apex, which is their point of attachment, and provided with six longitudinal ridges in the form of thin projecting lamellæ, each of which terminates at the distal extremity in a free-pointed process which arches over the summit of the gonangium. In the female gonangium (woodcut, fig. 23) the longitudinal ridges are eight in number, while two opposite ones being greatly more developed than the others give to the gonangium the very elegant and striking form which caused Ellis to compare it to a "lily or pomegranate-flower just opening." A very similar difference exists between the male and female gonangia of *Sertularia fallax*, and generally in the group which under the name of *Diphasia*, Agassiz has separated from *Sertularia*. In all these cases the difference depends on the formation in the female of the remarkable marsupial chamber whose structure has been already described (see p. 52).

It will also be borne in mind that, in those species which develop an acrocyst on the summit of the gonangium, this body is formed only in the female; while it is on the female gonangium alone of *Halecium halecinum* that the little geminate hydranth already described (p. 58) is produced; and to these cases we may also add the difference presented by the male and female meconidia in *Gonothyrea Lovéni* (see p. 56).

Among the gymnoblastic hydroids, also, certain differences may be occasionally observed between the male and female. Thus, the tentaculoid tubercles which, in certain *Tubulariæ*, crown the gonophore are in some species more fully developed in the female than in the male; but the most striking difference is found in the genus *Eudendrium*, whose male gonophores are situated in a verticil on the body of the hydranth, and present the remarkable polythalamic condition already described, while the female gonophores originate irregularly for some distance backwards on the branch, and are always monothalamic (see Pls. XIII and XIV). This difference between the male and female gonophores in *Eudendrium* struck Cavolini long before the presence of a male element in the Hydroida was suspected, and led him to suppose that *Eudendrium* reproduced

cells) uniting to form a protecting capsule or germen; which metamorphosis is exactly comparable with that which occurs in the reproductive organs of flowering plants, in which the floral bud (normally a branch clothed with spirally arranged leaves) is constituted through the contraction of the axis and the whorling of the (individual) appendages borne on that axis, and by their transformation into the several parts of the flower (reproductive organs)."

The theory, however, involved in the above statement, attractive though it be, is contradicted by the actual development of the parts in question. When Forbes wrote, so little was known of the structure and development of the Hydroida, that this accomplished and lamented naturalist may well be excused if some parts of his very suggestive paper have refused to stand the test of subsequent research.

[1] It is apparently the male gonangia which Ellis has figured in his description of this species.

itself by two different kinds of eggs. In accordance with this view, he called the female gonophores in his *Sertularia* (*Eudendrium*) *racemosa* "uova a racemo," and the male gonophores "uova a corimbo."[1]

The differences above described between the male and female are all confined to the gonosome; the trophosome, however, does not appear to be always exempt from a participation in sexual difference, for in *Hydractinia polyclina*, Agass., the hydranths of the male colony are described by Agassiz as differing from those of the female colony by their more elongated proboscis.[2]

We may now consider how the principal modifications which we have described as presented by the gonosome are distributed among the leading groups of the Hydroida.

There is no fully established instance of the same species of hydroid producing both phanerocodonic and adelocodonic gonophores, either simultaneously or consecutively; and Sars[3] is certainly in error when he includes under his *Podocoryne carnea*, two forms of hydroids, one with developed medusæ, and the other with sporosacs. Neither is there any known instance of a species with blastochemes producing gonophores in any other way than through the medium of the blastocheme, and there can be little doubt that Van Beneden[4] has made some confusion between two distinct species when he figures a portion of a hydroid colony, which he names *Campanularia geniculata*, with two kinds of gonangia, one containing medusæ and the other sporosacs.

Among the gymnoblastic hydroids the gonophores may be borne either by the trophosome directly or by blastostyles, but they are never included within a gonangium. We have here some species with phanerocodonic and others with adelocodonic gonophores, and the two forms would seem to be pretty equally distributed through the group. Unless *Nemopsis* should prove an exception, there is no known example of the occurrence of a blastocheme among the *Gymnoblastea*. It is, however, by no means impossible that the sexual lobes of *Nemopsis* whose bases extend over portions of both the manubrium and radiating canals, ought to be regarded as true zooids. If this be so, then the *Nemopsis* medusa must be regarded as a blastocheme, though M'Crady has shown that its trophosome is that of a true tubularian.

Among the *Campanularinæ* we meet with medusiform planoblasts, as well as with fixed sporosacs, both forms being produced in nearly equal proportion. The planoblasts, however, belong, with only a single known exception,—that, namely, which is afforded by *Leptoscyphus tenuis*—to the type of the blastocheme. Both planoblasts and sporosacs are in the *Campanularinæ* always developed upon blastostyles within a gonangium.

The *Geryonidæ*, a group composed of medusæ which have not yet been traced to a hydraform trophosome, must probably, as we shall see below, be regarded as true blastochemes.

Finally, among the *Sertularinæ* we know as yet of no instance of a planoblast, the generative elements being among these hydroids always produced in fixed sporosacs, which, as in the *Campanularinæ*, are invariably borne on the blastostyle of a gonangium.

[1] Cavolini, 'Mem. Polypi Marini,' 1785.

[2] Agassiz, 'Nat. Hist. United States,' vol. iv, p. 228.

[3] Sars, 'Fauna lit. Norv.,' p. 7, pl. ii, fig. 5.

[4] Van Beneden, 'Mém. sur les Campanulaires,' pl. iii, figs. 1—6.

9. *The Generative Elements.*

I have thus far endeavoured to give a complete account of the morphology of those parts which are destined for the origination and protection of the generative elements. These elements themselves may next be examined.

The existence of generative elements—ova and spermatozoa—has now been fully determined in every important group of the Hydroida.

Ova.—The hydroid ovum (woodcut, fig. 40 A), in all those cases where its structure has been satisfactorily seen, consists of a granular vitellus enveloping (except in the genus *Tubularia* and probably the other *actinula*-producing hydroids) a distinct, more or less excentric, germinal vesicle, in which one or more germinal spots may be almost always demonstrated, and occasionally with one or more puncta or nucleoli in the interior of the germinal spot. The whole is invested by an exceedingly delicate vitellary membrane, which, though it sometimes escapes detection, is probably always present, at least during some period in the existence of the ovum. In the genus *Tubularia* the most careful investigation has as yet failed in detecting any trace of germinal vesicle or spot.

From some observations which I have been enabled to make on certain very early stages of the ovum, it would seem that the germinal vesicle shows itself before any distinctly differentiated vitellus has begun to envelope it, and that the vitellus afterwards accumulates round the germinal vesicle as round a separate centre of differentiation. (See below, where this process is more fully described in the physiological section.)

In *Coryne pusilla* and many other species, the ova, when escaping from the gonophore under the pressure of the compressorium, present a peculiar appearance. They are then seen to be each invested by a special membrane of great delicacy, which is continued backwards by a narrow neck-like prolongation; so that in this state the whole ovum presents a pyriform shape. This membrane is probably nothing more than the vitellary membrane of the ovum, which, from the mode in which the pressure is applied, assumes the form described.

In no hydroid ovum have I found any evidence of a micropyle.

Spermatozoa.—The spermatozoa possess the form which so generally characterises those bodies throughout the animal kingdom, being here in all cases active caudate corpuscles (woodcut, fig. 31 D *d*). The caudal filament is sometimes of such extreme tenuity as to render it very difficult of detection, while the head varies in form, being usually conical—and then with the filament attached to the wide end of the cone—but sometimes spherical, or cylindrical, or "guitar-shaped,"[1] according to the species. In *Eudendrium ramosum* a very minute granule may always be seen attached to one side of the head of the spermatozoon, where it looks like a parietal nucleus. (Pl. XIII, fig. 17.)

The spermatozoa seem to be always developed in true sperm-cells, which are themselves

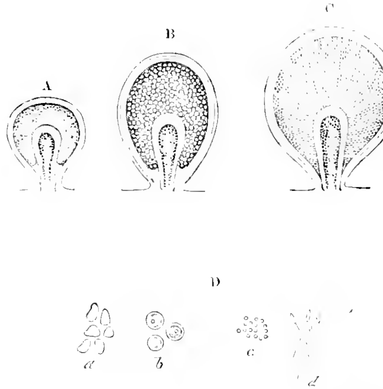
[1] The spermatozoa of *Eudendrium dispar*, Agass., and some other species, are so described by Agassiz. 'Nat. Hist. United States,' vol. iv.

frequently contained as a brood in the interior of mother-cells, as may be very well seen in *Sertularia polyzonias*, where the cells which give immediate origin to the spermatozoa form groups of from two to four enclosed within a common mother-cell. The spermatozoon itself seems due to the metamorphosis of the nucleus of the sperm-cell.

In *Laomedea flexuosa* I have carefully followed the progress of the spermatogenous tissue from a very early period to the formation of the mature spermatozoon. In the very young gonophore of this hydroid (woodcut, fig. 31 A) the spadix may be seen surrounded by a nearly transparent mass, which is destined to become developed into spermatozoa, but which presents as yet no obvious structure beyond a minutely granular condition, which under the action of acetic acid becomes more distinct.

In a stage a little further advanced (B) the gonophore has increased in size, and the spermatogenous mass has become more voluminous and has acquired a manifest structure, being now plainly formed of a peculiar tissue which, when liberated from the confinement of the gonophore and spread over the field of the microscope, is seen to consist of a multitude of bodies of a rather irregularly pyriform or conical shape, and about $\frac{1}{3000}$th of an inch in diameter (D *a*). These bodies, when set free, present for the most part an evident vibratory movement, which seems distinct from mere molecular motion, though as yet no filament or other source of the motion can be detected. When treated with acetic acid, they assume a regularly spherical form, and have then all the appearance of thick-walled cells with an undoubted nucleus in their interior (D *b*).

Fig. 31.



Development of the Spermatozoa in *Laomedea flexuosa*.

A, Very young male gonophore, showing the spermatogenous plasma interposed between the ectoderm and the endoderm.
B, Gonophore further advanced.
C, Mature gonophore.
D, Structure of spermatic tissue at various stages; *a*, spermatic tissue from B; *b*, the same after treatment with acetic acid; *c*, spermatic tissue, from a gonophore somewhat further advanced than B; *d*, mature spermatozoa from C.

In a more advanced stage the contents of the gonophore have still further increased in opacity, and are now seen to be entirely composed of very minute spherical corpuscles (D *c*) about $\frac{1}{9000}$th of an inch in diameter, and presenting a close resemblance to the nuclei of the cells composing the spermatogenous tissue in the stage last described. They exhibit distinct but not active motion under the microscope, though no filament can as yet be demonstrated in them.

In the next stage (C) the gonophore has attained maturity, and the spermatogenous mass has become still more opaque than in the preceding stage, and presents a peculiar striated appearance, the striæ radiating from the sides of the spadix to the walls of the gonophore. Soon after the gonophore has attained this condition it bursts, and allows its contents to escape into the surrounding water as mature active spermatozoa (D *d*). These spermatozoa have an ovoconical head, with a caudal filament of extreme tenuity; the head is about $\frac{1}{3000}$th of an inch in its longer diameter, and about $\frac{1}{5000}$th in its shorter. The tail is attached to the wide end.

In attempting an interpretation of the above appearances, we must, I think, regard the nucleated cells which constitute the contents of the gonophore in the second of the stages (woodcut, fig. 31 B) just described as spermatic cells which in the next stage have set free their nuclei; these nuclei, after liberation from the cells, acquiring a more elongated form, developing a filament, and becoming converted into true spermatozoa.

Allusion has been just made to the peculiar striated appearance presented by the mature spermatic mass while yet contained within the gonophore. This appearance, which is very common in the mature male gonophores of the HYDROIDA, suggests to us the idea that the corpuscles composing the mass are confined in an exceedingly fine tubular tissue. I have, however, in vain sought for any indubitable evidence of tubes, and I believe that the appearance in question is the result of a mere arrangement of the corpuscles—a condition induced in the plastic mass by the pressure exerted on it by the resisting walls of the gonophore as the mass within increases in volume; for the component corpuscles have now become changed from the spherical form of the previous stage to a more oval form, and their axes are compelled by the surrounding pressure to take a definite direction. It is a phenomenon which in this view would be purely physical, and which we cannot avoid comparing to that of slaty cleavage, though occurring in an organized and living mass.

IV. DEVELOPMENT.

There can be no doubt that the phenomena of development, involving as these do the changes of form undergone by the organism in successive periods of time, constitute a department of MORPHOLOGY, and should, when possible, be treated in connection with other morphological phenomena instead of being included under the head of PHYSIOLOGY, as is the usual, and perhaps in some cases the more convenient, practice.

In the account already given of various parts of hydroid organisation, it has been found necessary to dwell with more or less detail on their development. A more systematic treatment of hydroid development may now be attempted. This may be best considered under two heads, the one treating of the development of the bud, the other of that of the embryo.

These two kinds of development, notwithstanding certain differences which necessitate their separate consideration, possess close analogies with one another. The progress of the bud in its development, like that of the embryo, is always from the general to the special; and just as it is impossible at first to point out any difference between embryos which are destined to branch off into widely separated types, so in their early stages it is impossible to distinguish from one another buds which are destined to become developed into very different forms. Thus, no difference whatever can be detected on their first appearance between three buds, one of which is destined to become a hydranth, another a sporosac, and another a medusa; and the analogy will appear still closer when we bear in mind that buds formed by entirely different bud-bearing types may in their early stages be undistinguishable from one another.

While the hydroid embryo, however, continues to develop as an independent organism, the bud remains for a longer or shorter time dependent on the parent stock; but it will yet be seen that the stage of differentiation on which the bud stands at the earliest period at which any differentiation is perceptible corresponds to that of the embryo at the moment when the ectoderm and endoderm of the planula become differentiated as distinct structures, and the further development of the planula and of the hydranth-bud present a close parallelism with one another.

1. *Development of the Bud.—Zooidal Development.*

Reproduction by budding or gemmation is the phenomenon which, of all others, most vividly impresses us in our study of the Hydroida, and is that which confers upon this remarkable group of organisms its peculiar and characteristic physiognomy. It struck with all its force the earlier observers, and united with the flower-like form of the hydranth in suggesting the term "zoophyte," by which the wonderful budding and blossoming plant-like animals which adorn our rocks at low water, and are dredged up at various depths from the bottom of the sea, have long been known to the naturalist.

Gemmation in the Hydroida has for its object, 1, the extension of the trophosome; 2, the origination and extension of the gonosome.

The primordial trophosome (Pl. I, fig. 11; Pl. III, fig. 8; Pl. XIII, fig. 16) is quite simple; but it soon begins to complicate itself by budding, and this complication is frequently carried to a great extent, the primary buds giving rise to secondary buds, and these again to tertiary, while buds of a fourth, fifth, or even higher order, may continue to be produced in succession; and as every bud may develop itself into a branch, the result will be the production of those complicated dendritic groups (Pls. III, IV, IX, XIII, &c.) which attain to such perfection in numerous species among the *Tubularian*, *Campanularian*, and *Sertularian* hydroids.

The complex trophosomes which thus result from successive buddings may present symmetrical and asymmetrical forms. Symmetrical forms are, as a general rule, presented throughout the *Sertularians;* the hydranths, with their hydrothecæ, being in these hydroids developed upon points which are symmetrically disposed in relation to a common axis or a common plane; while the ramification of the trophosome is here also usually symmetrical—distichous in most species, verticillate in others. The *Campanularians*, on the other hand, and especially the *Tubularians*, present in most cases an asymmetrical disposition of their branches. The genus *Pennaria* among the *Tubularians* affords a remarkable exception in this respect, its gemmation being so singularly symmetrical as to give to the entire trophosome a close resemblance to that of a *Plumularia*—so close, indeed, as to have led the earlier systematists to place it in that genus.

Under the general head of Gemmation, we may here consider the development of the hydranth, the development of the blastostyle, the development of the sporosac, and the development of the medusa.

a. Development of the Hydranth.

It is exceedingly rare to find the trophosome retaining through life the simple condition which it presents during its primordial state. Cases, however, of permanently simple trophosomes occur. We meet with them, for example, in *Corymorpha* (Pl. XIX) and certain allied forms. The curious free trophosome of *Nemopsis* as described by M'Crady, and of *Acaulis*, as described by Stimpson, are probably only the detached hydranths of some fixed Tubularians which may possess the habit of throwing off their hydranths, as we know to be the case in certain European species of *Tubularia*.

Hydranth-bud in the Gymnoblastea and Eleutheroblastea.—When a hydranth-bud is about to become developed from any part of the cœnosarc in the gymnoblastic hydroids, the two layers of the cœnosarc are seen at this spot to be pushed outwards as if by an incipient hernia, and the little hollow tubercle thus produced forces before it the investing perisarc, which is first extended over the advancing bud, and—except in the very young parts, where it is still in the condition of a mere film—is at last absorbed or ruptured.

The little bud, however, has been in the mean time clothing itself with a new perisarc, which, now that it has escaped from the confinement of the old one, is seen to cover it with a very delicate, transparent, structureless pellicle. The bud continues to increase in size, becoming longer and thicker, with its endoderm and ectoderm very distinct, and with its cavity opening freely into that of the branch from which it springs, and admitting into its interior the fluid with the floating granules which fill the general cavity of the cœnosarc, and which are kept in a state of active rotation within the bud. It continues to enlarge, but has its distal extremity still closed, while the entire bud is still invested by its delicate perisarc (Pl. II, fig. 5, &c.).

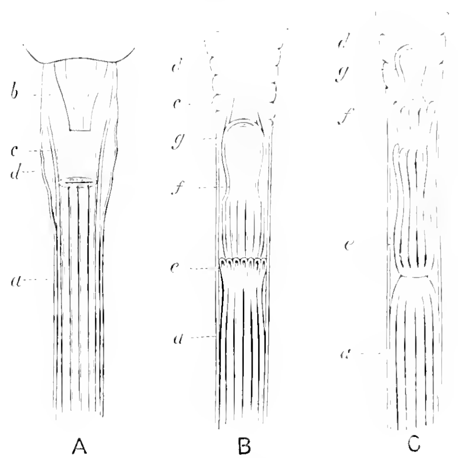
We next find that the little bud has acquired a somewhat clavate form by the enlargement of its distal extremity. While the perisarc which clothes the growing bud continues, by means of new layers deposited upon its inner surface, to increase in thickness over the proximal part of the bud, these new layers cease, in almost every case, at a very early period to be excreted from the free extremity of the bud, and the perisarc here accordingly remains in the condition of a transparent structureless pellicle of extreme tenuity, which at last, in most cases, entirely disappears. We now find tentacles begin to grow out from the enlarged extremity of the bud, and a terminal mouth to become developed; the form is thus gradually assumed which is to characterise the adult hydranth.

In some cases, however (*Coryne vaginata*, Hincks (Pl. IV, fig. 8), and *Eudendrium vaginatum*, Allm. (Pl. XIV, fig. 7)), the perisarc which clothes the free extremity of the growing branch attains considerable thickness, and does not disappear until a later period; but it ceases in such cases to be in close contact with the ectoderm, and forms an outer chitinous capsule, within which the hydranth continues to become developed; and this development proceeds to the formation of tentacles and the assumption, more or less, of the adult form of the hydranth-bud, before the rupture of the enclosing capsule places the young hydranth in direct relation with the surrounding water.

The development of the hydranth-bud in *Hydra*—our only representative of the *Eleutheroblastea*—seems to be in all essential points the same as in the *Gymnoblastea*, the most important differences being those which depend on the absence of a perisarc in *Hydra*. The ultimate destination of the bud, however, is very different in the two cases; for while in the *Gymnoblastea* it remains fixed as a permanent part of the hydrosoma, it is in *Hydra* destined to become detached and enjoy henceforth an independent existence.[1]

Spontaneous Decapitation and Re-formation of successive Hydranths.—Our account of the development of the hydranth-bud in the *Gymnoblastea* would be incomplete without some reference to a very remarkable phenomenon presented by certain species of *Tubularia*, namely, the periodical shedding and renewal of the hydranths. This phenomenon was several years ago observed by Dalyell,[2] and described with all his usual accuracy by this excellent observer. I cannot find, however, that any author has followed the process with that exactness which is necessary to enable us to form a correct idea of its nature. My own observations have been principally made on *Tubularia indivisa*, where I have bestowed upon the process in question a very careful examination.

FIG. 32.



Shedding and Renewal of the Hydranth in *Tubularia indivisa*.

A, Part of a stem in which a breach of continuity has just taken place below the hydranth; *a*, the perisarc, closely investing the proximal segment of the stem; *b*, the endodermal tube of the distal segment, which has become separated and retracted from the proximal segment and from its own ectoderm; *c*, the detached ectoderm of the distal segment; *d*, the perisarc, where it forms a loose membranous sheath, just below the old hydranth.

B, Early stage of the new hydranth, with the commencement of the proximal zone of tentacles; *a*, the perisarc, where it invests the stem just below the new hydranth; *c*, remains of the ectoderm, which had belonged to the detached part of the stem; *d*, remains of the perisarc, where it had formed a loose, thin membranous sheath, below the old hydranth; *e*, commencement of new proximal tentacular zone; *f*, distal constriction, from which the distal circlet of tentacles is to become developed; *g*, the truncated extremity of the proximal segment, now closed over, and containing a cavity formed by the coalesced canals of the endoderm.

C, More advanced stage of the new hydranth, showing the formation of the second or distal circlet of tentacles; *a*, perisarc, closely investing the stem just below the new hydranth; *d*, remains of the distal part of the perisarc, where it had formed a loose membranous sheath; *e*, proximal zone of tentacles, now much elongated; *f*, distal zone of tentacles; *g*, terminal part of the proximal segment, forming the hypostome of the new hydranth.

When the hydranth of this species, with its clusters of gonophores, has acquired full maturity, the time is come when it is to be cast off (woodcut, fig. 32 A), and its place taken by a successor. A breach of continuity now occurs in the endoderm of the stem at a short distance behind the hydranth; while the ectoderm (*c*) having already become detached from the endoderm (*b*)

[1] The curious free reproductive bodies which occur in *Corymorpha nutans*, and which probably originate as gemmæ, though their exact significance has not yet been determined, will be described below.

[2] 'Rare and Remarkable Animals,' 1847, vol. i, p. 4.

in the space between this breach and the base of the hydranth, the upper end of the stem slips out of its ectoderm, carrying the hydranth with it, and leaving behind it the empty ectoderm as a thin, collapsed, membranous sheath, surrounded by the perisarc, which here exists as a delicate loose pellicle (*c*).

The hydranth thus detached falls to the ground, where it retains for some time its vitality, the gonophores which still hang from it discharging such of their contents as had not escaped before the decapitation.

In the mean time the wound which had been formed in the cœnosarc by the detachment of the hydranth heals over, and the truncated end of the cœnosarc becomes closed.

Two slight constrictions, one a little behind the other, are next seen (B) to take place in the cœnosarc at a short distance from the decapitated extremity, while the peculiar tubular lacunæ which exist in the cœnosarc of the *Tubularia*, and which had hitherto extended as separate canals through the whole cœnosarc of the stem, now coalesce in front of the anterior constriction (*f*), where they form a single cavity by the breaking down of the partitions of endoderm which had upon this time separated them from one another.

A girdle of minute tubercles (*e*) may next be seen budding forth from the cœnosarc, at the site of the posterior constriction. These soon become extended into tentacles (C *e*), which embrace the distal part of the cœnosarc.

In the next stage a similar zone of tubercles (*f*), becoming, like the others, elongated into tentacles, shows itself close below the anterior constriction; and there are thus established the two sets of tentacles, the proximal and distal ones of the new hydranth.

By the elongation of the cœnosarc from below, the new hydranth is gradually lifted up out of the tube of the perisarc, when the tentacles, having room to expand, immediately fall into their normal position, while the rudimental clusters of gonophores may be seen as minute lobulated elevations between the anterior and posterior series of tentacles, and the free extremity of the hydranth has by this time become perforated by a mouth.

The hydranth now increases in size, raised higher and higher on the elongating cœnosarc, which clothes itself with a perisarc as it lengthens, and the hydranth with its clusters of gonophores, having finally attained complete maturity, is then in its turn cast off, to be succeeded in an entirely similar way by a new one.

The formation of successive hydranths is always accompanied by a periodical elongation of the stem, and this is indicated by annular markings of the periderm separated by rather wide intervals, each interval corresponding to a single decapitation and renewal.

From the above description it will be seen that the formation of successive polypites is not so much a process of ordinary budding, as a true metamorphosis of the decapitated extremity of the cœnosarc.

Polarity of the Hydroid.—In connection with the phenomena now described, those which accompany the artificial section of the stem deserve special notice. When the stem is cut across, the cœnosarc of the upper segment soon heals over at the place of section, the tubular lacunæ become again closed, and the cœnosarc now begins to grow downwards through the cut extremity of the periderm, presenting the same lacunar structure as in the older portions, and excreting upon its surface a very delicate perisarc. The well-known cyclotic currents may generally be seen with great distinctness in the fluid which fills the tubular lacunæ of the young elongated cœnosarc.

The lower segment, on the other hand, instead of pushing forth from the cut extremity a simple continuation of the cœnosarc, develops from this extremity a hydranth.[1] There is thus *manifested in the formative force of the Tubularia-stem a well-marked polarity*, which is rendered very apparent if a segment be cut out from the centre of the stem. In this case, no matter in what position the segment may lie, that end of it which was directed downwards or proximally while it formed a part of the unmutilated hydroid will never develop a hydranth, but will extend itself as a simple cylindrical prolongation of the cœnosarc; while the upper or distal end, instead of becoming simply elongated, will shape itself into a true hydranth; and all this though, of course, not the least difference in structure or form, can be detected between the two extremities at the time of section.

It is further manifest from these facts that, when the hydroid is placed under conditions which allow of perfect freedom of growth, there is no such thing as a stationary extremity, both ends being really growing ends, while there exists in every segment a neutral plane midway between the two ends.

Hydranth-bud in the Calyptoblastea.—In the development of the bud, the Campanularian and Sertularian hydroids differ in some important features from those which characterise the process just described. The development may be easily watched in many species, as, for example, in *Laomedea flexuosa*. We may here (woodcut, fig. 33) see it proceed, in the first place, to the formation of a hollow cylindrical branch (*a*), whose cavity is in free communication with that of the cœnosarc, and whose distal extremity ends in a cul-de-sac invested, like the rest of the young branch, by the chitinous perisarc. Up to this point the phenomena are precisely similar to what we have just seen in the *Tubularians*; but now the distal extremity of the branch begins to enlarge, and at the same time continues to coat itself with a chitinous perisarc in the form of a capsule, which acquires increased thickness by successive deposits of new matter to its inner surface, thus contrasting with the much thinner pellicle which forms the temporary capsule in certain *Tubularians*.

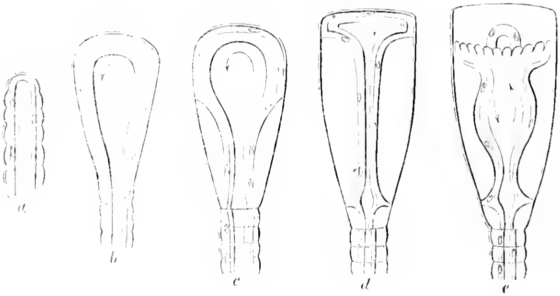
The extremity of the branch (*b*) now presents the shape of an inverted cone, plainly recognisable as the body of the budding hydranth, invested with a strong chitinous covering, which is closely applied over its whole surface, and is continuous below with the perisarc covering the rest of the branch. The interior of the young hydranth is hollowed out into a wide cavity lined by a layer of loose cells—the most internal cells of the endoderm—which are filled with a granular pigment.

The conical enlargement at the extremity of the branch continues to increase in size (*c*), and we soon see the soft parts within become contracted towards the proximal end of the cone, where they withdraw themselves from contact with the walls of the chitinous capsule, which had up to this time closely embraced them. At the wide or distal end of the cone they still remain adherent to the capsule for some distance downwards, while at the proximal end itself there is also a distinct but narrow zone of contact and adhesion maintained between the internal soft parts

[1] The first observations on this subject are those of Dalyell, who has made numerous experiments on the section of the stem in *Tubularia indivisa*, with results similar to those here recorded. (See Dalyell, 'Rare and Remarkable Animals,' vol. i, p. 23.)

and the external chitinous capsule. In the cavity which occupies the interior of the soft contents of the capsule very distinct rotating currents may be now seen, excited, doubtless, by the action of vibratile cilia, though a direct view of these cilia cannot be obtained through the thickness of the walls.

Fig. 33.



Development of Hydranth and Hydrotheca in *Laomedea flexuosa*.

a. Very early condition, in which the bud forms a simple cylindrical cæcal offset from the cœnosome.
b. The distal extremity of the bud has become enlarged, so as to present the form of an inverted cone.
c. The cone has increased in size, and the soft parts towards its proximal end have become retracted from the external chitinous walls.
d. The internal structures have still further withdrawn themselves from the chitinous walls, with which they are now in contact only by a narrow proximal and a wider distal zone, between which they present the form of a tubular cylindrical column.
e. The distal zone of contact has become retracted from the summit of the cup-like envelope of chitine, tentacles have begun to sprout from its circumference, and a hypostome has risen from its centre. The leading features of the completely formed hydranth are thus established, and its chitinous envelope has become the hydrotheca.
The arrows in the figures indicate currents in the somatic fluid.

Between the proximal and distal zones of contact the internal structures become more and more withdrawn from the walls of the capsule, while the whole body continues to elongate (*d*); and this may now be seen in the form of a cylindrical column occupying the axis of a conical cup of chitine, and expanded below into a narrow ring, which at this point connects it with the walls of the cup, while above it expands into a broad disc, which fills up the distal extremity of the cup like a lid or plug. The axis of the column is permeated by a tubular cavity in continuation below with the cavity of the branch, and expanding above into a wide chamber, which occupies the interior of the plug-like enlargement of its distal end. It is now plain that, while the soft contents of the cup are the developing hydranth, the cup itself is to become the hydrotheca.

The excreting of the chitine and the shaping of the hydrotheca would seem to devolve on the terminal plug-like disc alone, from the time that the lower parts of the nascent hydranth had withdrawn themselves from contact with the walls of the external capsule; and as the hydranth continues to elongate itself, the surrounding cup is extended at the same rate, by addition to its wider end from the sides of the disc, while the lower parts of the cup undergo little or no change.

The upper surface of the disc has been all along covered with a thin layer of chitine, whose periphery is continuous with the chitinous walls of the cup, but which does not interfere with the growth of the young hydranth; for as the latter continues to extend itself, the layer of chitine on the upper surface of the disc is carried onwards before it, without becoming thereby detached from the side of the cup—a fact which we can scarcely explain otherwise than by supposing considerable extensibility in the recently deposited chitine of the cup. At last the hydrotheca has attained its complete size and shape, and now the young hydranth becomes more or less retracted within it, the terminal plug-like disc withdrawing itself from the layer of chitine which it had excreted on its upper surface, and which is now left behind as a roof closing over the mouth of the cup.

The whole circumference of the retracted disc now begins to develop a circle of minute tubercles (*e*), which gradually elongate themselves into short thick tentacles, while the central part becomes elevated into a blunt conical proboscis (hypostome), and the cylindrical tubular column which occupies the axis of the hydrotheca has become dilated into a more oval-shaped body, with a wide internal cavity—the stomach of the developing hydranth.

The young hydranth, still included within a completely closed cup, presents greater and greater contractility, now withdrawing itself towards the bottom, and now extending itself through the entire height of the surrounding cup. The tentacles in the mean time have become longer, the extremity of the terminal cone has become perforated by a mouth, and at last the hydranth pushes off the chitinous roof of its hydrotheca, and emerges into free contact with the surrounding water.

b. Development of the Blastostyle.

In the gymnoblastic genera the development of the blastostyle is essentially similar to that of the first stages of the hydranth. Instead, however, of proceeding to the development of prehensile tentacles, an arrest takes place, sporosacs bud from its sides, and the nutrition of the colony, to which the hydranth is destined, becomes replaced by the duty of supporting the sexual buds. In the calyptoblastic genera the development of the blastostyle is accompanied by some additional features which render necessary a more detailed description.

Laomedea flexuosa will afford here too a very convenient subject for tracing the process of development. The blastostyles of this hydroid arise close to the axillæ of the branches, and present the form of a long cylindrical column, expanded at its summit into a disc, occupying the axis of a spacious gonangium, and carrying along its whole length adelocodonic gonophores, which increase in maturity as they approach the summit of the column. The whole is elevated on a short annulated peduncle.

The blastostyle here originates in a bud precisely in the same way as a hydranth; and up to the stage to which we have already followed the development of the hydranth and hydrotheca, when these parts present the condition of a conical enlargement of the extremity of the branch, there cannot be found any difference between the hydranth-bud and the blastostyle-bud. It would seem, however, that at this stage the soft parts, instead of absolutely withdrawing themselves from contact with the external chitinous capsule, present in their ectodermal layer a number of lacunæ, which, increasing in size, become confluent with each other, and the ectoderm thus becomes split into two layers by a true *chorization.* The external layer remains in contact with the chitinous capsule, while the internal layer, remaining adherent to the endoderm, becomes more and more withdrawn towards the axis of the bud, where it now constitutes the external or ectodermal layer of an axile column or blastostyle. The capsule thus becomes lined with a thin layer of ectoderm, which is continuous with the ectoderm of the blastostyle only at its distal and proximal extremities, these two membranes being in the whole of the intermediate region separated from one another by a wide interval. This interval, which constitutes the cavity of the developing gonangium, is thus nothing more than a large lacuna; and it is in this lacuna that the sporosac or blastocheme now begins to bud forth from the axile column. The exereting and modelling of the chitinous gonangium would seem to devolve for some time still on the ectodermal lining instead of being, as in the hydranth-bud, transferred at a very early period exclusively to the disc-like summit of the axis. After a time, however, the lining membrane entirely disappears, and henceforth the exereting and modelling of the gonangium seems to devolve on the terminal disc of the blastostyle. While the gonangium is yet young, numerous irregular fleshy bands may be seen stretching across the cavity from the blastostyle to the external wall. These bands are the remains of the original union between the two layers into which the ectoderm has split. They are generally torn, and disappear as the gonangium, increasing in size, has its walls more and more widely separated from the blastostyle; but they are also occasionally more or less visible in the full-grown gonangium.

A comparison between the developing hydranth and its hydrotheca, on the one hand, and the developing blastostyle and its gonangium on the other, affords a most instructive parallelism, showing the close connection between the hydranth and the blastostyle. If in the hydranth-bud the development were arrested at the point to which it arrives just before the terminal disc has withdrawn itself from the roof of the young hydrotheca (woodcut, fig. 33 *d*), in order to develop its tentacles, we should have in almost every particular a gonangium with its blastostyle (see woodcut, fig. 18). The development of a mouth and tentacles, however, points towards a different destination; and now, instead of producing zooids destined for generation, the hydranth applies itself solely to the nutrition of the colony.

The gonangium does not always present the simple form which we find in *Laomedea flexuosa,* and we have already seen the remarkable modification which it undergoes in the female colonies of *Sertularia rosacea, S. fallax,* and *S. tamarisca,* by the formation of a marsupial chamber for the protection of an extra-capsular sac, in which the ova are retained during the earlier periods of their development.

c. Development of the Sporosac.

The development of the sporosac or adelocodonic gonophore, in its simplest form, may be easily studied in *Hydractinia echinata.* In this hydroid the gonophores are borne on a blastostyle (Pl. XV, and woodcut, fig. 4 *bb, c*), which here, just as in the blastostyle of the *Sertularians* and *Campanularians,* is morphologically nothing more nor less than an arrested hydranth, but in *Hydractinia* never developing a gonangium.

In their earlier stages the sporosacs may be seen as minute hollow tubercles, projecting from the sides of the blastostyle. They are composed of two layers, endoderm and ectoderm, directly continuous with the corresponding layers of the blastostyle, with whose cavity that of the young bud is in free communication. At first we can detect no change beyond a simple increase in size; but we soon find the ectoderm separated from the endoderm by the interposition of a minutely granular mass between them. This mass constitutes the basis of the generative elements, and is afterwards to become ova or spermatozoa. In the mean time the ectoderm has itself become differentiated into two layers; and we have thus laid down the foundation of all the parts which we meet with in the full-grown gonophore. The wall of endoderm which surrounds the central cavity of the developing gonophore, and is itself immediately surrounded by the generative elements, is the spadix; the more internal of the two layers into which the ectoderm has divided is the endotheca, the more external the ectotheca.

The sporosac now becomes more and more distended by the increasing volume of the generative mass, while the spadix at the same time continues to grow, and now constitutes a club-shaped hollow organ, extending through the axis of the mass, while floating particles from the cavity of the blastostyle are freely admitted into its interior, where they may be seen performing active rotatory movements.

The sex of the gonophore becomes evident at an early period, by the appearance of ova with their germinal vesicle and spot in the generative plasma of the female, while in the male the interval between the spadix and endotheca continues still to be occupied by a uniform grumous plasma, in which, at a somewhat later period, spherical cells and ultimately free-moving spermatozoa may be detected.

The gonophore of *Hydractinia echinata* does not pass to any higher grade of development than that here described; but in some other forms of adelocodonic gonophore a further differentiation takes place by the development of an additional membranous sac or mesotheca, with gastrovascular canals, between the endotheca and ectotheca (*Tubularia indivisa*—Pl. XX, fig. 3, and Pl. XXIII, figs. 8 and 11). I have never succeeded in following the development of the mesotheca, and cannot say under what condition it begins, or how it proceeds, the membrane appearing always fully formed from the moment it is recognisable.

It will be seen that in the above account I differ in some important points from the interpretation given by Agassiz to the appearances which present themselves in the development of the adelocodonic gonophore. In his account of this process in his *Clava leptostyla*, Agassiz[1] regards the perigonium or walls of the gonophore as simple, and as homologous with the umbrella of a medusa. In *Clava multicornis*, however, the existence of two membranes may with care be demonstrated in these walls, though I admit that I have frequently failed in detecting more than a single one. In no case, however, can the walls of the gonophore in *Clava* be regarded as the homologue of an umbrella. When two membranes can be demonstrated in them, these will be an endotheca and ectotheca; if only a single membrane be present, as Agassiz believes to be the case in his *Clava leptostyla*, this will be an endotheca, while the part which would really represent an umbrella, namely, a mesotheca, is not developed.[2]

[1] *Op. cit.* vol. iv, p. 221.

[2] In my earlier researches into the anatomy of the reproductive system in the *Hydroida* ("On the Anatomy and Physiology of *Cordylophora*," Phil. Trans. 1853), I entertained the view here advo-

Again, in the gonophores of *Hydractinia polyclina*, Agass., *Tubularia* (*Parypha*) *crocea*, Agass., and *Tubularia* (*Thamnocnidia*) *spectabilis*, Agass., Agassiz correctly figures the two membranes which enter into their walls; but he assuredly assigns an incorrect origin to the more internal of these membranes when he describes it as rising, subsequently to the formation of the generative mass, from the proximal end of the gonophore in the manner of a cup closely pressed against the outer wall, and, at least in *Hydractinia* and *Tubularia spectabilis*, ultimately closing over the contained structures so as to form a continuous internal wall.

Now, the internal wall in the gonophore of *Hydractinia* is undoubtedly formed, not *after*, but simultaneously with the appearance of the generative mass, and is nothing more than the internal of the two layers into which the ectoderm of the primary bud has become divided simultaneously with its separation from the endoderm by the interposition of the generative elements; it is thus the endotheca of the sporosac, while the more external layer is the ectotheca.

Having had no opportunity of examining the development of the gonophores in either of the two *Tubulariæ* cited above, I am unable to bring any direct observation into opposition with the views of Agassiz as to the gonophores of these hydroids; but the analogy of *Hydractinia* and of other hydroids, whose adult gonophores correspond in all essential points with those of the American forms, leads me to believe that the process is in all the same as in *Hydractinia*.

It is only in those cases where a mesotheca becomes developed, as in *Tubularia indivisa*, that the adelocodonic gonophore presents any true representative of the umbrella of a medusa, the mesotheca being properly the homologue of this part. Agassiz, in his account of *Tubularia Couthouyi*, Agass., ignores the existence of any membrane between the well-developed mesotheca of this species and the generative mass which surrounds the spadix. In *Tubularia indivisa*, however, this membrane cannot be overlooked, especially in the male, though in the female it would seem to disappear at an early period, and may thus escape detection.

d. Development of the Medusa.

The medusa, whether gonocheme or blastocheme, shows itself at first in every case as a minute hernia (woodcut, fig. 34 A), consisting of endoderm and ectoderm, and having its cavity in free communication with that of the blastostyle, or of the trophosome from which it springs; thus in no respect differing at this period from the corresponding stage in the development of the adelocodonic gonophore, or, indeed, in that of a hydranth branch.

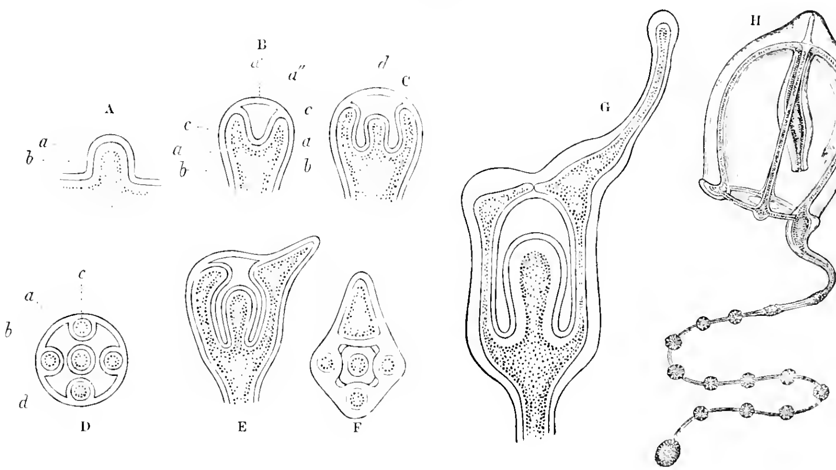
It is very difficult to follow satisfactorily the several steps by which this primordial tubercle becomes ultimately converted into a medusa. I have bestowed great attention on it in different species of HYDROIDA, and have more recently subjected the development of the medusa bud

cated by Agassiz, as to the homology of the parts in question. Subsequent more extended observations, however, have induced me to modify in some respects the views then expressed, and to adopt those which are advocated in the present Monograph. (See my paper "On the Reproductive Organs of *Sertularia tamarisca*," in the Report of the British Association for the Advancement of Science, 1858.)

in *Corymorpha nutans* to a laborious examination, which has led me to adopt the process now about to be described, as the true interpretation of the phenomena presented in this hydroid.

We first find that four equidistant processes (woodcut, fig. 34 B *c*), consisting of endoderm and ectoderm, with an included cavity, which is a continuation of that of the hernia-like tubercle just mentioned, have begun to grow upwards from a circle round the summit of this primordial bud. These, however, do not show themselves as free processes; for simultaneously with their appearance the ectoderm of the summit of the bud becomes split into two layers (*a'*, *a''*), which become more and more widely separated from one another as the processes continue to elongate, the outer layer arching over the space which is surrounded by the four processes. During this elongation the ectodern which occupies the four intervals between the roots of the processes is carried upwards as a continuous membrane, stretching across from one process to another in the manner of a web.

FIG. 34.



Development of the Planoblast in *Corymorpha nutans*.

A, Very early stage of the medusa-bud when it presents the form of a simple hernia-like tubercle, whose cavity is in communication with the somatic cavity of the hydroid; *a*, ectoderm; *b*, endoderm.
B, More advanced stage. *a*, ectoderm; *b*, endoderm; *a'*, the more external of the two layers, into which the ectoderm of the bud has split; *a''*, the more internal of these two layers; *c*, commencement of radiating canals.
C, Stage still more advanced, *a*, ectoderm; *b*, endoderm; *c*, radiating canals; *d*, manubrium.
D, Transverse section of C. *a*, ectoderm; *b*, endoderm; *c*, radiating canals; *d*, manubrium.
E, A stage still more advanced than C. The distal ends of the radiating canals have become dilated into bulb-like expansions, one of which has begun to extend itself as a marginal tentacle.
F, Transverse section of E.
G, A stage somewhat more advanced than E. The bulbous terminations of the radiating canals have coalesced, and one of them has become projected into a thick tentacle.
H, Medusa, just after liberation from the trophosome.

The result of this is, that we have now the distal portion of the bud in the form of a deep cup, closed over by a layer of ectoderm, and having its walls traversed by four equidistant cæcal tubes, whose cavity is continuous with the original cavity of the bud, and which are lined by a continuation of the endoderm of the bud. There is no difficulty in recognising in these tubes the radiating canals of the future medusa, and in the web of ectoderm which unites them the umbrella.

From the central point of the area included between the bases of the four canals another hernial process (C *d* and D *d*) has already begun to make its appearance, composed of ectoderm and endoderm, and containing a prolongation of the original bud cavity. It advances as a thick process in the axis of the cup, and is at once recognisable as the future manubrium.

The four peripheral processes continue to elongate, and are soon seen to be dilated into bulb-like expansions at their extremities (E, F). The bulbs increase in size, and come in contact by their sides; while one of them, enlarging much more rapidly than the three others, gives a marked preponderance to its side of the bud, and makes the distal end of the bud appear as if obliquely truncated. It then begins to extend itself beyond this distal end into a thick, hollow tentacle.

In the mean time the four bulbs which had come in contact have coalesced, and their cavities now communicate with one another (G); but, by the gradual enlargement of the distal end of the bud, the bulbous ends of the radiating canals are again drawn away from one another. The communication, however, between their cavities is not thereby interrupted, but continues to be maintained by a tubular elongation of their original points of union; and in this tube we now recognise the circular canal of the medusa.

The cavity of the umbrella is still closed by the more external of the two laminæ into which the ectoderm had originally split at the distal end of the bud. In the final stage this lamina is either perforated in the centre, in order to form the velum, or, what I now believe to be more probable, it entirely disappears, and the velum is formed by a centripetal extension of the ectoderm on a plane with the bulbous extremities of the radiating canals, at the time when these bulbs are withdrawn from contact with one another, in order to form the circular canal.

The manubrium, previously imperforate, has now acquired a mouth at its extremity. The solitary tentacle, too, has now become elongated, and presents its characteristic moniliform structure, the umbrella rapidly contracts and expands with vigorous systole and diastole, and the medusa at last hangs on its stalk, a true *Steenstrupia*, ready to break away from the restraint of its fostering hydranth, and enter upon an independent existence (H, and Pl. XIX, fig. 5).

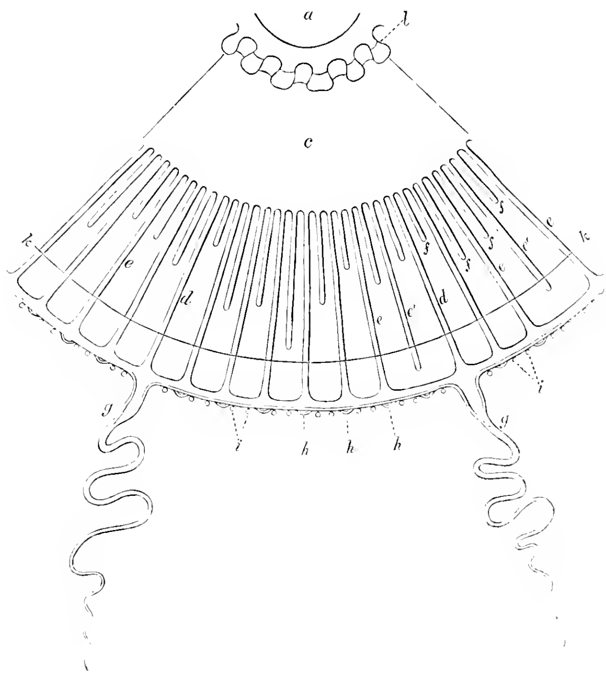
From the above account of the development of the medusa bud, it will be seen that here also I am not entirely in accordance with the views expressed by Agassiz on this subject. The distinguished American naturalist gives a very detailed account of the process as he has interpreted it in the development of the medusa-bud springing from his *Syncoryne mirabilis*, and in which he describes this development as starting with the separation of the endoderm from the ectoderm in the primordial tubercle, and the inversion of the endoderm into itself, so as to form the cup of the future umbrella. "In doubling on itself the retreating fold does not press closely on all points upon the stationary one, but leaves four equidistant spaces into which the chymiferous fluid penetrates."[1] These four spaces are the foundation of the four radiating canals, which would thus originate in an entirely different way, and have a significance entirely different

[1] 'Natural History of the United States,' vol. iv, p. 192, &c.

from what my observation of the process in *Corymorpha* and other genera has led me to regard as the true one.

M'Crady[1] believes that those medusæ which occur among the gymnoblastic hydroids, where, as we have already seen, they belong to the type of the gonocheme, are developed in a different way from those which we find among the *Campanularians*, and where they present the type of the blastocheme. He describes the umbrella in the former as produced by an excavation of

Fig. 35.



Segment of a young *Æquorea* captured off the west coast of Scotland, showing the development of the radiating canals.

a. Mouth; *b,* frill-like lip; *c,* floor of the greatly expanded base of the manubrium, from whose circumference the radiating canals are emitted; *d, d,* primary radiating canals; *e, e,* canals developed later, and already united with the circular canal; *e', e',* canals which have not yet reached the circular canal; *f. f. f. f,* canals still less developed, on their way to the circular canal; *g, g,* developed marginal tentacles; *h, h, h,* rudiments of marginal tentacles; *i, i,* lithocysts; *k, k,* margin of velum.

the substance of the young bud, forming thus a completely closed cavity in which the manubrium is included, and which only at a subsequent period becomes perforated at its summit to form the

[1] Op. cit. p. 110.

orifice of the umbrella. In the *Campanularians*, on the other hand, he believes that the umbrella grows up from below as a ring round the manubrium, which is thus never included in a closed cavity, but is from the first directly exposed to the surrounding medium. In accordance with these views, M'Crady divides the gymnophthalmatous or hydroid medusæ into the "endostomata" and the "exostomata." My own observations, however, will not allow me to adopt this division of M'Crady. In the medusa of *Campanularia* at all events the development is essentially the same as that just described in the medusa of *Corymorpha*.

The medusa has not necessarily attained its complete development at the time when it has become fitted for an independent existence, and has detached itself from the trophosome in order to spend its future life in the open sea. It is very common to find both tentacles and lithocysts less numerous at the time of liberation than at a more advanced period; while in some cases (*Æquoria*) the radiating canals continue to increase in number with the age of the free medusa [1] (woodcut, fig. 35).

In every case in which I have had an opportunity of observing the formation of new radiating canals, these have been developed in a centrifugal direction. They commence as offsets from the base of the manubrium (woodcut, fig. 35, *f*), or from the previously existing canals, and then becoming elongated in the gelatinous substance of the umbrella, they direct themselves towards the umbrella margin until they meet the circular canal with which they inosculate. This penetration of previously formed tissue by the nascent canals, their invariable maintenance in it of a definite direction, and their inosculation with a canal already completed, are phenomena not without their general significance in the formative forces of living beings.

In some cases still more striking transformations have been witnessed in the free medusa. Thus Gegenbaur observed that the *Trachynema ciliatum*, Gegenb., a medusa not yet traced to a polypoid trophosome, is in its young state a free-swimming flask-shaped body, with three or four minute tentacles in a circle round the base of its contracted neck-like portion, and with a clothing of vibratile cilia over its whole surface. It subsequently developes an umbrella and gastrovascular canals, and becomes provided with numerous imperfectly contractile tentacles.[2]

It is, however, in the family of the *Geryonidæ* to which the *Æginidæ*, as follows from Haeckel's observations, must now, notwithstanding their very different form, be united, that we meet with medusæ which, during their free state in the open sea, undergo the most striking change, passing through a series of metamorphoses which consist, not only in the development of new parts, but in the loss of organs which, being destined to enjoy only a transitory existence, disappear, as is described below, to make way for permanent ones of an entirely different form. It is true that none of these medusæ have as yet been traced to a hydraform trophosome; but they are not on that account of less importance in the general history of hydroid development.

[1] Alexander Agassiz has shown that in their order of succession the marginal tentacles of the Hydroid Medusæ obey a law very similar to that which Milne-Edwards and Jules Haimes have shown to regulate the formation of the successive septa in the Actinozoa. A. Agassiz in 'Proc. Bost. Soc. Nat. Hist.,' vol. IX, Aug. 1862.

[2] 'Generationswechsel,' p. 51.

An exceedingly interesting case of metamorphosis in an Æginidian medusa has been described by M'Crady.[1] He observed, lying free in the umbrella-cavity of an Oceanidan medusa, to which he gives the name of *Turritopsis nutricula* multitudes of little organisms, presenting various forms, from that of a minute club-shaped hydroid to that of a well-developed medusa belonging to the type of the *Æginidæ*, and all undoubtedly connected with one another as stages of a simple developmental process.

Though he at first believed these to be the proper offspring of the *Turritopsis* in which they occurred, he afterwards rejected this notion, and recognised in them the young of a species of *Cunina* (*Cunina octonaria*, M'C.), which had selected the umbrella-cavity of the Oceanidan in order to spend there as parasites the early stages of their existence.

The untentaculated, club-shaped larva (the earliest stage observed) was followed by a bitentacular hydroid form with long imperforate proboscis and distinct internal digestive cavity, and he noticed the interesting fact that this bitentacular stage freely repeats itself by budding. Next, two other tentacles make their appearance symmetrically between those first formed, while the extremity of the proboscis seems now to be perforated by a mouth. The umbrella next begins to make its appearance by an annular extension of the circumference of the body close to the oral side of the roots of the tentacles; and four new tentacles begin to sprout between those already formed, while lithocysts become developed on the margin of the incipient umbrella. After this the larva assumes the form of an adult *Cunina* in all essential points, except in the possession of a long proboscis, like that of a *Geryonia*, in which stage it leaves the umbrella-cavity of the *Turritopsis* to spend a free life in the surrounding water. It is only after it has quitted the medusa on which it had been hitherto living as a parasite that it loses its proboscis, and that the digestive cavity thereby assumes the form characteristic of the family of the *Æginidæ*. M'Crady views this case as presenting an instance of direct development from the ovum, believing that the *Cunina* originally gained access to the umbrella of the *Turritopsis* in the condition of a free-swimming planula.

Fritz Müller[2] has given an excellent account of the metamorphosis of a Geryonidan medusa, *Liriope cathariensis*, Fr. Müller; and his observations have been confirmed and extended by Haeckel,[3] who has described similar metamorphoses in two other Geryonidans, *Glossocodon* (*Liriope*) *eurybia* and *Carmarina* (*Geryonia*) *hastata*. In all these cases the medusa in its earliest observed condition was found swimming free in the open sea. The youngest medusa noticed presented the form of a minute hyaline gelatinous sphere; on one point of whose surface was a small pit-like depression closed over by a perforated diaphragm; and the most striking feature in the subsequent metamorphosis consisted in the development of two sets of peculiar larval tentacles, of which one or both sets were destined after a period to disappear, their place being supplied by an entirely different set, which remained as permanent organs during the life of the medusa. The larval tentacles are solid and rigid, and have no connexion with the gastrovascular system; while the permanent tentacles are hollow offshoots from the circular canal, and are eminently flexible and extensile.

While we are entirely ignorant of the origin of the free-swimming bodies which have been

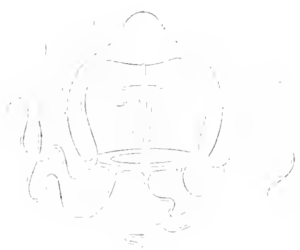
[1] Proc. Elliott, 'Soc. Nat. Hist. Charleston, 1856,' p. 55.

[2] 'Wiegmann's Archiv,' 1859, p. 310.

[3] Haeckel, 'Die Familie der Rüsselquallen.'

thus traced through a series of metamorphoses into adult Geryonidans, it has been proved that certain other free medusæ of the Æginidan type have originated as buds from adult forms. This, however, leads us to consider the formation of buds by the medusa.

Fig. 36.



Medusa, probably young *Lizzia*, captured in the open sea, with medusa-buds springing from the base of the manubrium.

Formation of Buds by the Medusa.—The phenomenon of medusa-budding does not necessarily find its extreme term in the formation of the medusa itself. Many free-swimming medusæ, some of which are known to have originated in hydroid trophosomes, complicate themselves by gemmation, which manifests itself in the production of other medusa-buds upon various parts of their bodies. A fine example of this phenomenon is afforded by the medusa of the tubularian hydroid, *Hybocodon prolifer*, Agass. In this beautiful animal, Agassiz[1] describes the base of the solitary tentacle which is continued from the distal extremity of one of the radiating canals of the medusa as itself producing a cluster of medusa-buds, which in time assume the form of the primary medusa, and may themselves repeat the same process, through the production of successive broods of similar buds, before they become detached as free natatory medusæ. Steenstrup[2] has observed buds developed from the base of the tentacles in a medusa which he believes to have originated in a Coryne-like trophosome, which he names *Coryne fritillaria;* Greene has described the production of buds, not only from the bulbous base of the tentacles, but also along the course of the tentacles themselves in a nearly allied medusa, *Diplura*, Greene;[3] while the emission of buds by medusæ has also been described by Forbes,[4] Sars,[5] Busch,[6] and others.

I have several times witnessed this phenomenon in medusæ captured while swimming in the open sea. In some of these cases the buds were borne on the base of the manubrium (woodcut, fig. 36), in others, on an elongated tubular peduncular extension of the manubrium (woodcut, fig. 37), and in others upon the bulbous bases of the marginal tentacles (woodcut, fig. 38). The singular ambulatory medusa of Clavatella also multiplies itself by budding from the intertentacular spaces on the umbrella-margin (see Pl. XVIII, fig. 5). In these various cases the buds seem destined to assume the form of the medusa which gave origin to them, but observations on

[1] Op. cit. vol. iv, p. 245, pl. 24.

[2] J. J. Steenstrup, 'Alternation of Generations,' p. 26; Roy. Society's Translation, 1845.

[3] J. R. Greene, in 'Nat. Hist. Rev.,' 1857, vol. iv. The Medusæ is there named *Diplonema*, but from this name having been already given to a genus of plants, it was subsequently changed by Greene to *Diplura*. See my paper "On the Genera of the Hydroida," in 'Ann. Nat. Hist.' for May, 1864.

[4] 'British Medusæ.'

[5] 'Fauna lit. Norveg., erste Lieferung.'

[6] 'Beobachtungen ueber Wirbellos. Seethieren.'

their history after detachment from the parent-medusa are still wanting, in order to enable us to speak positively on this point.

In certain medusæ belonging to the family of the *Geryonidæ* it would seem, from the observations of Gegenbaur,[1] Kölliker,[2] Krohn,[3] Fr. Müller,[4] Keferstein and Ehlers,[5] and, above all, from the remarkable researches of Haeckel,[6] that the formation of buds within the cavity of the stomach is a constant and normal phenomenon. It would further appear that these buds, for the most part, detach themselves while still in a very immature state, and that after becoming free they undergo a metamorphosis before arriving at their adult condition; and, still further, it has been shown that in at least some of these cases there is a heteromorphism, the buds becoming developed into a form very different from that of the medusa which gave rise to them.

FIG. 37.

Sarsia, captured in the open sea, with medusa-buds borne by the manubrium.

a. Wide oral extremity of the manubrium; *b*, *b*, attenuated proximal portion of the manubrium, carrying the buds in various stages of development.

FIG. 38.

Medusa, probably the planoblast of a *Syncoryne*, captured in the open sea, and bearing clusters of medusa-buds on the bulbous bases of the marginal tentacles.

This last phenomenon has been witnessed in a case recorded by Fritz Müller,[7] who describes the formation of ciliated buds from the internal surface of the stomach in an eight-tentacled *Cunina*, which he names *C. Köllikeri*. He traced these buds through various stages until he

[1] 'Generationswechsel,' p. 56.

[2] 'Zeit. f. wissen. Zool.' 1853, p. 327.

[3] 'Archiv. fur Naturgesch.' 1861, p. 168.

[4] Ibid., p. 51.

[5] 'Zoologische Beiträge,' 1861.

[6] 'Die Familie der Rüsselquallen (Geryonida),' 1865, p. 115, &c.

[7] 'Wiegmann's Archiv,' 1861.

saw them detach themselves and swim free in the cavity of the stomach. Here they underwent further development, which he continued to observe until he saw them transformed into true *Cuninæ*, differing, however, from the parent by the fact of their having twelve tentacles and twelve stomach-pouches, instead of eight, the number characterising the medusa which gave origin to them. Beyond this point Müller lost sight of them, and we are accordingly ignorant of their further changes and destination.

But in no recorded case of the production of one medusa from another by budding is the heteromorphism between the budding medusa and the buds produced by it so striking, and nowhere has it been so fully traced as in the observations of Haeckel, described in his remarkable memoir on the *Geryonidæ*, in which he has shown that a sexually mature Geryonidan medusa (*Carmarina hastata*, Haeckel), having its segments a multiple of six, produces upon the tongue-like process which in this genus projects from the fundus of the stomach into its cavity a multitude of buds which become developed, not into a six-rayed form resembling that of the Geryonidan which gave rise to them, but into true *Cuninæ*, Æginidan medusæ having eight instead of six elementary body-segments, and like all the Æginidan medusæ belonging to a type which had been previously regarded as possessing no relation whatever with the *Geryonidæ*.

It is not alone in the fact that the buds belong to a very different medusa-type from the budder that the phenomena described by Fritz Müller and by Haeckel present features peculiar and anomalous; for the situation of the buds within the stomach cavity of the bud-producing medusæ is without parallel in any other group of Hydroida. In every case where medusa-buds have been observed among other families of the Hydroida, the somatic cavity of the bud has been in communication with some part of the somatic cavity of the hydroid which produces it; while here such a communication is impossible before the development of the mouth in the bud shall enable the young Æginidan to receive nutriment through this orifice from the stomach cavity of the supporting medusa.

Two other cases, however, both among the Æginidan type of the *Geryonidæ*—namely, that of *Cunina prolifera*, described by Gegenbaur,[1] and that of *Ægineta gemmifera*, described by Keferstein and Ehlers[2]—have also been recorded, in which the young medusæ are formed as buds within the cavity of the stomach, in both of these instances the buds having been developed from the internal surface of the stomach walls. In all these cases the buds must have been formed in a very different way from that which takes place in the ordinary cases of budding medusæ—so different, indeed, that were it not for the competency of the observers who have described them as cases of true budding, we should be disposed to regard them as suggesting parasitism, rather than gemmation.

It is not, however, only in the *Geronyidæ* that we meet with cases of heteromorphic budding from the medusa; for the blastocheme, as we have already seen, is constructed on the plan of a fully developed hydroid medusa; while its sexual buds are simple sporosacs.

[1] 'Generationswechsel,' p. 56. [2] 'Zeit. fur wissen. Zool.,' 1853, p. 352.

2. *Development of the Ovum.—Embryonal Development.*

The general form and structure of the ovum has already been considered; the phenomena presented by the development of the embryo now remain for discussion.

Development of the Embryo from the commencement of the segmentation of the Vitellus to the attainment of the free locomotive stage.—I shall here describe this process as I have observed it in *Laomedea flexuosa*, which may be regarded as affording a type of embryonal development throughout the HYDROIDA. In this species the gonophores, which belong to the adelocodonic class, are included within a gonangium, where they are borne along the whole length of a blastostyle, regularly increasing in maturity as they recede from the base towards the summit of their supporting column (woodcut, fig. 18). Each gonophore in the female colony contains but a single ovum—a fact which facilitates the observation of the development.

The mature-ovum (woodcut, fig. 39 A), previous to the commencement of segmentation, is about 0·01 inch in diameter; it is of a granular structure, and contains a very distinct clear germinal vesicle about 0·002 of an inch in diameter, situated very excentrically, and easily separated from the surrounding vitellus, when it may be isolated as a perfectly spherical vesicle upon the stage of the microscope. There is occasionally a single germinal spot, but its place is usually taken by several (2 to 10) minute more or less spherical or oval bodies, which lie in the perfectly transparent and colourless fluid contents of the germinal vesicle. When the germinal vesicle is freed from the surrounding vitellus, and floated in sea-water on the stage of the microscope, these bodies almost instantly disappear without leaving a trace behind, being apparently dissolved by water absorbed from without through the walls of the vesicle. If, however, a little tincture of iodine be previously added to the water, they continue visible, and are now plainly seen to be themselves vesicles, containing within them a few minute granules which have been rendered obvious by the action of the iodine.

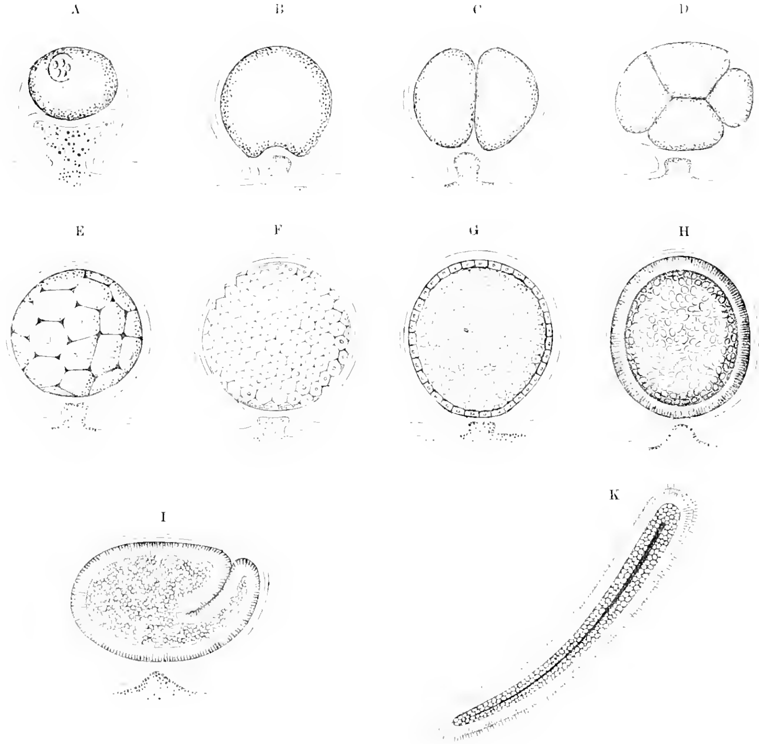
The vitellus is entirely composed of minute spherical corpuscles of apparently homogeneous structure, about 0·0002 of an inch in diameter, along with granules so small as not to admit of measurement. There is no obvious vitellary membrane in the mature ovum, but I have satisfied myself of its presence while the ovum is still in a very young state. In other species, *Hydractinia echinata* for example, this membrane is very obvious in the ovum just before segmentation. There is no trace of a micropyle in the ovum of this or of any other hydroid which I have examined.

As already said, there is never more than a single ovum in each gonophore of *Laomedea flexuosa;* and as this ovum continues to enlarge, it presses back the spadix until the latter is reduced to a small hollow projection in the bottom of the gonophore.

Up to this time the germinal vesicle continues quite distinct, but it now entirely disappears (B). The disappearance of the germinal vesicle is unaccompanied by any apparent change in the structure of the ovum, which retains the same peculiar composition of spherical corpuscles and granules. I have little doubt that the vesicle now ceases to exist, and that its disappearance is not due to its being merely concealed in the mass of the vitellus. It has probably burst, and in so doing must have liberated its peculiar contents, which will then, of course, be no longer visible in the vitellus. The disappearance of the germinal vesicle is probably the immediate result of impregnation; for I have seen active spermatozoa a little before this time in the cavity of the female gonophore.

Until, however, we have further evidence of what really becomes of the germinal vesicle,

FIG. 39.



Development of the ovum in *Laomedea flexuosa*.

A, Young ovum in the gonophore previously to the disappearance of the germinal vesicle; the germinal vesicle is here seen to contain several germinal spots. B, The germinal vesicle and spots have disappeared. C, The vitellus has become cleft into two segmentation-spheres. D, The ovum after the second cleavage. E, The segmentation-spheres have become numerous, and many of them now show a distinct nucleus. F, The segmentation-spheres have greatly increased in number, and a nucleus may now be detected in each of them. G, The segmentation-spheres have still further increased in number, while the most superficial have become arranged into a stratum distinguishable from the deeper portion of the ovum. H, The superficial stratum has become more distinct, and is now seen to be composed of long prismatic cells. I, The ovum has begun to elongate itself, and one end has become folded on the remainder. K, The embryo just after its escape in the form of a ciliated planula.

it is useless to speculate upon the influence which the supposed liberation of its contents may exert in exciting the new series of phenomena which are now about to take place in the ovum; at all events, shortly after the disappearance of the germinal vesicle, the process of segmentation sets in. This process is certainly not preceded by the visible occurrence of a new nucleus destined to take the place of the germinal vesicle. It is quite possible, however, that such a nucleus may exist, though, from its small size, and from being so deeply imbedded in the mass of the vitellus, it may have eluded our attempts to discover it.

The first step observable in the segmentation-process is the cleavage of the yolk into two segments (C), immediately followed by the cleavage of these into other two, so that the vitellus is now composed of four cleavage-spheres (D). In none of them, however, can a nucleus be as yet demonstrated.

The segmentation would now appear to proceed very rapidly, but not always with absolute regularity; for it would seem occasionally to advance more rapidly in some of the previously formed spheres than in others. By the time that the vitellus presents about thirty-six or more cleavage-spheres (E) we begin to recognise in some of these spheres a distinct nucleus; while, as the spheres become smaller and more numerous, the nuclei become more and more apparent, until at last there may be seen in every minute sphere, of which the segmented yolk is composed (F), a brilliant nucleus, visible not only in the superficial spheres, but also in the deeper ones which come into view when the ovum is broken down under the compressor. It is, therefore, highly probable that in the earlier stages also a nucleus exists in every cleavage-sphere, but that in consequence of the thickness and opacity of the enveloping vitellus it is withdrawn from observation. The cleavage-spheres at this stage present the same peculiar structure which we find in the yolk just before the commencement of segmentation, consisting, as they do, of minute spherical corpuscles, with still more minute granules. When the vitellus has thus become broken up into a great number of minute spheres, it is evident that the most superficial of these spheres have arranged themselves into a distinct stratum, consisting of a single layer of spheres, and completely enveloping the more internal parts (G).

We next find that the spheres composing this layer have increased in number, while at the same time they have become longer in the direction of the radius of the ovum, and now form a rather thick layer of undoubted cells, arranged with their long axes perpendicular to the surface of the ovum, having their sides in close contact and investing, as with a continuous wall, the whole interior of the mass (H).

It is impossible not to see in the entire process here described an exact parallelism with the early stages in the development of the holoblastic vertebrate ovum, while the superficial layer of cells, to the formation of which we have just arrived, must—though as yet showing no obvious tendency to a splitting into distinct laminæ—be at once recognised as the representative of the vertebrate blastoderm.

The nuclei, which were previously visible in the cleavage-spheres, have now ceased to be distinguishable, while these spheres at the same time show a distinct investing membrane. In fact, on now carefully breaking down the ovum under the microscope, its interior is found to consist entirely of loosely aggregated cells, some spherical, some more elongated, and all with a more or less copious endogenous brood of secondary cells within them.

The external enveloping layer having thus attained a considerable thickness, and a well-defined differentiation between it and the more internal parts having been established, the ovum begins to elongate itself, and at the same time the interior has undergone a further change; for we no longer find in it the large mother-cells with their endogenous brood, but a multitude of small, free, clear vesicles, of various sizes, mingled with minute granules, similar to those which had all along formed a part of the constituents of the segment spheres.

At this point we may conveniently, though somewhat arbitrarily, designate the developing body as the "embryo." We next find that one end of the oval embryo begins to be prolonged beyond the rest, upon which it becomes bent back as it continues to elongate itself (I). By this time the embryo has become endowed with evident contractility, as manifested by sluggish changes of contour.

Shortly after this the embryo escapes from its confinement by the rupture of the walls of the gonophore, when it speedily straightens itself, and then, in the form of an elongated, nearly cylindrical body, slightly tapering towards one end, is discharged through the summit of the gonangium into the surrounding water (K).

We now find that its whole surface is clothed with vibratile cilia, by whose aid it moves slowly along the bottom of the vessel, while the cells and granules which occupied its deepest parts seem to have undegone a kind of liquefaction, resulting in the formation of an elongated cavity in the axis of the embryo which is thus, at this period, a nearly cylindrical sac, without, as yet, any appearance of a mouth, but with an endoderm and ectoderm already differentiated, while multitudes of very minute elongated oval bodies, with a high refractive power, soon make their appearance in the ectoderm; these are most probably thread-cells, though no sign of a filament can as yet be discovered in them.

I am unable to form any decided conclusion as to whether the endoderm, which thus about this period becomes demonstrable, is to be regarded as the remains of the more central cells of the segmented ovum, or as an inner lamina formed by a differential splitting of the peripheral layer or blastoderm. The appearances are rather in favour of the former view; but if the latter be the true interpretation, the analogy up to a certain point with the development of the vertebrate ovum will be the closer. At all events there can be little doubt that the two membranes which now make their appearance and continue as the endoderm and ectoderm of the developing hydroid are functionally equivalent, the endoderm to the internal or vegetative layer, and the ectoderm to the external or animal layer of the vertebrate blastoderm. It will be seen in the sequel that the parts which are concerned in digestion and in generation have their seat in the endoderm, while those which are destined for the functions of sensation, locomotion, and protection, originate in the ectoderm—a state of things which has its exact parallel in the two laminæ of the vertebrate blastoderm.[1]

We have thus arrived at the ciliated and locomotive stage of the embryo. To this stage Sir John G. Dalyell has given the name of "planula"—a name, however, suggested by a mistaken view of its form, which he compares to a *Planaria*. In this comparison he has probably been led astray by the imperfection of his microscope; for the locomotive embryo has no tendency whatever to a flattened shape, as indicated by the name of "planula," but is always conical or cylindrical. Instead of "planula," therefore, one is strongly tempted to employ for

[1] The comparison of the structure of the Hydrozoa to the early stages in the development of the highest animals has been very distinctly made by Professor Huxley. "The outer and inner membranes appear to bear the same physiological relation to one another as do the serous and mucous layers of the germ; the outer becoming developed into the muscular system and giving rise to the organs of offence and defence; the inner, on the other hand, appearing to be more closely subservient to the purposes of nutrition and generation."—"On the Anatomy and Affinities of the Medusæ." 'Phil. Trans.,' 1849, p. 426.

this form of embryo some term which shall not tend to convey a false impression of its figure. The term "planula," however, has passed into such general use, and has, moreover, become so intimately associated with the memory of one to whose admirable and conscientious observations our knowledge of the HYDROIDA owes so much, that the defects of the term will hardly justify our suppression of it.

Further Development from the Planula to the attainment of the Adult Form.—The further progress of the animal, up to that stage in which it has acquired all the essential features of the adult, admits of being easily traced in many different species. I shall take as a good type of the changes which the ciliated embryo undergoes in this progress the development of *Eudendrium ramosum* (Pl. XIII), in which I have satisfactorily followed the various steps.

After the embryo (Pl. XIII, fig. 10) has enjoyed for a period (which probably extends over two or three days) its locomotive existence, it loses its cilia, and with them all power of active locomotion, though still apparently retaining the power of slowly creeping from place to place by the contractility of its body. It may now be occasionally seen with one end dilated, so as to assume a flask-shaped form (fig. 11).

We next find that the animal has attached itself to some fixed object by the enlarged extremity of its body, which becomes flattened over the surface to which it thus adheres (fig. 12). From the centre of this enlarged base the rest of the embryo rises perpendicularly as a little cylindrical or somewhat clavate hollow column. The base now expands laterally, while, at the same time, it becomes compressed vertically, so as to acquire the condition of a little circular disc of adhesion; and simultaneously with these changes the embryo becomes enlarged a little behind its distal or free extremity by the formation of a slightly prominent circular ridge, while an exceedingly delicate perisarc has been excreted as a scarcely perceptible film over its whole surface (fig. 13).

It will next be seen that a remarkable change has taken place in the disc of attachment by the division of this part into lobes separated from one another by radiating fissures, which commence as shallow notches at the circumference, and thence gradually increase in depth until they nearly reach the central vertical column (fig. 14). These lobes, like the rest of the young hydroid, consist of a layer of endoderm enveloped by one of ectoderm, while each contains a prolongation from the cavity of the column, and is invested by a delicate perisarc, which may be traced into the bottom of the dividing fissures. The lobes of the disc increase in number by successive dichotomous division, though absolute regularity is not usually maintained.

In the mean time the young *Eudendrium* has increased in size, and the circular ridge has become more pronounced, while the part at the distal side of this ridge has in the same proportion become more decidedly marked off from the rest of the body, and the perisarc has here become more distinct by the partial withdrawal from it of the included structures.

Soon after this the circumference of the ridge will be found to have extended itself as a circle of about ten short, thick tentacles, while at some distance behind these the body is seen to be narrowed into a short, nearly cylindrical stem, springing directly from the centre of the basal disc; and the more contracted portion which lies at the distal side of the circle of rudimental tentacles is now plainly recognisable as the proboscis or hypostome of the future hydranth. The tentacles now rapidly multiply by the intercalation of others between those already formed (fig. 15). The second set may at first be easily distinguished by their shortness; but the bases of all seem to be on the same level, and the whole appear to constitute a single uninterrupted series. The tentacles, though short and thick, will have thus soon attained the full number which we meet with in the adult. They consist in this stage of an endodermal and an ectodermal layer, the ectoderm apparently formed of a single layer of prismatic cells, while the endoderm seems to fill the entire axis with a mass of minute, spherical, loosely aggregated cells. Just behind the tentacles the body of the young hydranth is seen to be excavated by a large cavity, in which is a multitude of loose spherical cells, filled with a red granular pigment, and undoubtedly thrown off from the inner surface of the walls.

The whole of the young hydroid is still completely enveloped by the delicate chitinous perisarc, which forms a sheath extending over even the distal free extremity, and within which the various changes just described, including even the formation of the tentacles, have been going on. We now find, however, that this sheath (which has for some time lain loosely over the distal parts of the hydroid, and which it seemed to invest as in a sac) becomes ruptured in front of the tentacles, so that the water gains direct access to the surface of the young hydranth, and the tentacles have full freedom to extend themselves. It would seem, too, that the distal extremity of the proboscis had now, for the first time, become perforated by a mouth; for up to this stage, no undoubted evidence of an oral aperture could be detected.

The young *Eudendrium* has thus acquired the form of a true hydranth borne on the extremity of a short simple cylindrical stem, which still springs from the centre of the radiating disc (fig. 16). The stem elongates itself, and the body, tentacles, and hypostome rapidly acquire all the characters of the adult. It still, however, remains for it to develop from its base a creeping stolon which will take the place of the primordial disc, and which would seem to originate in the elongation of some of the lobes of this disc, to compiicate itself by the budding of new hydranths and the development of branches, and, finally, by the formation of sexual zooids, to combine a gonosome with a trophosome, in order that the little hydroid whose progressive changes we have been thus following may attain the condition of the adult *Eudendrium* (figs. 1 and 2).

Development by Actinulæ.—The developmental phenomena above described are, in all their essential points, so far as we know, universal among the Hydroida, with the exception of the genera *Tubularia*, *Hydra*, and, probably, also *Myriothela* and *Actinogonium*.

In *Tubularia* a minutely granular plasma, which, except in its more obviously cellular structure, is entirely similar to that which in other Hydroida becomes differentiated into ordinary ova, may be seen enveloping the spadix of the young gonophore. Instead, however, of becoming transformed in the usual way into ova, portions become detached from the mass and lie loose in the cavity of the gonophore, where they undergo a development into free embryos in the manner to be presently described, while the residual plasma continues to detach from its mass fresh fragments, which are in their turn transformed into embryos (Pl. XX, fig. 3, and Pl. XXIII, figs. 11, 13, 14, 15, 16, 23, 24).

In the portions (Pl. XXIII, figs. 11 *g* and 23 *g*) thus successively detached from the central plasma (*f*) it is impossible to detect any decided trace of germinal vesicle or germinal spot, and yet we should certainly not be justified in regarding them as mere gemmæ, or in attributing to them any other significance than that of true ova,[1] though, possibly, of ova after they had already passed

[1] Agassiz calls the central plasma in *Tubularia* the "germ-basis," and refuses to regard as ova the masses which are thrown off from it and become developed into hydriform young. (*Op. cit.*, vol iv, pp. 255 and 269.)

the earlier stages of their development. The plasma in which they originate holds in the gonophores which contain it a position precisely similar to that held by the undoubted spermatogenous tissue in the male gonophores (figs. 8 *f*, 9 *f*, and 21 *f*) of the same species; and as nothing else is presented by the hydroid which can in any way be regarded as ova, we should, by denying to these the essential attributes of ova, be reduced to the anomalous alternative of admitting the existence of the male element without the correlative female one.

The fact, however, that the plasma at a very early period, as well as the masses which have been detached from it in order to become developed into embryos, consist almost entirely of cell-like elements, indicates a difference between the matter composing them and the more simple protoplasmic matter of the unfecundated vitellus in other hydroids.

The phenomena connected with the development of the embryo in *Tubularia indivisa* and *T. larynx*, in both of which I have carefully examined them,[1] will afford a good example of the difference between this form of development and that which is usual among the Hydroida; they would seem to be in all essential points similar in the other species of *Tubularia*.

In the very young female gonophore of *Tubularia larynx*, while yet only $\frac{1}{200}$th of an inch in diameter, the spadix may be seen lying in the axis of a cavity bounded externally by a double wall (Pl. XXIII, fig. 19). Surrounding the spadix, and occupying the whole of the space between it and the wall of the cavity, may be seen the generative plasma (*f*), consisting of a uniform mass of small spherical cells, about $\frac{1}{2000}$th of an inch in diameter. When liberated from the young gonophore, and floated in water, these cells seem perfectly transparent, their contents appearing to consist of a clear colourless fluid, with a somewhat higher refractive power than the surrounding water. Under the action of acetic acid their contents become granular, and a nucleus-like particle usually becomes visible in the midst of the granular contents (fig. 20).

At a slightly more advanced stage (fig. 21) the gonophore has reached to about $\frac{1}{120}$th of an inch in diameter, and the apical tubercles (*a'*) which characterise the mature gonophore have begun to make their appearance. The inner layer (*b*) of the walls of the gonophore may now be seen to have become separated from the outer (*a*), and thereby rendered more distinct. This inner layer is plainly composed of minute spherical cells, and is thinner than the outer wall, which is composed of prismatic cells, among which thread-cells are already developed. At this period the gonophore begins to become perforated at its summit by an aperture, which opens externally between the bases of the apical tubercles.

The tubercles continue to increase in size with the enlarging gonophore; the plasma becomes more voluminous, and among its component cells may be seen several of somewhat larger size than the rest; under the action of acetic acid these larger cells show a very distinct nucleus, with nucleolus, in the midst of granular contents (fig. 22). It is just possible that these cells may represent germinal vesicles with the germinal spot and its contained *punctum*, but with no vitellus as yet differentiated around them. The plasma, retaining the same structure, continues to increase in volume with the growth of the gonophore; while the inner layer of the wall—that which had immediately invested the plasma, and must be regarded as the endotheca—would seem to undergo absorption, and finally to disappear. We now find that a portion (fig. 23 *g*) of the plasma has become detached from the mass, and soon undergoes a special development into an embryo within the cavity of the gonophore. As has been said, no obvious trace of germinal

[1] "Notes on the Hydroid Zoophytes," 'Ann. Nat. Hist.,' July, 1859.

vesicle or spot can be found either in the entire mass or in any of the detached portions, unless the nucleated cells just referred to (fig. 22) can be so regarded; so also the phenomenon of yolk-cleavage, if present at all, is very obscure, but the detached mass may be easily broken up into cells filled with secondary cells.

The ovum (for I have no hesitation in so designating the mass detached from the primitive plasma, notwithstanding its anomalous character) lies in contact with the remainder of the plasma, and while in this position becomes developed into an actiniform embryo, as has been already noticed by Van Beneden,[1] Mummery,[2] myself,[3] and others. In the act of development, as shown in figs. 11—16, which represent the corresponding process in *Tubularia indivisa*, it becomes first (fig. 13) extended as a disc over the residual plasma. In this disc we can always recognise a differentiation between its peripheral and central portions. Next (fig. 14), from the circumference of the disc short and thick processes radiate all round, and these soon elongate themselves into tentacles (fig. 15); the disc at the same time gradually becomes more gibbous on the side turned away from the axis of the gonophore, its interior has already become hollowed out into a digestive cavity, and a mouth now makes its appearance in the centre of the opposite side, or that in contact with the plasma. The embryo now retreats from the plasma, the mouth is seen to be elevated on a conical prominence (fig. 16 *a*, fig. 24 *k'*), while the side opposite to the mouth becomes more and more prolonged with the general cavity of the embryo continued into it. The extremity of this prolongation presents in *Tubularia larynx* and some other species the appearance of delicate striæ (probably fibres) radiating for a short distance from its central point (Pl. XXI, fig. 6)—a peculiar structure which might easily lead to the belief that an aperture was here present. The appearance of an aperture, however, I believe to be entirely deceptive. In this state it escapes from the gonophore, a circle of very short tentacles having first become developed round the mouth in some species (*T. indivisa*, fig. 16); while in others (*T. larynx*, fig. 24) the oral tentacles do not make their appearance until after the escape of the embryo. After continuing free (Pl. XX, fig. 4, Pl. XXI, fig. 6) for a period, the side opposite to the mouth becomes ultimately developed into a cylindrical stem, which soon clothes itself with a perisarc and fixes the young *Tubularia* to some neighbouring object (Pl. XX, fig. 5, Pl. XXI, fig. 7). After the escape of the embryo, or even during its development within the gonophore, the remains of the plasma may still throw off portions (Pl. XXIII, fig. 24 *g'*), which become developed, in a similar way, into free actiniform embryos. To such embryos the name of *actinulæ* may be given, in order to distinguish them from the *planulæ* of other hydroids.[4]

[1] "Recherches sur l'Embryogénie des Tubulaires," p. 37, pl. 1, in 'Nouv. Mém. de l'Acad. Roy. de Bruxelles,' tom. xvii, 1844.

[2] "On the Development of *Tubularia indivisa*," 'Trans. Micr. Soc.,' 1853, p. 28.

[3] Allman, "On *Tubularia indivisa*," 'Ann. Nat. Hist.,' July, 1859.

[4] Prof. H. J. Clark has given a detailed account of the development of the gonophore and ovarian plasma in Tubularia ("Tubularia not Parthenogenous," 'American Journal of Science and Arts,' vol. xxxvii, Jan., 1864). I cannot, however, accept in all points his interpretation of the appearances presented in the microscopic investigation of these parts. He regards as the true ova certain very minute cells which are visible in the gonophore while yet in a rudimentary state, and which would seem to be those described above as composing the very young tissue of the plasma. Notwithstanding, however, a certain resemblance of these cells to ova, I cannot so regard them. They cannot be followed through any of the changes which characterise the development of a true ovum; they

The generative process in the freshwater *Hydra* offers some striking resemblances to that just described in *Tubularia*. Usually towards the end of autumn, but occasionally even in spring, peculiar tubercles may be seen budding from the body of various species of *Hydra*. They are produced chiefly towards the anterior end of the body. I have especially examined them in *Hydra vulgaris*. They are here of a conical form, and when mature have their apex perforated by a short canal, through which the contents of the tubercle escape. These contents are then seen to be active spermatozoa of the usual form, and the tubercle must be regarded as a male gonophore.[1] Its external wall consists of a single ectodermal layer, and its cavity is traversed by a process of the endoderm, which, at least in the younger stages, extends from the base to the summit of the gonophore, where it remains for some time united to the ectodermal wall. Between this axile process of endoderm, which plainly corresponds to a spadix, and the outer wall of endoderm, the spermatogenous plasma is developed. The entire plasma has the appearance of being divided into longitudinal masses, as if by septa, which pass from the outer wall to the axile spadix. It increases in maturity as we examine it from the base towards the summit of the gonophore, the reproductive elements being still enclosed towards the base in their generating cells, while towards the summit they may be seen as free active spermatozoa, ready to escape through the perforation which is now found in the summit of the gonophore for their exit.

But, besides the spermatogenous tubercles, there also occur, usually on the same specimen, others which, instead of containing spermatozoa, have their cavity occupied by a peculiar cellular plasma, destined to give origin to ova. Their position on the body of the *Hydra*, in every specimen which has come under my observation, was at the proximal side of that part of the animal which carries the spermatogenous tubercles. They form rounded elevations, with a broad base of attachment, and are of less defined form than the others. They seem to be produced by a simple separation of the ectoderm and endoderm of the *Hydra*, with the plasma interposed between the two membranes. They certainly correspond to the female gonophore of other hydroids, but they

simply constitute a portion of the general tissue of the plasma, as well as of the masses which are subsequently detached from it in order to become developed into actiniform embryos. As stated above, however, it is possible that the nucleated cells (Pl. XXIII, fig. 22) which make their appearance at a somewhat later period represent germinal vesicles.

Claparède ('Beobacht. über Anat. u. Entwickel. wirbelloser Thiere an der Küste von Normandie,' 1863, p. 2) also takes a different view of the development of *Tubularia* from that given above. His observations were made on certain minute organisms which he found swimming in the open sea, and which are undoubtedly the actinula-stage of some species of *Tubularia*. He compares them to small medusæ, the body of the actinula representing the umbrella, and the long tentacles the marginal tentacles of the medusa, while that portion which is subsequently to become developed into the stem of the *Tubularia* is viewed by Claparède as corresponding to the manubrium—the mouth of the future *Tubularia*, with its circle of short tentacles, being developed on the summit of the umbrella. Claparède believes that he had found an aperture in the extremity of that portion which is to become the stem, and he has apparently been thus led to interpret this part as the manubrium of a medusa. I have little doubt that Claparède has been here deceived by the peculiar structure described above, and which might easily lead to an error of interpretation.

[1] We owe to Ehrenberg the original determination of the nature of these bodies. His account of them is given in the 'Mittheilungen aus den Verhandl. der Gesellsch. Naturf. Freunde in Berlin,' 1838, p. 14.

present little or no trace of a spadix; and if this ever existed, it must have been depressed at an early stage by the ovarian plasma, which now lies upon an even floor of endoderm.

The contents of these bodies consist in an early period of development of minute spherical cells distributed through a semifluid granular blastema, and generally exhibiting a distinct nucleus. As this cellular and granular material increases in volume, we find it becoming broken up into detached masses. These masses vary much in size and form; they frequently present a very irregular outline, with projecting lobes and processes of no definite or permanent shape. At a somewhat later period some of them burst through the confining wall of ectoderm, and then usually remain for some time in the form of irregularly spherical bodies, attached to the external surface of the gonophore, as if by the adhesive properties of their constituent blastema.

The escaped masses may usually be seen to be themselves composed of an agglomeration of smaller masses, reminding us of a segmented vitellus; but I am, nevertheless, not prepared to regard this complex condition as a true vitelline segmentation. Further, no appearance of a germinal vesicle or spot can at any time be detected in any part of the ovarian plasma, and yet I believe we should not be justified in denying to the masses which have become detached the significance of true ova.[1]

Beyond this point my observations have not extended, but other observers have described the liberated masses as enveloping themselves with a tough membrane, which in some species would seem to develop over its surface peculiar forked spines. On the rupture of this membrane its contents become directly developed into an actiniform embryo, which gradually assumes the form of the adult Hydra.[2]

The resemblance between the embryonic development in Hydra and that in Tubularia is thus very close; indeed, it is impossible not to regard them both as presenting the same essential modification of the reproductive process—a modification whose most striking feature shows itself in the formation of an actinula instead of a planula.

I have had no opportunity of studying the genus *Myriothela* of Sars; but from the observations of Mr. W. P. Cocks, who was the first to meet with this remarkable hydroid genus on the British shores, as well as from those of Mr. Joshua Alder, it would appear that actiniform embryos closely resembling those of *Tubularia* are the immediate result of the development of the ovum.

Several years ago M. Van Beneden described and figured a *Coryne*-like hydroid from the coast of Belgium, and assigned to it the name of *Syncoryne pusilla*, under the belief that it was identical with the original *Coryne pusilla* of Gaertner.[3] In this determination M. Van Beneden was wrong; but his hydroid possesses special interest from the nature of its gonophores, which are described as giving origin to actinula-like bodies, whose form is compared by the Belgian

[1] Rouget, who has examined with much care the reproductive system of Hydra ('Mém. de la Soc. de Biologie,' tom. iv, 1852, p. 387), compares these masses to a Graafian vesicle rather than to a true ovum.

[2] Pallas, 'Karakteristik der Thierpflansen,' p. 53; Ehrenberg, 'Abhandl. der Berl. Akad.,' 1836, p. 115, taf. ii Laurent, 'Froriep's Neue Notizen,' No. 513, p. 101; and 'Nouveaux Recherches sur les Hydres d'eau douce, Voyage de la Bonite,' 1844. See also 'On the Generative System of *Hydra*,' by Prof. Allen Thomson, *loc. cit.*, and Hancock, "Notes on a Species of *Hydra* found in the Northumberland Lakes," in the 'Annals of Natural History,' vol. v, 1850; and more especially Ecker, 'Entwickelungsgeschichte des Grünen Armpolypen,' Freiburg im Breisgau, 1853.

[3] Van Beneden, 'Embryogénie des Tubulaires.'

zoologist to that of a cuttlefish with four arms. Taking for granted that there is here no error of observation, the obvious interpretation is that Van Beneden's hydroid affords an example of development from an actinula instead of a planula.

This is a very important character, and one which, notwithstanding the general resemblance of the trophosome to that of a *Coryne*, must remove the hydroid into a new genus, to which the name of *Actinogonium* may be given.

3. *Significance of the Medusa in the Life-Series of the Hydroid.*

In our attempts to determine the significance of the sporosac, and the part it plays in the life of the hydroid, no difficulty is encountered, for its entire history, from its origin to the fulfilment of the purpose it is destined to serve in the economy of the hydroid, passes uninterruptedly before our eyes, and proves it to be a true generative zooid, giving origin in some cases to spermatozoa, in others to ova, whose development, as we have just seen, may be followed, and we are thus enabled to trace back the hydroid in an unbroken series through the egg from which it is developed, and the sporosac in which this egg originates, to the hydroid trophosome from which the sporosac buds.

The cases in which a similarly unbroken chain can be traced back through the free generative bud or planoblast are naturally far less frequent, for in the majority of cases the planoblast does not produce its generative elements until a considerable time after it has become free, and has undergone more or less change of form as it continues to develop itself in the open sea; and it is very seldom that we can succeed in rearing the free medusa, in the confinement of our tanks, up to the period when it shall attain to sexual maturity, either directly, as in the gonocheme, or indirectly, as in the blastocheme.[1] We thus, then, almost always lose absolute evidence of identity in both gonocheme and blastocheme, when presented at two distant periods of their lives; and there is in such cases, necessarily, an interruption in the series of continuous observations.

Some uninterruptedly continuous observations, however, have been made, and we now know of various instances in which the generative elements have been detected, either in the walls of the manubrium or in special sexual buds developed from the gastro-vascular canals, in medusæ which have been themselves traced to hydriform trophosomes; while in others, though the free medusa in which the eggs or spermatozoa have been found have not been traced by *direct* observation to a trophosome, their resemblance to forms which have been so traced is so close as to justify us in assigning to both a similar origin.[2] There thus remains no longer any doubt that the significance of the medusa in the life-series of the hydroid is in all essential points identical with that of the sporosac; and the assertion here made applies to both gonocheme and blastocheme, with this difference alone, that in the latter the generative elements are not produced directly, but only

[1] In the *Siphonophora* the opposite condition is prevalent; for here the gonophores, even such as present the more complete medusal or phanerocodonic form, usually become loaded with ova or spermatozoa before they detach themselves from the trophosome.

[2] I have elsewhere brought together all the known instances in which medusæ, whether gonophores or blastochemes, traceable to trophosomes, have been observed to develop generative elements. See 'Report on the Reprod. Syst. in the Hydroida,' p. 411, &c.

through the intervention of its sexual buds. We are thus brought up to an important point in the developmental history of the Hydroida, and are enabled to enunciate the following fundamental proposition :

THE FIXED PLANT-LIKE HYDROIDA GIVE ORIGIN TO SEXUAL BUDS, NOT ONLY IN THE FORM OF CLOSED SACS (*the sporosac*), WHICH DEVELOP WITHIN THEM THE GENERATIVE ELEMENTS ; BUT ALSO IN THAT OF A MORE SPECIALISED FORM OF BUD, WHICH BECOMES A FREE (RARELY FIXED) MEDUSA, AND THIS ULTIMATELY ATTAINS EITHER DIRECTLY (*the gonocheme*) OR INDIRECTLY (*the blastocheme*) TO SEXUAL MATURITY, AND PRODUCES OVA OR SPERMATOZOA.

But the point to which we thus arrive does not present us with the entire life-series of the medusa-producing hydroid, for the important question still remains, What is the result, immediate and remote, of the development of the ovum produced by the medusa? and how far does this development correspond with that of the ovum produced in a sporosac without the intervention of a true medusiform bud ?

A considerable number of facts bearing upon this question have also been accumulated ; and the development of the ovum formed in the medusa has been traced, with more or less minuteness, by various observers, so that we are now enabled to present the terms which were still wanting to complete the life-series of the hydroid.

As the observations which have thus aided in completing our knowledge of hydroid development are of great importance in the present inquiry, it will be necessary to give here some account of those cases in which the development of the egg of the hydroid medusa has been satisfactorily traced.

Dujardin[1] observed that a remarkable little medusa, which he described under the name of *Cladonema*, was developed as a bud from a hydriform trophosome, to which he gave the name of *Stauridium*. He had noticed the production of eggs by his *Cladonema*, and had also seen young *Stauridia* developed from these eggs, though the planula stage seems to have escaped him.

Krohn,[2] having placed in a jar of sea-water some mature specimens of Dujardin's *Cladonema*, observed that after a time they had deposited eggs, which adhered to the sides and bottom of the vessel. Soon after deposition, the segmentation of the yolk commenced ; and in about forty-eight hours after the beginning of the cleavage the ovum had become changed into a free-swimming ciliated infusorium-like embryo (planula).

This embryo was successfully watched by Krohn through all the subsequent stages—the disappearance of its cilia, the fixing itself to the sides of the jar, its conversion into a little circular disc, the growth of a short column from the centre of the disc, and its final conversion into a hydroid, identical with the *Stauridium* from which Dujardin had originally seen the *Cladonema* thrown off. To Dujardin and to Krohn are thus due the first grand observations by which the whole circle of hydroid development, in the case of a free phanerocodonic gonophore, has been completed.

[1] Dujardin, 'Ann. des Sc. Nat.,' ser. iii, vol. iv, 1845, p. 273.

[2] Müller's 'Archiv,' 1853, p. 420, tab. xiii.

Gosse[1] has seen the medusa described by Forbes under the name of *Turris neglecta*, discharge from the generative mass formed in the walls of its manubrium ciliated planulæ, which, after some time, fixed themselves to the glass, and became elongated into adherent, branched, stolon-like bodies, which threw up a perpendicular stem, on whose summit a circle of four tentacles was developed, and the whole became thus changed into a *Clava*-like hydroid.

Strethill Wright[2] subsequently watched the development of the ovum in this same medusa. His observations agree with those of Gosse, but he has succeeded in tracing the development a step further; for he saw the tentacles increase in number by the growth of others behind those first formed, giving by their scattered disposition a still more *Clava*-like appearance to the hydroid, while he also noticed the formation of a chitinous periderm which clothed the creeping stolon.

Gegenbaur[3] describes the development of the egg in a medusa, which he names *Lizzia Köllikeri*. He has seen the segmentation of the vitellus, and the formation of a ciliated planula, which, after enjoying for a time its locomotive existence, loses its cilia, fixes itself to the side of the vessel, expands one extremity into a disc of adhesion, elongates the rest of its body into a cylindrical stem, which after clothing itself with a chitinous polypary, develops a mouth upon its free extremity, and just below this throws out a verticil of tentacles, while the expanded base becomes extended into short stolon-like prolongations.

The development of the ova in another medusa, named by Kölliker *Oceania armata*, was also observed by Gegenbaur.[4] He traced the segmentation of the vitellus, the formation of a ciliated planula, the fixation of the planula, and its development into a stolon-like body; but beyond this point his observations were not carried.

Wright[5] noticed the occurrence of numerous planulæ which had made their appearance in a vessel in which he had placed some isolated specimens of *Thaumantias inconspicua*, Forbes. He believed that these planulæ were produced by the *Thaumantias*, and he saw some of them fix themselves to the sides of the vessel and develop a lobed disc of attachment. From this disc arose a stem, which after developing from its summit a hydranth closely resembled the *Campanularia raridentata* of Alder.

In the *Zygodactyla* (*Æquorea*) *vitrina* of Gosse, Wright[6] also observed free ciliated planulæ to escape from the generative bodies, and, after fixing themselves to the sides of the vessel, become developed each into a hydroid, with hydranth, hydrotheca, and perisarc, bearing, as he informs us, a close resemblance to the *Laomedea acuminata* of Alder.

Alexander Agassiz[7] has followed the development of the egg in two forms of hydroid medusæ—*Melicertum campanula*, Esch., and *Tima formosa*, Agass. In both he has seen the formation of the ciliated planula, the fixation of the planula, and its gradual conversion into a young campanularian trophosome.

[1] 'A Naturalist's Rambles on the Devonshire Coast,' 1853, p. 348, pl. 13.

[2] 'Edinb. New Phil. Journ.,' July 1859, pl. 8, f. 1.

[3] 'Generationswechsel,' 1854, p. 23, pl. ii, figs. 1-9.

[4] *Loc. cit.*, p. 28, pl. 2, figs. 10—16.

[5] 'Micr. Journ.,' vol. ii, new ser.

[6] 'Micr. Journ.,' vol. ii, pl. iv, figs. 1—6.

[7] 'Illustrated Catalogue of the Museum of Comp. Zool. at Harvard College,' No. II, pp. 115 and 134.

I have myself traced the development of the egg of a *Tyaropsis* as far as the planula stage; but though the planulæ continued to live in my jars for some weeks, they ultimately perished without passing into any further phase of their metamorphosis.

The class of observations here enumerated enable us to complete the circle of hydroid development, and justify us in the enunciation of a second proposition, which, taken along with the former one, will express the entire life series of the hydroid:

THE OVA OF THE MEDUSIFORM BUD UNDERGO, LIKE THOSE OF THE SPOROSAC, A CONTINUOUS DEVELOPMENT, BY WHICH THEY BECOME TRANSFORMED INTO HYDRIFORM TROPHOSOMES, WHILE THESE TROPHOSOMES ULTIMATELY GIVE ORIGIN, BY BUDS, TO MEDUSÆ IDENTICAL WITH THOSE FROM WHOSE OVA THE TROPHOSOME WAS DIRECTLY DEVELOPED.

It will be further seen, from the facts now stated, that the earliest stage of the hydroid trophosome is always free and locomotive, and that it shows itself under one or other of two types. One of these types is presented by the great majority of the HYDROIDA, and has been described above as the *planula* of Sir J. G. Dalyell; the other occurs in the genus *Tubularia*, and apparently also in *Myriothela*, *Hydra*, and *Actinogonium*, and has been already described under the name of *actinula*. Every hydroid, if we except such forms as may be proved to pass to the medusal condition directly from the egg, thus commences its free existence either as a planula or an actinula.

Direct Development of the Medusa from the Egg.—In by far the majority of cases in which the development of the hydroid has been successfully traced, the life series of the individual has presented a non-sexual hydra-like form, interposed between the ovum and the directly or indirectly sexual medusal form.

Against the absolute universality of this law, however, certain observations have been adduced, as tending to show that in some cases a direct development from the egg to the medusa takes place without the intervention of a non-sexual trophosome. There is no reason why this should not be so, and yet a careful examination of the cases adduced in support of it will render it evident that most of them afford no evidence which can be relied on as conclusive in favour of the direct development of the medusa from the egg.[1]

It is chiefly among the Æginidan and Geryonidan medusæ that cases believed to afford evidence of direct development have been observed. The first observation bearing immediately on this question is due to Johan. Müller,[2] who captured, on several occasions in the sea, at Marseilles and Nice, a minute free-swimming hydroid. It was of an oval form, about half a line in its longer diameter, ciliated over its entire surface, with two tentacle-like processes near one end, and having at the opposite end an opening which led into a central cavity.

Müller considers this little animal to have been developed directly from the egg, and from its resemblance to a peculiar two-tentacled medusa which he obtained in considerable abundance at Nice, he believes himself justified in regarding it as one of the stages in the development of this

[1] Among the DISCOPHORA a single case also of direct development has been made known; that, namely, of *Pelagia*, a medusa which has been shown by Krohn to be developed from the egg without the intervention of a *Scyphostoma* or polypoid form.

[2] Müller's 'Archiv,' 1851, p. 272.

medusa, into which he supposes it to pass by direct metamorphosis. He refers it to the genus *Æginopsis*, Brandt, and names it *Æginopsis Mediterranea*, Müll. Müller does not seem to have obtained any specimen of his *Æ. Mediterranea*, so far matured as to present traces of the generative elements; but his observations have been in this respect supplemented by Kölliker,[1] who afterwards obtained the same species at Messina in a sexually mature state.

Now, we cannot overlook the fact that Müller has not, in the above case, traced his ciliated hydroid through a continuous series of developmental phases into the adult form of *Æginopsis*; and, without denying the probability that the ciliated bitentacular hydroid is really the larva of the *Æginopsis*, we cannot regard this relation as absolutely proved, while there is no evidence whatever that the ciliated form is the immediate result of the development of an ovum. Indeed, its remarkable resemblance to the singular generative zooid of *Dicoryne* (see above, p. 31) would seem to show the probability of another origin than that by direct development from the egg. Müller, led apparently by the analogy of the planula-stage of the *Hydroida*, considers the ciliated condition of the surface as affording evidence of such a direct development; but the fact that the *Dicoryne*-zooid is also richly ciliated over its whole surface shows that this argument goes for nothing.

Kölliker[2] found in the stomach-cavity of a ten-tentacled Æginidan medusa, captured in the sea at Messina, and described by him under the name of *Eurystoma rubiginosum*, a number of small organisms resembling medusæ in various stages of development, and which he believed he could follow from stage to stage until he found them assume the form of a sixteen-tentacled medusa. To this last, which also belongs to the family of the *Æginidæ*, he gives the name of *Stenogaster complanatus*.

The great difference between these two medusæ appears to Kölliker sufficient proof that the one could not have been produced by the other, and he regards the young stenogasters as having been swallowed by the *Eurystoma*. He views, however, the young *Stenogaster*, exhibiting as it does, various steps in a metamorphosis from a very early stage, as affording evidence of the direct development of *Stenogaster* from the egg. It is, nevertheless, plain that there are no more valid grounds for such a conclusion in this instance than in Johan. Müller's case of *Æginopsis*, while Fritz Muller's case of *Cunina Köllikeri*, as well as the cases described by Gegenbaur and by Keferstein and Ehlers, and the more recent observations of Haeckel, all of which are cited above (p. 83), suggest the probability that the stenogasters noticed by Kölliker originated as buds from the *Eurystoma*.

Other instances which have been adduced as affording evidence of direct development from the egg without the intervention of a trophosome have been already referred to as cases where the medusa passes through a series of metamorphoses before arriving at its adult state. They are M'Crady's case of *Cunina octonaria*, Fritz Müller's of *Liriope cathariensis*, and Haeckel's of *Glossocodon eurybia* and *Carmarina hastata*, all of which, from the very imperfect state of development in which the earliest stages of the medusæ present themselves, have been regarded by their describers as instances of direct development from the egg, though there is no positive evidence of such an origin; and, lastly, there is the instance afforded by *Trachynema*, the ciliated condition of whose youngest discovered stage has led Gegenbaur to consider it also as a case of

[1] 'Zeit. für wissensch. Zool.,' 1853, vol. iv, p. 327.
[2] Ibid.

direct development, though, as we have already seen, the analogy of the *Dicoryne* gonophore is sufficient to show that no conclusion of the kind can be based on such a character.

Though the cases thus adduced afford no absolute proof of the direct development of the medusa from the egg, some recent observations leave us no longer in doubt as to the reality of this phenomenon. The observations alluded to have just been made by M. Mecznikoff of St. Petersburgh, who has traced the development of a *Cunina* as well as that of a *Geryonia* continuously from the egg. In the case of the *Cunina*, a ciliated planula is immediately developed from the egg, and the planula becomes gradually changed—in a way very similar to that already described by M'Crady—into the form of the medusa. In the *Geryonia* there is no ciliated planula, and the medusa form is here attained immediately by the development of the ovum.[1]

Besides these cases of undoubted development from the egg without the intervention of a hydriform trophosome, both of which occur in a group of medusæ of peculiar and exceptional conformation, an instance has been published in which, if the appearances be correctly interpreted, we have in the hydroid medusa of the ordinary type a case of direct development from the ovum. For our knowledge of it we are indebted to Claparède,[2] who obtained on the west coast of Scotland a species of *Lizzia* whose manubrium is described by him as loaded with eggs, some in an early stage, with the germinal vesicle and germinal spot still visible, while others appeared to contain an embryo in various stages of development. Similar ova, with the contained embryo, are stated to have been found floating free in the sea.

Claparède informs us that the embryo, while still confined within the vitellary membrane, presented all the features of a young medusa: from the centre of the bell-shaped umbrella there depended a thick-walled manubrium, whose cavity extended itself into four radiating gastrovascular canals, which ran in the substance of the umbrella, and opened at the margin into a circular canal, while round the margin were to be seen the rudiments of eight tentacles. Claparède's observation on the development of the embryo did not extend beyond this point; it is clear, however, that but slight changes were now needed to convert it into the form of the parent *Lizzia*.

This observation of Claparède has not been confirmed, and it is quite possible that the appearances here interpreted as ova in various stages of development are in reality only buds. A very young bud might be easily mistaken for an ovum, and in a medusa, by no means remotely allied to that described by Claparède, buds occur in an exactly similar position, and might easily give rise to an erroneous interpretation of their nature. (See woodcut, fig. 36.)

[1] For a knowledge of these facts I am indebted to M. Mecznikoff, who allowed me not only to inspect his drawings, but to examine his animals in the progress of their development. M. Mecznikoff's observations necessitate some modification of a statement made in an earlier part of the present work (see p. 23), and already printed before they came to my knowledge.

[2] 'Zeit. für wissen. Zool.,' 1861, p. 401.

1. *Relation between zooidal and embryonal multiplication in the* HYDROIDA; *Polymerism and Heteromorphism; Genetic succession of zooids.*

Having now examined the various modes, whether zooidal or embryonal, by which multiplication is effected in the HYDROIDA, it remains for us to see how the two forms of reproduction are related to one another, and how they are associated in the complex phenomenon which constitutes the life of the hydroid.

From all the facts which the study of the HYDROIDA has made apparent, we may regard it as certain that however long zooidal multiplication may continue, this is not sufficient for the perpetuation of the species, but that a period must at last come in the life of the hydroid when, by an act of true sexual reproduction, new individuals are produced for the indefinite extension of the species through time.

These facts find their expression in a remarkable law originally propounded by Chamisso, when he made his memorable discovery of the true genetic relation between the solitary *Salpæ* and the associated chain-like colonies of these animals; though it was reserved for Steenstrup, by correlating with Chamisso's discovery, not only the genetic phenomenon of the Hydroida, but also various analogous phenomena observed in other members of the animal kingdom, to give a wider comprehensiveness and a more definite enunciation to the law henceforth known as the law of "alternation of generations," an expression originally employed by Chamisso himself when describing the genetic phenomena of Salpa. It is true that Steenstrup's mode of stating his law of alternation of generations was destined to undergo some modification, but it has, nevertheless, received in all essential points abundant confirmation, and will explain, in a way which it alone can do, a host of phenomena which would otherwise have appeared isolated and exceptional.[1]

The law of alternation of generations manifests itself wherever it prevails, in the fact that every act of embryonal development is followed by one or more acts of zooidal development, which invariably conduct us to an ovum in which embryonal development, followed by zooidal development, again occurs, and the entire series becomes thus repeated.

Now, the various series expressing this alternation of sexual with non-sexual development exhibit among the HYDROIDA different degrees of complication, which will be more easily understood if we attempt to present them in the somewhat technical shape of formulæ.

Let t be the trophosome, and g the gonosome then—

$$\text{I.} \quad \underbrace{t + g} \times \underbrace{t + g} \times \underbrace{t + g} \times \quad . \quad . \quad . \quad \&c.$$

will be the general expression for the genetic succession in the life of the hydroid, the sign $+$, indicating succession by zooidal development, and $\times$ by embryonal.

[1] The true significance of the facts on which the law of Alternation of Generations is founded, was for the first time clearly pointed out by Dr. Carpenter. See 'Brit. and For. Med.-Chir. Rev.,' vol. i, Jan., 1848, p. 183, &c.

It is very seldom, however, that the trophosome consists of only a single zooid. Such rare instances are presented by *Corymorpha*, and by certain allied forms whose trophosomes never become developed into a colony of mutually dependent hydranths, and I believe it better to regard the hydrorhizal fibres here as elsewhere in the light of mere extensions of the hydrorhizal base rather than in that of proper zooids—a view supported by their mode of development in the primordial hydranth. In almost every other case, on the contrary, the hydranths composing the trophosomes become greatly multiplied by budding; and in this respect *Hydra* affords no exception, though here the trophosome, by the subsequent detachment of the buds, may become restored to its original condition of a simple hydranth.

Still less tendency is there in the gonosome to present an absolutely simple condition. Indeed, the gonosome is perhaps never limited in its normal state to a single zooid, and we frequently find hundreds and even thousands of zooids entering into the composition of this portion of the hydroid colony.

But the zooids of which the colony is thus composed, whether in its trophosome or its gonosome, may not only be numerous, but may also *vary in form*. Those, indeed, which constitute the trophosome are always of a different form from those of the gonosome. In the trophosome it is rare to find any other form of zooid than that of the proper hydranth. In *Hydractinia*, however, there is associated with the ordinary hydranths the peculiarly modified ones, whose spiral form confers upon the trophosome of this genus so striking a feature; while the nematophores of the *Plumularidæ* can scarcely be regarded otherwise than as special zooids, whose morphological differentiation from the other zooids of the colony is carried to an extreme.

While the type of *heteromorphism* or variety of form among the zooids is fixed for every species, the *polymerism* or simple multiplication of the component zooids is indefinite, and varies with the age, perfection of nutrition, &c., of the individual.

If we specialise the general expression already given (I), so as to make it directly applicable to particular cases of heteromorphic succession in the life of the hydroid, we shall obtain the following formulæ, where h is used for hydranth, bls for blastostyle, $blch$ for blastocheme, gph for gonophore:

II. BINARY. $\underbrace{h + gph} \times \underbrace{h + gph} \times$ . . . . &c. *Corymorpha.*

III. TERNARY. $\underbrace{h + bls + gph} \times \underbrace{h + bls + gph} \times$ . . &c. *Dicoryne.*

IV. QUATERNARY. $\underbrace{h + bls + blch + gph} \times \underbrace{h + bls + blch + gph} \times$. &c. *Campanularia.*

These formulæ present three types of heteromorphism. In II the heteromorphism is binary (woodcut, fig. 40), in III ternary (woodcut, fig. 41), in IV quaternary (woodcut, fig. 42).

But the hydranth may and does in almost every instance—either directly or through the medium of the common basis or hydrophyton—repeat itself indefinitely by budding before the

FIG. 40.

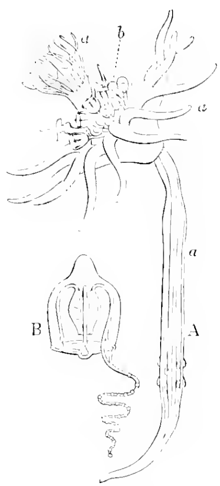


Diagram of *Corymorpha.*

A. An entire colony, consisting of two forms of zooids. *a a a*, the trophosome, consisting of a single hydranthal zooid; *b*, the gonosome, composed of many meduciform zooids.

B. A single zooid of the gonosome after having become free and attained to sexual maturity.

FIG. 41.

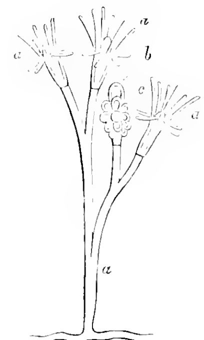


Diagram of *Dicoryne.* Colony composed of three forms of zooids.

a a a a. The trophosome, composed of numerous hydranthal zooids; *b c*, the gonosome, composed of two forms of zooids, namely, *b*, blastostyle, and, *c*, gonophores.

FIG. 42.

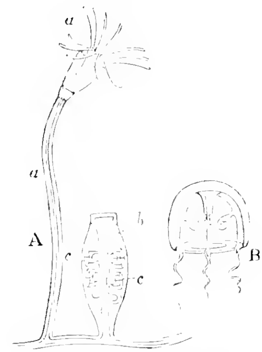


Diagram of *Campanularia.* Colony composed of four forms of zooids.

A. Portion of a colony, with trophosome and gonosome. *a a.* Trophosome, showing one of the hydranths of which it is composed; *b c*, gonosome, composed of three forms of zooids, namely, blastostyles, blastochemes, and gonophores; *b*, blastostyle; *c, c*, blastochemes.

B. A blastocheme, which has become free and attained to maturity, showing the gonophores springing within it from the radiating canals.

time arrives when an element of the gonosome is to be budded off; and a series of homomorphic zooids may thus introduce themselves (woodcut, fig. 41) into the heteromorphic succession, as expressed in the following formula:

$$\text{V. } \underbrace{h+h+h+ \;\ldots\; \&c.+bls+gph \times h+h+h+ \;\ldots\; \&c.+bls+gph} \times \;\ldots\; \&c.$$

where the hydranth becomes indefinitely repeated in the formula of ternary heteromorphism (III given above, and the same will apply to each of the other two types of heteromorphism.

Now, in all these cases the succession from the primordial nutritive zooid to the ultimate generative zooid or gonophore admits of being expressed in a continuous line; but one or more of the zooids of the trophosome may emit buds which will diverge from the direct line of succession, and which may then either form the starting point for another similar line of succession, or may be destitute of all power of continuing the succession of the zooids. Thus (woodcut, fig. 43) the primordial hydranth, or any of its derivative hydranths, may repeat itself by a bud which will diverge from the direct line, produce other zooids by gemmation, and thus start off a new series, as expressed in the following formula:

$$\text{VI.}\quad \underbrace{h\left\{\begin{array}{l} h + h + h + \quad . \quad . \quad . \quad \&c. + bls + gph \\ + \\ h + h + h + \quad . \quad . \quad . \quad \&c. + bls + gph \end{array}\right\}} \times h \left\{ \quad \right\} \times \quad . \quad . \quad \&c.$$

And this state of things may also repeat itself indefinitely, giving rise to an indefinite number of collateral series, diverging from one another and from the primary axis of succession.

Fig. 43.

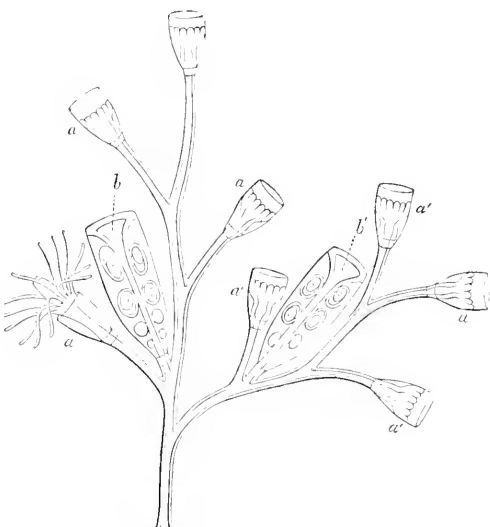


Diagram of *Laomedea*.

a, a, a, a. Hydranths belonging to the primary or direct line of succession; *a', a', a', a'*, hydranths belonging to a secondary or diverging line of succession; *b*, blastostyle of the primary line of succession, bearing gonophores and surrounded by a gonangium; *b'*, blastostyle, with gonophores and gonangium of the diverging line.

As already said, however, the diverging zooid may have no power of continuing the succession. Thus, the spiral hydranth of *Hydractinia* is not intercalated in the direct succession of zooids. It is a diverging zooid, like that which starts off the collateral series in Formula VI, but one which never gives rise to buds, and is therefore incapable of either continuing or originating a new succession.[1]

The following formula, where h' is the spiral hydranth, will express the place and power of this zooid in *Hydractinia*:

$$\text{VII.} \quad \underline{h \left\{ \begin{array}{l} + bls + gph \\ + h' \end{array} \right.} \times \underline{h \left\{ \begin{array}{l} + bls + gph \\ + h' \end{array} \right.} \times \quad . \quad . \quad . \quad . \quad \&c.$$

The case expressed in Formula VI is the simple one where only the last hydranth in the succession of buds composing a period is supposed to give origin to a bud of the gonosome. But any other hydranth in the succession may just as well bud off a member of the gonosome, which may thus form a collateral gonosomal axis. This, which is by far the most usual case, is what is actually represented in the diagrams (see figs. 41, 42, 43). The axis, however, thus formed will be necessarily definite, and will contrast in this respect with the indefinitely extended axis of the trophosome, while it will differ from the diverging bud, h' in VII, by the fact of its having the power of repeating the colony by sexual reproduction, while h' has no power of reproduction either sexual or non-sexual.

This condition may be expressed by the following formula, in which not only the last hydranth of the period gives off a bud of the gonosome, but the primordial hydranth itself emits a collateral gonosomal axis:

$$\text{VIII.} \quad \underbrace{h \left\{ \begin{array}{l} + h + h + h + \quad . \quad . \quad \&c. + bls + gph \\ + bls + gph \end{array} \right\}} \times h \left\{ \quad \right\} \times \quad . \quad . \quad \&c.$$

Besides the particular cases now given certain other modifications of the plan of gemmation will at once occur to any one who has made the HYDROIDA a subject of study. Those here adduced, however, will serve to convey a sufficiently adequate idea of the more important features in hydroid gemmation. It is thus, by the combination of heteromorphic and homomorphic multiplication, and of direct and diverging series indefinitely repeated, that the animal attains to the condition of those wonderful complex colonies which impress themselves so strongly on the mind of the observer.

So also the gonosome may present, not only a heteromorphic, but a homomorphic multiplication of zooids. In no case, however, so far as I am aware, does any zooid of the gonosome repeat itself by homomorphic gemmation, except in some comparatively rare instances of budding in the Medusa; for though the homomorphic repetition of zooids may be in the gonosome, as in the trophosome, carried to a great extent, it is almost always the result of budding from a zooid of a different form. Thus, the blastostyle never emits buds destined to repeat its own form, and this form, however frequently repeated in the gonosome, is always budded off from the hydranthal element in the trophosome, its own buds, however numerous, being always heteromorphic with itself.

It is a universal law in the succession of zooids that no retogression ever takes place in the series. In other words, no bud ever becomes developed into a zooid which is of a different

[1] The bifurcation occasionally observed in the spiral hydranth of *Hydractinia* is evidently abnormal, and cannot be regarded as contradicting the above statement.

form from the budder, and has, at the same time, preceded it in the line of succession. Thus, true hydranths are never emitted either by blastostyle, blastocheme, or gonophore; and to this law the peculiar gemminate hydriform bodies which are found on the summit of the female blastostyle in certain species of *Halecium* form no exception; for though closely resembling true hydranths, they appear to have a different signification, contributing rather to the generative functions of the hydroid, while they have no power of continuing the succession either in a direct or collateral line like the proper hydranths of the trophosome.

Now, a glance at any of the formulæ given above renders it evident—1. That between every two acts of true generation there are interposed one or more acts of non-sexual multiplication. 2. That the heteromorphic elements in each recurring period of the succession are invariably connected with one another by a non-sexual and not by a sexual genesis. 3. That the type of heteromorphism exactly repeats itself after each true generative act.

A still further fact, however, is apparent in all the cases here adduced, namely, that a certain number of zooids, incapable of attaining to sexual maturity, and hence becoming multiplied only by zooidal reproduction, occur in every succession. To the universality, however, of this principle, Haeckel regards the case of the *Geryonidæ* already referred to (p. 82), as affording an exception. He has found Geryonidan medusæ swimming freely in the open sea, in such an early stage of their development, that he believed them to have been produced by the direct development of an ovum, and yet these medusæ have been traced by him into a condition which he regards as that of sexual maturity, in which state they not only produce generative elements, but give origin, by heteromorphic budding within the stomach, to Æginidan medusæ (*Cuninæ*), these *Cunina*-buds also attaining to a condition of sexual maturity.

These facts are regarded by Haeckel as presenting an entirely new type of genesis—a type totally different in its fundamental principles from the phenomena hitherto included under the head of "Alternation of Generations;" and, believing a new term to be needed for it, he proposes to distinguish it by the designation of "Alleogenesis." It is worth while to inquire how far Haeckel is borne out in this mode of viewing the phenomena of Geryonidan development.

Admitting that Haeckel is right in regarding his Geryonidan as developed directly from the egg without the intervention of a non-sexual trophosome, I am by no means prepared, as I have elsewhere[1] stated, to take for granted the proper sexuality of this medusa. On the contrary, I am still disposed to consider the sexual pouches of the radiating canals as truly zooidal developments corresponding, notwithstanding their flattened leaf-like form, to the more prominent pouches developed on the radiating canals of such forms as *Obelia;* so that, in accordance with this view, the Geryonidan medusa would be a true blastocheme. If this be so, then the non-sexual character of the Geryonidan must be admitted, and a non-sexual element will thus become intercalated in the series, even though the hypothesis of a non-sexual hydriform trophosome be given up. Haeckel, it is true, referring to my view of the zooidal nature of the sexual pouches of *Geryonia*, argues against it, and states his conviction, from personal examination of these pouches, that they are simple lateral dilatations of the canal, with the generative products developed out of the epithelium of their walls.[2]

1 'Ann. and Mag. of Nat. Hist.,' 1865.

2 Haeckel, 'Die Familie der Rüsselquallen. Vorwort,' vii.

Against the direct testimony of so able and conscientious an observer as Haeckel, I should not consider myself justified in insisting on a hypothesis which I have had no opportunity of verifying by direct examination; but yet I can scarcely avoid seeing that Haeckel's description of the structure of these pouches is in some points favorable, rather than contradictory, to my view; thus the currents of nutritive fluid which he has observed flowing in ramified channels through the mass of the ova appear to me to be explicable only on the admission that these currents are contained within a ramified spadix, for the supposition that the generative elements are directly bathed in the fluid of the gastro-vascular canals is so completely at variance with the analogy of these parts in all the other HYDROIDA, that we can scarcely bring ourselves, without very strong evidence, to accept it. If we admit the presence of a true spadix penetrating the pouch, and surrounded by the ova or spermatozoa, we have all the parts needed to establish a detailed homology between the leaf-like pouches of *Geryonia* and the prominent sacs of *Obelia*, and these last are, without any doubt, true zooids, strictly homologous with the sporosacs of *Clava*.

It is more difficult to recognise a zooidal origin in the generative pouches of the *Cunina* which Haeckel has shown to be produced as a bud from the *Geryonia*, and there seems no reason why we should not, with Haeckel, regard the *Cuninæ* as truly sexual medusæ. What may be the subsequent history of these *Cuninæ*, is as yet entirely unknown; and until this shall have been determined, the significance of Haeckel's beautiful discovery of the relation between the Geryonidans and Æginidans must remain but partially recognised.

In the genetic phenomena of the Hydroida, so far as these have been accurately determined, one fact stands out in prominent relief, and its recognition is of great importance in enabling us to perceive the true import of these phenomena, and the mode in which they are associated in the life of the hydroid. I again refer to the fact that in every hydroid the groups included between every two acts of embryonal development (the groups connected by horizontal brackets in the above formulæ) are exactly similar in the nature and succession of their heteromorphic elements,—in other words that the life series of the hydroid may be represented by definite groups of zooids exactly repeated after each generative act.[1] It is plain, too, that each of these groups—which we may conveniently designate as the "periods" of the series—exactly corresponds to the "individual" which constitutes the proper logical element of the *species* in animals which do not present the phenomenon of alternation, the period here repeating itself by true generation, and this repetition continuing itself indefinitely like a circulating decimal, so as to represent the indefinitely extended life of the *species*, while the life of the *individual* is expressed by each period singly. It is further evident that the conception of the individual involved in the above view is in no respect invalidated by the fact that one or more of its zooidal elements may become free, and enjoy an independent existence.

For the views of Hydroid individuality, embodied in the above paragraph, we are indebted to Prof. Huxley, who first assigned to our conception of the biological individual its proper limits when he defined it as "the total result of the development of a single ovum" — a most important determination by which alone the genetic phenomena of the *Hydroida* can be properly understood and brought into comparison with those of the higher animals. At the same

[1] The mere *number* of zooids in two or more of these groups may of course vary, depending as this does on the accident of abundant or deficient nutrition and the like.

time it must be borne in mind that it is "the individual" in the somewhat technical sense of the component of a *biological species* which is to be here understood, and that individuality, in its more ordinary acceptation, cannot be excluded from our conception of the life-series of a hydroid. In this sense every zooid has an individuality of its own—an individuality, however, of a very different kind from that which characterises the successively repeated *groups* of zooids constituting the individuals which logically make up the biological species.

The hydranth normally continues the axis in the hydroid colony, just as the leaf-bud in the plant continues the vegetable axis; the gonophore, on the other hand, has no power of continuing the axis, and constitutes the terminal zooid in each "period" of the series, just as the flower-bud stops the elongation of the axis in the plant. This analogy, however, must not be pushed too far, for while the hydranths and gonophores are simple zooids, the leaf-buds and flower-buds are complex associations of the corresponding element of individuality in the plant.

The normal order of succession of the buds in the trophosome is from the proximal to the distal end of the hydrosoma, so that the older buds are met with towards the base or hydrorhizal end of the main stem and branches, the younger ones towards the summit. In the gonosome, on the other hand, the order of succession is sometimes towards the distal, sometimes towards the proximal end of the axis. In the calyptoblastic genera the order of succession of the sporosacs or blastochemes is invariably from the distal towards the proximal extremity of the blastostyle, on which, in these genera, they are always borne. When a blastostyle is present in the gymnoblastic genera, the gonophores succeed one another, sometimes (*Hydractinia echinata*) from the proximal towards the distal end of the blastostyle, sometimes (*Dicoryne conferta*) from the distal towards the proximal. In *Tubularia* their succession is from the distal towards the proximal end of the common peduncle, which is more or less developed in the various species of this genus, and the same order of succession occurs in *Corymorpha*.

Where no special gonosomal axis is developed the succession is usually from the proximal to the distal extremity of the branch (*Bougainvillia*, *Perigonimus*), thus corresponding to that of the zooids of the trophosome. Sometimes, however (*Syncoryne*, *Gemmaria*), it is from the distal to the proximal.

We have thus, then, in the gonosome of the Hydroida, as in the inflorescence of plants, both a centripetal and a centrifugal order of succession. It is possible, however, that irregularities may occur, and that a new bud may be abnormally emitted at the distal side of a centrifugal series, or at the proximal side of a centripetal one, so as to disturb in individual cases the normal sequence of the zooids.

Some further points admitting of comparison with the inflorescence of plants may be noticed in the gonosome of such hydroids as possess a special gonosomal axis. In *Tubularia indivisa* (Pl. XX, fig. 2, 3), and in the male colonies of *Tubularia larynx* (Pl. XXI, fig. 1) the gonophores are—like the flowers of a raceme—carried on short pedicels along the sides of a long common peduncle which springs from the body of the hydranth (woodcut, fig. 44). Their order of development, however, is centrifugal, or from the distal to the proximal extremity of the peduncle, so that the whole group may be compared to a reversed raceme. In the female colonies of *Tubularia larynx* (Pl. XXI, fig. 2, and woodcut, fig 45), and in *Corymorpha nutans* (Pl. XIX, figs. 1 and 3), the pedicels become branched, with a similar order of development which thus gives us the compound reversed raceme or cyme.

The reversed spike, or spike with a centrifugal development, shows itself in such forms as *Dicoryne conferta* (Pl. VIII, fig. 1, and woodcut, fig. 41); while in *Laomedea* (woodcuts, figs. 18 and 13), *Obelia*, woodcut, fig. 19), and other calyptoblastic forms, we have a reversed spike

Fig. 14.

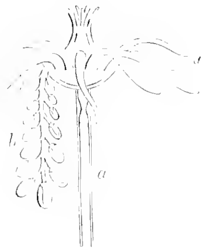


Diagram of *Tubularia indivisa*.

a, a. Hydranth with its stalk; *b*, shortly stalked gonophores, borne on a common peduncle, and increasing in maturity from the proximal to the distal extremity of the peduncle.

Fig. 15.

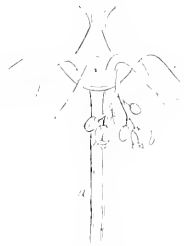


Diagram of *Tubularia larynx*—female.

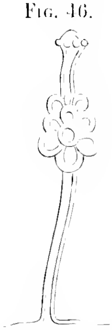
a, a. A hydranth with its stalk; *b*, gonophores, attached by short stalks to a common branched peduncle, and increasing in maturity from the proximal to the distal extremities of the branches.

surrounded by the gonangial sheath, and, were it not for its centrifugal development, strongly recalling the spadix with its spathe in the inflorescence of an araceous plant.

In certain proliferous medusæ (woodcuts, figs. 36 and 37) the buds are borne on the manubrium with a centripetal order of development, thus giving us, according as the buds are sessile or pedunculated, the true spike or the true raceme.

In *Eudendrium* (Pls. XIII and XIV) the male gonophores are disposed in an umbel with the axis, in some cases prolonged beyond it, while in others there is no extension of the axis beyond the depressed portion which carries the gonophores. Though we cannot here recognise any difference in the order of development among the gonophores composing the umbel, we are probably justified in assuming this order to be, as in the true umbel, a centripetal one; for in the female colonies of most species, such as *Eudendrium ramosum* (Pl. XIII, fig. 3), the gonophores are separated from distance to distance upon the stem immediately below the hydranth, and here their order of development is plainly seen to be centripetal.

Fig. 16.



Hydractinia. A blastostyle with gonophores clustering round it, and increasing in maturity from the free or distal to the attached or proximal end.

Fig. 17.

Clava. A hydranth surrounded by a verticil of globular clusters of gonophores.

In *Hydractinia echinata* (Pl. XV, figs. 1 and 3, and woodcut, fig. 46) we have the closely approximated gonophores sessile on a blastostyle, and the development centripetal, as in the true spike, while the axis extends beyond it as a naked prolongation, reminding us of the naked prolongation of the spadix in certain *Araceæ*.

In *Clava squamata* (Pl. I, figs. 1 and 3) and in *Clava multicornis* (Pl. II, fig. 1, and woodcut. fig. 47) the gonophores form dense clusters surrounding the hydranth in a sort of verticil. Each cluster consists of sessile gonophores borne on a greatly depressed common peduncle, and thus recalling the form of inflorescence known as a capitulum. The order of development, however, appears to be centrifugal, instead of being, as in the true capitulum, centripetal, and would therefore, perhaps, more truly suggest a comparison with the depressed cyme which constitutes the axillary inflorescence in many *Labiatæ*.

In the comparison just instituted between the gonosome of the HYDROIDA and the inflorescence of plants it will be noticed that, whenever in the HYDROIDA the generative buds are borne upon a special gonosomal axis like the flowers in an inflorescence, the order of succession is far more frequently a centrifugal than a centripetal one. In the calyptoblastic forms, indeed, it is always centrifugal. This is exactly the opposite of what prevails in plants, for here the centripetal forms of inflorescence greatly exceed the centrifugal ones.

We must be careful, however, not to assign to the resemblances which may be noticed more importance than they are justly entitled to. Yet, after setting aside such as are merely superficial and accidental, many still remain which have their origin in certain deep-seated properties. They may be referred to the common phenomenon of gemmation, which, by agamic multiplication in the animal as well as in the plant, gives rise to colonies whose members, in each case mutually dependent on one another, continue to be organically associated into definitely arranged and determinate groups.

V. HISTOLOGY.

Both trophosome, gonosome, and cœnosome have now been considered in their broader morphological features; their morphology, however, cannot be regarded as complete without some further anatomical details, embracing a histological examination of the tissues.

The HYDROIDA possess an exceedingly simple structure. Every hydroid, as we have already seen, is composed of two layers, an ectoderm and an endoderm. Each of these may present in itself various degrees of differentiation, and we can, perhaps, best study the minute texture of the tissues by examining them first in the ectoderm, and secondly in the endoderm.

1. *The Ectoderm.*

General structure of Ectoderm.—In many cases it is impossible to detect in the ectoderm of the mature hydroid any well-defined structure. A homogeneous blastema with granules and scattered nucleus-like corpuscles, and thread-cells more or less thickly immersed in it, are all that the microscope has as yet in such cases succeeded in demonstrating, though a cellular structure of this layer can almost always be observed in the embryo.

Sometimes, however, the ectoderm of the adult hydroid may be seen to be composed of very distinct cells, which can occasionally be isolated without difficulty under the microscope. In *Hydra viridis*, for example, the ectoderm can be broken down under the microscope into spherical cells, in which a nucleolated nucleus may occasionally be detected. These cells are provided with distinct membranous walls, within which is contained a homogeneous vacuolated protoplasm, in which are often immersed secondary nucleated cells, and also in many of them one or more thread-cells.

In some cases in which it is not easy to detect definite structure in the normal state of the ectoderm, this membrane, by a natural hystolytic decomposition after death, will become broken up into very distinct cells (Pl. I, fig. 1).

Palpocils.—Leydig[1] has called attention to the occurrence in *Hydra* of a minute bristle-like projection of the surface over the site of each thread-cell, without having any immediate connection with the thread-cell itself, and Dujardin[2] had already noticed and correctly described similar bodies as existing on the surface of the capitula which terminate the tentacles in his *Stauridium*. Dujardin further compares them to the processes which are emitted by an *Actinophrys* or an *Acineta*. These bodies, however, had been previously noticed by Corda,[3] where they lie over the smaller kind of thread-cell which occurs in the tentacles of *Hydra;* but he erroneously describes them as direct prolongations from the thread-cell, so as to constitute with it a special organ, which he calls an "organ of touch." They have also been examined by Dr. T. S. Wright,[4] who follows Dujardin and Leydig in showing that they are not directly continuous with the thread-cell, and who also maintains their very simple protoplasmic nature. He proposes for them the name of "palpocils." I can entirely confirm the views of Dujardin, Leydig, and Wright with regard to those bodies which I have examined in various hydroids (Pl. IV, fig. 4).

In the marine hydroids a very delicate structureless pellicle can usually be shown to exist for a greater or less extent over those parts which are not covered by the ordinary perisarc. I believe it to be either a simple excretion from the surface of the ectoderm or the result of a metamorphosis of the most superficial portions of this structure. Sometimes, however, the place of this pellicle is taken, at least on the tentacles, by an exceedingly thin layer of a transparent semifluid substance, which seems to possess the properties of sarcode (woodcut, fig. 48). The minute filaments just described as occurring over the site of the thread-cell would seem to be mere continuations of this sarcode layer, which also frequently presents here and there little conical elevations, which have no relation with the thread-cells, and whose summit is continued into a filament of extreme tenuity (woodcut, fig. 48 *e, e, e*). These filaments were first pointed out by Wright, who includes them along with the organs of Corda under the common name of "palpocils."

Leydig is of opinion that there exists over the whole surface of *Hydra*, except the surface of attachment of the foot-disc, a very thin homogeneous cuticle. I am inclined to believe that what Leydig names cuticle is really the sarcode layer, which here, as in the marine hydroids, is continued into the palpocils.

[1] Müller's 'Archiv,' 1854.

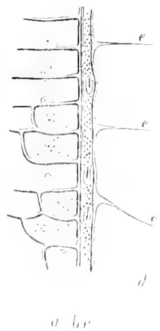
[2] 'Ann. des Sci. Nat.,' 1843, p. 370.

[3] Ibid., 2me série, 1837, p. 363.

[4] 'Proc. Roy. Phys. Soc. Edinb.,' vol. i, p. 311.

Fibrillated tissue.—In a great many cases there is developed upon the inner surface of the ectoderm a peculiar tissue, forming an abrupt boundary between the ectoderm and endoderm. It may be well seen in those elongated hydranths which present an extensive surface uncovered by the more or less opaque chitinous perisarc, such as *Clava*, *Hydractinia*, and *Clavatella*, and in the very contractile body and tentacles of the hydranths of different *Corynidæ*, and in the stem and hydranth of *Corymorpha*. In all these cases it presents the appearance of fine, close, longitudinal and parallel striæ between the ectoderm and endoderm. From the body of the hydranth these striæ usually extend into the tentacles, and may be very distinctly seen in the tentacles of *Coryne pusilla*, where they can be easily traced as far as the terminal capitulum.

FIG. 48.



Part of a tentacle of *Syncoryne pulchella*, showing the superficial protoplasmic layer.

a, Large-celled tissue of endoderm, forming the axis of the tentacle, the cells containing nucleated, and often radiating, masses of protoplasm; *b*, fibrillated layer; *c*, ectoderm, with immersed thread-cells; *d*, superficial layer of protoplasm, which has become extended here and there into *e*, *e*, *e*, filaments of extreme tenuity.

I have succeeded in isolating the fibrillated tissue of the large tentacles in specimens of *Tubularia indivisa*, which had been kept some years in spirits. The fibrillated tissue here (Pl. XXIII, fig. 5) consists of two layers, one composed of fibres which take a longitudinal course parallel to the axis of the tentacle, and the other of fibres which take a circular course transverse to the axis. The circular fibres seem to lie externally to the longitudinal, and both form a muscular envelope which is intimately connected with the ectoderm of the tentacle, and comes away with the latter when this is separated from the endoderm.[1]

The fibres thus isolated appear to be tubular, having a diameter of about $\frac{1}{5000}$ of an inch; they are perfectly smooth, but in most cases a very distinct oval nucleus, having a greater diameter of about $\frac{1}{2500}$ of an inch, and with a brilliant nucleolus, may be demonstrated in them. They may sometimes be seen to taper away at each end to a point, when they present the appearance of greatly elongated fusiform cells (fig. 6).

That the fibres thus demonstrated in the Hydroida constitute a true contractile tissue would follow, not only from the analogy suggested by structure, but from the fact of contractility manifesting itself with great intensity in those parts where they are best developed.[2]

[1] In some cases the fibrillated tissue would seem to be more intimately united to the endoderm than to the ectoderm. I have found, at least, that in specimens of *Clava squamata*, which had been preserved in spirits, the ectoderm could be detached, leaving the fibrillated layer still adherent to the endoderm.

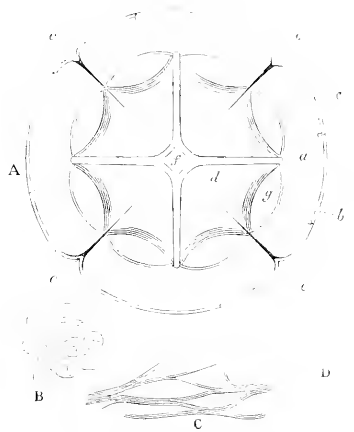
[2] Reichert ("Ueber die contractile Substanz und den feineren Bau der Campanularien," &c., 'Monatsbericht der Akad. der Wissens. zu Berlin,' July, 1866, p. 504) denies the existence of the contractile fibrillated layer whose presence is here insisted on, and maintains that its place is taken by a structureless membrane, to which he gives the name of supporting lamella ("Stützlamelle"), and which he regards as a sort of internal skeleton secreted from the inner side of the ectoderm. He believes that the whole contractility of the hydroid resides in the ectoderm itself, which he says is entirely destitute of cells or cell-constituents. My own observations will not allow me to adopt the views of Reichert.

The fibrillated tissue is largely developed in the umbrella of the medusa, where the fibres are arranged circularly, and where, instead of lying between the ectoderm and endoderm, they are situated on the concave surface of the umbrella, as well as in the membranous velum, of which they constitute nearly the entire substance. We shall examine this tissue in connection with the other structures which enter into the umbrella of the medusa.

Umbrella of medusa.—A remarkable and important modification of the ectoderm is seen in the umbrella of the medusa, where it forms nearly its entire mass, the ectoderm becoming almost wholly changed into a perfectly transparent, elastic, gelatinous-looking substance, traversed by the gastro-vascular canals, which are lined by endoderm.

The following observations on the structure of the umbrella have been chiefly made on the medusa of *Syncoryne pulchella* shortly after its liberation from the trophosome. In this medusa (Pl. VI, fig. 3, and woodcut, fig. 49) the convex surface of the umbrella is covered by a distinct epithelial layer (woodcut, fig. 49 A, *b*) formed of cells (B), containing a nucleolated nucleus, and separated from one another by narrow tracts of homogeneous intercellular substance. These cells appear to consist of simple masses of protoplasm, without distinctly differentiated walls. Under the action of acetic acid they undergo changes of form, becoming elongated oval or fusiform or conical, or even extended into irregular processes, while the protoplasm assumes a more distinctly granular appearance, and the nucleus, with its nucleolus, frequently becomes more evident. Immediately beneath the epithelial layer the proper gelatinous substance (A, *a*) of the umbrella begins. It is transparent, colourless, and elastic, and apparently of the consistence of soft jelly. I have in vain sought for anything like definite structure in it, though Haeckel[1] has shown that in the *Geryonidæ* the homogeneous gelatinous substance of the umbrella is traversed by numerous fine branching fibres in a direction chiefly perpendicular to the surfaces, while the researches of Max Schultze[2] have proved that in the *Discophora* or steganophthalmic medusæ the corresponding part consists of widely separated cells, which send out prolongations from their walls to meet similar prolongations from the neighbouring cells, and with a voluminous intercellular substance, which is composed of a semifluid matter in the meshes of a loose, elastic, fibrous

FIG. 49.



Structure of medusa of *Syncoryne pulchella* shortly after liberation from the trophosome.

A. Projected view of medusa from the summit of the umbrella; *a*, gelatinous substance of the umbrella; *b*, external epithelium-layer, and *c*, internal epithelium-layer of the umbrella; *d*, subumbrellar muscular sac united to the umbrella along the lines of the four radiating canals and along four intermediate lines corresponding to the four meridional furrows *e*, *e*, *e*, *e*, observable on the outer surface of the umbrella; *f*, summit of manubrium.

B. Cells composing the external epithelium of the umbrella.

C. Fibrillated tissue of the subumbrellar muscular sac.

D. Fibrillæ of the muscular sac treated with acetic acid, and viewed under a high power.

[1] Op. cit., p. 166.

[2] Schultze, "Ueber den Bau der Gallertscheibe der Medusen," Müller's 'Arch.,' 1856.

network. Schultze has recognised the close resemblance between this structure and that of certain forms of the so-called connective tissue.

Though I have failed in my attempts to detect structure in the gelatinous portion of the umbrella of those hydroid medusæ which I have examined, I do not desire on that account to insist on its absence. The comparatively small size and soft consistence of most of the hydroid medusæ, and the consequent extreme difficulty of obtaining thin slices fitted for microscopical observation, and freed from the confusing presence of the epithelium and fibrillated layers, throw much greater obstacles in the way of a satisfactory examination of the umbrella of the ordinary hydroid medusæ than what we meet with in the larger and more easily manipulated umbrella of the *Geryonidæ* and *Steganophthalmata*.

Lying immediately on the concave surface of the gelatinous substance of the umbrella, an inner epithelial layer (A, *c*) may under circumstances favorable for observation be demonstrated. It consists of a single layer of cells, and corresponds to the epithelium of the convex surface, but is much more difficult to detect.

The concavity of the umbrella is lined by a sac (A, *d*) which lies immediately upon the inner epithelium layer, and consists of a distinctly fibrillated membrane. The fibres composing it take, when at rest, a circular course parallel to the margin of the umbrella, and are usually in close contact with one another, though occasionally they become separated at intervals, so as to leave numerous fusiform spaces between them (C). They are very fine, measuring about the $\frac{1}{10000}$ of an inch in diameter, and under a high power of the microscope each fibril appears resolved into a single series of corpuscles, a structure which under the action of acetic acid becomes distinct (D). At the margin of the umbrella the fibrillated layer leaves the gelatinous bell and is inflected inwards over the codonostome, so as to constitute the perforated diaphragm or velum.

The fibrillæ of the umbrella and velum, which are thus much more minute than those which have been described in the trophosome, present a marked resemblance to the ultimate fibrillæ of striated muscle; but, instead of being united into fibres, they are spread out into a broad membrane.[1] That the fibrillated layer forms a true contractile tissue, conferring on the medusa those active natatory powers which constitute one of its most striking characters, there cannot be any doubt.

[1] Busk, in a paper full of excellent observations on the structure of some hydroid medusæ ('Trans. Mic. Soc. Lond.,' vol. iii, p. 14), describes the muscular fibres in the umbrella of *Turris neglecta* and in that of a *Thaumantias*-like medusa as "distinctly marked with transverse striæ."

In the swimming-bells of the Siphonophora the fibrillated tissue is very well developed. In a small species of *Diphya*, captured abundantly on the Irish coast, it was easy in very fresh specimens to get a good view of the contractile fibres which are largely developed in the swimming-bell of this Siphonophore. Besides the circular fibres, a longitudinal set seems also to be present. The circular fibres are flattened, and marked with close transverse striæ, which are rendered particularly evident by the application of acetic acid, which also brings out in the walls of the fibre distinct but distant nuclei with contained nucleoli.

According to Haeckel, the fibrillated layers of the umbrella and velum of the *Geryonidæ*, as well as that which invests the stiff tentacles which always exist in the young state of these medusæ, consist of very distinctly striated fibres, while smooth muscle-fibres occur in the walls of the manubrium. He also refers certain fibres and nucleated fusiform cells, which he has detected in the extensile marginal tentacles of these medusæ, to the group of smooth muscle-fibre.

The muscular sac which thus lines the umbrella in *Syncoryne pulchella* is not uniformly adherent to it, and receives its chief attachment along eight meridional lines. Four of these correspond to the direction of the four radiating canals, and the remaining four are so distributed that one lies exactly midway between every two radiating canals.

In medusæ, such especially as have been kept alive for some time in our jars, the muscular sac may be occasionally seen to be separated by a considerable interval from the rest of the umbrella in all the spaces which intervene between the eight meridional lines of attachment, though it still continues closely adherent to these lines (woodcut, fig. 49 A). A few delicate bands may here and there be seen, near the summit of the umbrella, stretching transversely across the spaces between the umbrella and the detached portions of the sac.

It is in this condition that the inner epithelium layer becomes apparent. I have failed to see it as long as the muscle-sac is uniformly in contact with the rest of the umbrella.

An inner epithelium layer has been shown by Haeckel to exist in the *Geryonidæ*. There, however, he describes it as lying on the concave surface of the muscular layer.

In the medusa of *Obelia geniculata* shortly after liberation, the inner epithelium is very distinct, but I have failed in satisfying myself of the existence of a distinct muscular layer in the almost disc-shaped umbrella of this medusa, which, moreover, presents the very exceptional condition of being entirely destitute of a velum. On the other hand, a distinctly fibrillated layer may be seen in the marginal tentacles (woodcut, fig. 59 A *a*), which indeed would seem by their fin-like action to be far more efficient than the umbrella in the locomotion of the medusa.

The inner epithelium consists here of distinctly nucleated cells with narrow intercellular spaces. In many of the cells the nuclei were plainly seen to be in process of division (woodcut, fig. 59 C).

The gelatinous portion of the umbrella thus lies between the two layers of epithelium, and is probably a product of one or both of these layers. In many hydroids the medusa immediately after liberation has this gelatinous portion still thin, but it often acquires great thickness as the medusa advances towards maturity—a phenomenon of which *Bougainvillia* affords a striking example (see Pl. IX).[1]

Nematophores.—The general form and relations of the nematophores have been already described (p. 28). The matter which fills the chitinous sheath of the nematophore is a clear semi-fluid substance with scattered granules, and without the slightest trace of structure, but having frequently imbedded in it a cluster of thread-cells. It differs in no respect from the sarcode matter composing the bodies of the *Rhizopoda*, and like it is capable of emitting true pseudopodia. When a specimen of *Antennularia antennina* (woodcut, fig. 50) or *Aglaophenia pluma* (woodcut, fig. 51) is examined in the zoophyte trough of the microscope shortly after removal from the sea, and before it has lost any of its original vigour, the contents of the nematophore-sheaths will be

[1] Haeckel (op. cit.) has described in the umbrella of the *Geryonidæ* certain structures which he has shown to be nearly allied to cartilage, not only in consistence, but in histological composition. This medusa-cartilage forms—1. A ring which runs in the gelatinous substance of the umbrella parallel to its margin, and below the circular canal. 2. Certain rib-like structures (mantel-spangen) which are imbedded in the outer surface of the umbrella, and extend from the margin in a meridional direction for a greater or less distance towards the summit. 3. The rod-like axis of the stiff, solid tentacles.

In all these cases the medusa-cartilage consists of rounded, nucleated, occasionally vacuolated, masses of granular protoplasm, contained in cavities of a clear homogeneous intercellular substance having a cartilaginous consistence.

seen extending themselves in the form of long processes and threads of sarcode, sometimes simple and undivided, sometimes breaking themselves up into branches, sometimes stretching themselves out as free processes into the surrounding water, and sometimes seeming to flow over the surface of the hydrosoma in simple or branching streams; and then again the whole will slowly withdraw itself into its chitinous receptacles, leaving not a trace visible of those wonderfully extensile processes and filaments of sarcode into which it had just before transformed itself. In all this the clusters of thread-cells, when they exist, remain quite stationary, being never carried out with the sarcode in its pseudopodial prolongations.[1]

Fig. 50.

Portion of a ramulus of *Antennularia antennina*, with hydranths and nematophores.

a, Hydranth extended; *b*, hydranth retracted; *c*, hydrotheca; *d*, *d*, *d*, *d*, consecutive segments of the ramulus; *e*, *e*, azygous or mesial nematophores, with their sarcode contents quiescent; *e'*, *e'*, *e'*, azygous nematophores, with the sarcode contents emitting pseudopodial prolongations; *f*, gemminate or lateral nematophores, with pseudopodial prolongations of the sarcode.

Thread-cells.—The most characteristic elements of the ectoderm are the thread-cells. They occur under various forms throughout the whole of the *Cœlenterata*, and though analogous bodies are occasionally found in some other invertebrate groups, they are nowhere so abundant and characteristic as in the *Cœlenterata*.[2]

The form of the thread-cell varies in different species of hydroids, and even in different parts of the same animal; but it consists essentially of a containing capsule, and a contained filament, which admits under certain conditions of being projected from the capsule (woodcut, fig. 52). The investigation of the thread-cell, with the view of obtaining a knowledge of its structure and mode of action, is one of the most difficult tasks in the anatomy of the Hydroida. The minute size, great transparency, and almost entire uniformity of action on the light, of all the parts of these really complex bodies, and the rapidity with which their characteristic function is performed, renders their study one which requires no ordinary patience and practice in microscopical observation, and, notwithstanding the labour which has been bestowed upon them, our knowledge of the thread-cell is by no means in all points satisfactory.

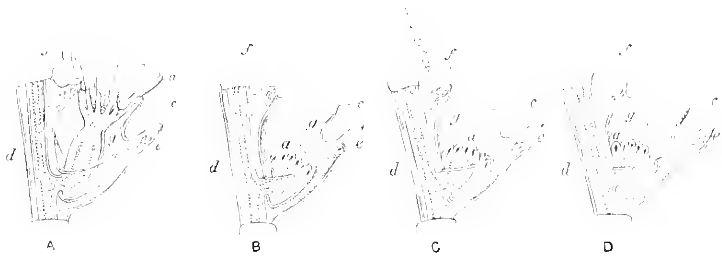
The large thread-cells which occur in the tentacles and body of *Hydra*, or in the capitula which terminate the tentacles in *Coryne*, may be taken as presenting the most usual type of these bodies among the Hydroida.

[1] See my "Report on the Reproductive System of the Hydroida," in 'Brit. As. Rep.' for 1863, and a paper "On the Occurrence of Amœbiform Protoplasm and the Emission of Pseudopodia in the Hydroida," 'Ann. Nat. Hist.' for March, 1864.

[2] Among the more recent authors who have studied the thread-cell in the *Cœlenterata*, refe-

If we examine one of the large thread-cells from the tentacle of *Coryne pusilla* previously to its being exposed to the conditions which result in the emission of its filament, we shall find it to consist of an external perfectly transparent oval capsule with rigid walls, and of certain remarkable contents which play an important part in the special function of the thread-cell (Pl. IV, fig. 1). The

Fig. 51.



Hydrothecæ of *Aglaophenia pluma*, with hydranths and nematophores.

A. Hydrotheca, with extended hydranth and with the sarcode contents of the nematophores quiescent. *a*, extended hydranth; *c*, serrated margin of hydrotheca; *d*, segment of the ramulus carrying the hydrotheca; *e*, mesial or azygous nematophore; *f*, lateral nematophore; *g*, lateral aperture through which the mesial nematophore communicates with the cavity of the hydrotheca.

B. Hydrotheca, with retracted hydranth and the sarcode contents of the nematophores emitting pseudopodial prolongations. *a*, retracted hydranth; *c*, margin of hydrotheca; *d*, segment of the ramulus carrying the hydrotheca; *e*, mesial nematophore, with its protoplasm projected in an irregular pseudopodial mass; *g*, through its lateral aperture into the cavity of the hydrotheca; *f*, lateral nematophore, with the commencement of a pseudopodium.

C. Same parts with pseudopodial processes more advanced. *a*, retracted hydranth; *c*, margin of hydrotheca; *d*, segment of ramulus; *e*, mesial nematophore from which a long clavate process, *g*, of protoplasm is projected into the cavity of the hydrotheca; *f*, laterd nematophore from which a long pseudopodium is projected into the surrounding water.

D. Same parts showing different states of extension of the pseudopodia. *a*, retracted hydranth; *c*, margin of hydrotheca; *d*, segment of ramulus; *e*, lateral nematophore with a branching process, *g*, of its sarcode projected into the cavity of the hydrotheca; *f*, lateral nematophore with the pseudopodium entirely withdrawn.

In all the figures a cluster of thread-cells is seen imbedded in the distal end of the protoplasm within the sheath of the nematophore.

capsule is completely closed, and its longer axis is occupied by a membranous tube somewhat wider near the centre than at either end. At one end of this tube, its walls are continuous with those of the capsule, and it is this part of the capsule which usually lies most superficially when the thread-cell is imbedded in the ectoderm; it may, for the convenience of description, be distinguished as the anterior end. The opposite end of the axile tube loses itself in a perfectly transparent mass which occupies nearly the whole of the posterior half of the cavity of the capsule, and in which I have in vain sought for anything like definite structure.

The peculiar phenomena, however, which characterise the evolution of the thread-cell, together with observations upon the structure of the thread-cell in other species, render it almost certain that the apparently homogeneous mass in which the posterior extremity of the

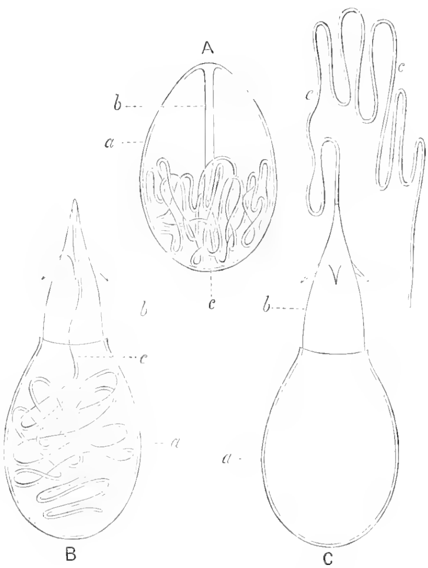
rence may be made to Leidy ("Marine Invertebrate Fauna of the Coasts of Rhode Island and New Jersey," in 'Acad. Nat. Sci. Philadelphia,' vol. iii, 1855), Gosse ('British Sea Anemones,' 1860), Clark (Agass., 'Cont. Nat. Hist. United States,' vol. iv, p. 209), and more especially to Möbius ("Ueber den Bau, den Mechanismus, und die Entwickelung der Nesselkapseln," from the 'Transactions of the Natural History Society of Hamburg,' 1866), who has given us a very full account of these bodies, which he has studied chiefly in *Caryophyllia Smithii*.

axile tube loses itself, is in reality here, as in other cases, a filament rolled upon itself, but of such extreme tenuity and transparency as to render it impossible to distinguish the individual coils.

By carefully adjusted illumination, the whole of the capsule appears to be lined by a membrane of extreme delicacy. The existence of an external capsule distinct from its lining membrane is particularly apparent in the thread-cell after the emission of its contents, for then the outer capsule is seen to terminate by a distinct slightly everted margin round the orifice through which the contents have been expelled (Pl. IV, fig. 5).

The characteristic action of the thread-cell may be brought into play under the microscope by some force artificially applied, such as the pressure of the compressorium, or the contact of alcohol or acetic acid. This action consists in a sudden change of form, the capsule opening at its anterior end, from which a very remarkable body is at the same time projected with a rapidity which renders it impossible for the eye to follow it in its progress (Pl. IV, fig. 5, and woodcut, fig. 52 B, *b*). When, however, this act is completed, the projected body may be seen to be an elongated sac whose walls are at one end continuous through the opening in the capsule with the membrane by which the latter is lined, and whose opposite end tapers away to a point. Just where this sac begins to thin away towards its point, three rigid spines are fixed in a verticil to the outer surface of its walls, their points being directed backwards like the barbs of an arrow.

FIG. 52.



Diagrammatic Views of the Thread-cell.

A. The thread-cell previous to the emission of its contents. *a*, the double wall of the capsule; *b*, reflected portion of the inner membrane of the capsule-wall, forming the axile tube of the unevolved thread-cell; *c*, the filament lying in complicated coils in the bottom of the capsule.

B. The thread-cell immediately after the first stage of evolution. *a*, the double wall of the capsule; *b*, the barbed sac formed by the eversion of the axile tube; *c*, the filament still lying within the capsule and barbed sac.

C. The thread-cell after the complete emission of the contents. *a*, the double wall of the capsule; *b*, the barbed sac; *c*, the ejected filament.

The projection of the barbed sac does not, however, constitute the whole of the phenomenon presented by the thread-cell under the influence of the force which gave origin to its evolution; for this first act is followed—in most cases instantaneously—by a second, which consists in the projection, from the pointed summit of the sac, of a filament (woodcut, fig. 52 C, *c*) of great tenuity and transparency, which rapidly shoots across the field of the microscope until it attains a length of between thirty and forty times that of the longer diameter of the original capsule; at the termination of the emission, one end of the filament always remains in connection with the free end of the barbed sac. The whole act of evolution is thus completed, and the capsule is now seen to contain nothing but an absolutely colourless homogeneous fluid.

Such are the phenomena presented by the thread-cell in the act of evolution, but the amazing rapidity with which the whole takes place renders it extremely difficult to determine in what the remarkable series of changes now described essentially consists. There can, however, be no doubt that the sudden appearance of the barbed sac is the result of a process of eversion of the membranous tube which in the original state of the thread-cell occupies its axis, and which is formed by the lining membrane of the capsule inverted into itself at its anterior end. The eversion of this tube, by which it becomes freed from the restraint of the capsule, is necessarily accompanied by its sudden expansion and development; and that this is the real nature of the phenomenon in question, receives ample confirmation from what may be witnessed in another kind of thread-cell to be presently described.

It is still more difficult to determine the nature of the act which shows itself in the emission of the filament, than of that which constitutes the emission of the barbed sac. Previously to emission, no trace of a filament can be detected in the thread-cell now under consideration; but, as already said, there can be little doubt that the transparent homogeneous-looking mass in which the posterior part of the axile tube loses itself before its eversion has commenced is nothing more than the filament closely coiled on itself (as shown diagrammatically in woodcut, fig. 52 A).

It is probable that the expulsion of the filament, like that of the barbed sac, consists also in an act of eversion; a view which would of course render it necessary to regard it, notwithstanding its extreme tenuity, as a flexible membranous tube.

It must be borne in mind, that the barbed sac and the filament are in no way continuous with the outer rigid wall of the capsule, but only with the delicate sac by which this is lined. The outer wall opens at its summit by a definite orifice which appears to have been previously closed by a minute lid which is thrown off in the act of evolution, and which may be occasionally seen after the completion of this act adhering in the form of a little disc to the edge of the now expanded orifice, through which the contents of the capsule had been emitted.

Another form of thread-cell which throws light on the structure and action of that just described, occurs also among the HYDROIDA. In *Hydra*, it is in the form of a minute oval capsule, much smaller than the former, and having its cavity occupied by a spirally coiled filament which may be easily seen through its transparent walls. The act of evolution consists in the emission of the filament, but the barbed sac which constitutes so important a feature in the evolved thread-cell of the first kind cannot here be distinguished.

In some other HYDROIDA, the second kind of thread-cell acquires a larger size than in *Hydra*. I have carefully examined it in *Gemmaria implexa*, where it is met with scattered in the ectoderm of the hydranth, and where, from its comparatively large size, it is well fitted for observation. It here consists of an oval capsule (Pl. VII, fig. 9), within which may be seen, previously to emission a long thread, consisting of a straight and a coiled portion. The straight portion crosses the capsule diagonally, and is continuous at one end with the walls of the capsule, while at the opposite end it begins to be rolled up in distinct coils which almost completely fill the capsule. The coiled portion of the thread, however, does not surround the straight portion, but is placed entirely on one side of it, as had been already noticed by Clark in the thread-cells of *Syncoryne mirabilis*.[1]

[1] Clark, loc. cit.

The phenomenon of emission consists here, as in the form of thread-cell first described, of two distinct acts (see Pl. VII, fig. 10). The immediate result of the exciting cause is the projection of a long tubular thread from the anterior end of the capsule. This thread attains the length of about eight times that of the longer diameter of the capsule; and on the completion of its emission one end remains attached to the capsule, while the free end presents a small oval dilatation, behind which the thread is furnished for a short distance with very minute spines, which seem to be arranged spirally on its walls.

The projection of this thread thus constitutes the first step in the evolution of the thread-cell; but it is no sooner completed, than a still finer thread is shot out with great rapidity from its free extremity to a length about equal to that of the first. The whole act of emission is thus completed, and the capsule seems entirely emptied of its contents.

It is probable that the smaller kind of thread-cell in *Hydra* has a structure similar to that now described, though the minuteness of the parts unfits it for a satisfactory demonstration. It is evident, too, that the long thread with its armature of minute spines, whose emission constitutes the first stage in the action of the last-described thread-cell, is the exact homologue of the barbed sac of the first kind, the fine terminal filament in the two being also homologous organs.

The first stage in the emission of the contents of the capsule in the second kind of thread-cell takes place occasionally so slowly, from accidental resistance, that the course of the thread may be easily followed by the eye; and then it will be plainly seen to roll outwards by an act of eversion, reminding us of the mode of extension of the tentacles of a snail. The emission of the finer thread from the extremity of this is, probably, also by an act of eversion; but I have never succeeded in following it so as to obtain direct evidence that it is so.[1]

A fact which has an important bearing on the structure of the thread-cell is the difference of capacity presented by this body according as it is examined in its unevolved or evolved state. It would seem that, in some cases, the capacity of the capsule after evolution is less than it was previously, and then we can understand that no necessity may exist for its emitted contents being replaced by others. In certain cases, however, the total cavity of the thread-cell after the evolution may occupy a space more than double that which characterised it before the commencement of this act. Now, as this occurs in a sac, one portion, at least, of which must consist of a flexible membrane which would yield to any pressure from without not counterbalanced by an equal pressure from within, and as no tendency to collapsing can be detected in the evolved thread-cell, it is plain that, simultaneously with evolution, a fluid must be admitted into it from without,

[1] The observations of Möbius (loc. cit.), made chiefly on the thread-cells of *Caryophyllia Smithii*, have led him to describe the axile tube as consisting of three tubes, included by invagination one within the other. I cannot find direct evidence of this triple invagination in the thread-cells of any of the Hydroida I have examined. It must, however, be borne in mind that the much larger size of the thread-cells of *Caryophyllia* render them more favorable for the determination of structural details; while this view of the axile tube receives support from the fact that the proximal portion of the exserted filament in the thread-cell of *Gemmaria* greatly exceeds in length the straight portion of the unexserted filament; for this portion is the representative, in the non-evolved state, of the proximal portion of the evolved filament, and the difference between the two can scarcely be otherwise explained than by supposing the straight unevolved portion to consist of a tubular filament several times invaginated into itself.

unless we suppose that the cavity of the thread-cell is occupied by a compressible and expansible aëriform fluid. This latter supposition cannot be maintained, and if the former view be accepted, we must either admit the power of rapid imbibition in the walls of the cell, or suppose the presence of some definite opening, not yet detected, through which the surrounding water may gain access to its cavity.

The two forms of thread-cells now described may be regarded as the principal types under which these bodies occur in the Hydroida. Of the nature of the force by which the emission of their contents is effected we cannot yet speak with certainty. Everything that has been observed, however, is opposed to the supposition that the act of evolution is a vital one, dependent on the irritability of certain tissues which enter into the structure of the thread-cell. It is far more probable that it is simply physical, depending on the mere elasticity of the parts, and brought into play when the internal structures are mechanically released from the tension in which they had been held during the previous state of repose.

One fact may here be mentioned which is inconsistent with the idea of the evolution of the thread-cell being a vital act; namely, that prolonged immersion in certain re-agents, such as alcohol, will sometimes have no effect in destroying its characteristic properties; for I have seen the thread-cells of hydroids which had remained for months immersed in alcohol retain the power of emitting their contents on the application of some other re-agent, such as acetic acid.

There is reason to believe that, in some cases at least, the thread-cell when brought into use is at the same time forcibly ejected from the ectoderm in which it had been previously imbedded, and not merely drawn out of its berth by its attachment to the prey; and there is no reason why this act should not be referred to an irritability residing in the ectoderm, and receiving its special stimulus from the conditions which rendered necessary the employment of the thread-cell, such as the contact of living prey.

The employment of the thread-cell by the hydroid would, under these circumstances, involve both a vital and a physical act—the vital manifested in the ejection of the thread-cell from the body of the hydroid, the physical in the emission of its contents.

The special purpose fulfilled by the thread-cells in the economy of the animal, and their probable employment as urticating organs, will be considered under the section which treats of the physiology of the Hydroida.

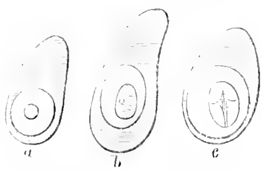
While the thread-cells in the Hydroida are entirely confined to the ectoderm and its appendages, they are by no means uniformly distributed in it. It is in the tentacles of both hydranth and medusa that they are usually most abundant; and here we find them either generally scattered through the ectoderm, or distributed through it in knot-like or wart-like or verticellate groups, or collected together in the spherical capitula in which the tentacles of some genera terminate (see Pls. IV, V, &c.). In many medusæ the ectoderm forms, at the base of the marginal tentacles, bulb-like thickenings which are loaded with thread-cells (see woodcut, fig. 56*e*). In many cases, minute thread-cells singly, or in clusters, are scattered superficially in the walls of the umbrella; in the genus *Gemmaria* (Pl. VII) we also find four piriform chambers extending from the circular canal of the medusa into the umbrella-walls, and filled with small oval thread-cells which have the appearance of lying loose within their cavity (figs. 3 and 6); while numerous similar but smaller sacs, filled with thread-cells, may be seen in *Willia* opening into the circular canal, and thence extending in a meridional direction along the walls of the umbrella.

In *Gemmaria* are also found certain remarkable pedunculated sacs which are developed from the marginal tentacles of the medusa, and filled with thread-cells (Pl. VII, figs. 3 and 4). Thread-cells are also, in many cases, specially developed in the nematophores—those peculiar sarcode appendages already described as characterising the family of the *Plumularidæ*.

It is almost certain that the thread-cells are always developed in the interior of proper cells, and they may be frequently separated from the ectoderm with the generating cell still surrounding them.

From observations which I have made on the larger kind of thread-cell in Hydra, it would seem that a portion of the protoplasm of certain ectodermal cells (generating cells) becomes differentiated as a spherical or oval mass which may be seen to occupy a vacuole in the midst of the remaining protoplasmic contents of the cell (woodcut, fig. 53), and in which one or more nuclei are usually apparent. This little mass is to become developed into the thread-cell. It continues to increase in size, and becomes invested by a distinct cell-wall, while its contained protoplasm becomes, in a way which I have not been able to follow, metamorphosed into the proper contents of the thread-cell. After this the now mature thread-cell becomes free by the rupture of the cell in which it had been generated.[1] The development of the thread-cell may thus to a certain extent admit of comparison with that of spermatozoa—a comparison already made by Leuckart—but we are still far from having a satisfactory notion of the origin and mode of development of these remarkable bodies.

Fig. 53.



Development of thread-cell in *Hydra*.

a. Generating cell of the thread-cell detached from the ectoderm, containing a very pale yellowish protoplasm, from which a small mass has become separated, and occupies the interior of a vacuole, where it looks like a nucleus in a cell.

b. The separated mass of protoplasm has become larger and more oval; two nucleolus-like corpuscles were in this instance apparent within it.

c. A developed thread-cell occupies the place of the protoplasm-mass in the vacuole of *a* and *b*.

To the ectodermal structures also belong the sense-organs—ocellus and lythocyst. These will be considered in the section on the physiology of the Hydroida.

2. *The Endoderm.*

Cellular structure of endoderm—contents of the cells.—The demonstration of a definite structure in the endoderm is much easier than in the ectoderm. Here, indeed, we seldom meet with any difficulty in making out a very distinct cellular composition.

Most usually, two sets of cells may be detected in the endoderm: an external set, with mostly clear, colourless contents, having but few granules; and an internal set, which forms the immediate boundary of the somatic cavity, and contains abundance of coloured granules.

The separation between these two sets of cells is often quite abrupt. In many hydroids those composing the external set are large, elongated, and with their longer axis in the direction of the radius of a transverse section of the hydroid, while those composing the internal set are

[1] Möbius has noticed that in the development of the thread-cells of *Lucernaria* and of certain *Actinozoa* amœboid changes of form are occasionally exhibited by the generating cell. Op. cit., p. 10.

much smaller and more spherical (see Pl. VII, fig. 5). Sometimes, however, the two sets pass imperceptibly into one another without any distinct boundary-line.

In *Hydra viridis*, the cellular structure of the endoderm is very distinct. The contents of most of the cells composing it are here peculiar, and consist of a colourless protoplasm with very definite green corpuscles imbedded in it, and in almost every instance with one and occasionally with two clear vacuolæ excavated in it.[1] It was the occurrence of these vacuolæ which caused Ecker,[2] by overlooking the proper cell-wall, to adopt the erroneous view that the whole tissue of *Hydra* was merely a mass of vacuolated protoplasm.

Among those cells which lie most internally and form the immediate boundary of the somatic cavity in *Hydra viridis*, are many which are destitute of green corpuscles, but contain brown, irregular granules, mostly included in a secondary cell which is itself imbedded in the vacuolated protoplasm of the mother-cell.

The green corpuscles possess a very definite form—a circumstance in which they contrast strongly with the brown granules. They are spherical, and present in their interior a lighter-coloured space which gives them a close resemblance to thick-walled cells. They will be again referred to. (See below, p. 136.)

Along with those cells which contain the green corpuscles, there also occur, especially in badly fed *Hydræ*, others in which the green contents are replaced by smaller spherical but colourless bodies, which are probably the green corpuscles in an undeveloped or transformed condition. Occasionally, also, an irregular mass of brown granules may be seen in the same cell with the green granules.

The cells which thus compose the endoderm of *Hydra* possess but a weak union with one another; they are easily separated by a slight force, and on becoming free immediately assume the spherical figure, without any trace of their having been previously united into a tissue.

No green matter is developed in the cells of any other species of *Hydra*. In *Hydra fusca*, there occur among the cells which form the boundary of the stomach cavity, many which are of an elongated piriform shape, with the broad thick end projecting into the cavity, and with their thin ends imbedded among the others. Within these piriform cells, secondary cells may usually be detected; these are spherical in shape, sometimes having clear colourless contents with a nucleus, while in other cases they are filled with irregular brown granules, and present no evident nucleus. Sometimes the piriform cells contain only free brown granules, while we may also often meet with instances in which, besides the free granules, the same piriform cell will contain the clear nucleated secondary cells, and the secondary cells filled with brown granules. This may be regarded as the typical condition of the same parts in the other Hydroida, though it is seldom so distinctly demonstrable as in *Hydra*.

The walls of the somatic cavity are probably in all Hydroida, if we except *Hydra*, clothed to a greater or less extent with vibratile cilia. These cilia are remarkably distinct among some of the *Tubularidæ*; while in other cases in which their existence has not been proved by direct observation, the peculiar currents visible in the fluid contents of the somatic cavity leave no doubt that it is to the agency of such cilia that these currents are mainly due. *Hydra* would appear to constitute a solitary exception in the non-ciliated condition of its somatic cavity.

[1] Allman, "On the Structure of *Hydra viridis*," in 'Brit. Assoc. Reports' for 1853.

[2] Ecker, "Zur Lehre vom Bau und Leben der contractilen Substanz der niedersten Thiere," 'Zeitsch. f. wiss. Zool.,' Bd. 1, 1849.

The endoderm of the proper digestive cavity is probably in all HYDROIDA thrown into more or less complicated lobes or ridges, which disappear where this cavity passes into the common cavity of the cœnosarc.

This condition may be well seen in *Hydra fusca*, especially when, as sometimes happens, we have an opportunity of looking down into the stomach of the uninjured animal through the widely open mouth. Numerous ridges may then be witnessed, extending from the walls of the cavity almost to its centre. These ridges are rendered papillose by the projection from their surface of the peculiar piriform cells already described, while the furrows between them are comparatively smooth. I have witnessed a similar condition of the endoderm in the digestive cavity of *Cordylophora lacustris*, *Coryne pusilla*, *Syncoryne eximia*, and many others, where thick, irregularly sinuous and lobulated ridges of endoderm project into the stomach from the inner surface of its walls. A furrowed and lobulated state of the endoderm may also be witnessed in the manubrium of the medusa, and in the spadix of the sporosac of many hydroids.[1]

The hydranth of *Tubularia indivisa* presents a very remarkable condition of its endodermal layer (Pl. XXIII, fig. 1). Immediately within the mouth, the cells containing the coloured granules form a narrow smooth zone of vermilion dots, immediately behind which the surface of the endoderm is disposed in irregularly oval prominent vermilion patches, separated by paler narrow sulci. In tracing these patches backwards, we find that they become smaller and more numerous, gradually resolving themselves into small spots, and ultimately into minute scattered puncta which at the posterior extremity of the hydranth, where its cavity passes into that of the stem, become more densely grouped, and are here arranged in radiating bands of a bright vermilion colour. Along the line where the anterior contracted portion of the hydranth passes into the wider basal portion, the endoderm is thrown into numerous remarkable pendulous lobes of a piriform shape and bright vermilion colour (Pl. XXIII, fig. 2). They consist each of a cluster of very distinct spherical cells, containing vermilion-coloured granules, among which are numerous small clear spherical elements, apparently oil-drops. They present a close resemblance, both in their form and in the nature of their contents, to the zone of gland-like lobes which occupies a very similar position in the interior of the hydranthal zooids of certain *Siphonophora*.

Canaliculation of endoderm.—In some HYDROIDA we have a very peculiar and exceptional condition of the somatic cavity and of its endodermal lining; for while this cavity in most HYDROIDA consists of a simple tube, it is in the cases here alluded to composed of numerous intercommunicating canals.

This condition is well seen in different species of *Tubularia*. The stem of *Tubularia indivisa* for example, presents immediately within the perisarcal tube a continuous layer of ectoderm enclosing the endoderm which extends to the very centre of the stem, and thus obliterates all trace of a central somatic cavity (Pl. XXIII, fig. 7). The place of this cavity, however, is supplied by numerous canals, which are excavated in the endoderm and take a longitudinal course through the stem, occasionally communicating by lateral offsets with one another, and finally all merging in a common central cavity at the base of the hydranth.

In a transverse section of the stem, the canals present a wedge-shaped form, the narrow end

[1] In certain *Geryonidæ* (*Glossocodon eurybia*, *Carmarina hastata*), Haeckel (op. cit.) describes, as gastric glands, peculiar leaf-shaped organs which occur in the inner walls of the manubrium (four in *Glossocodon*, six in *Carmarina*). They are composed of clusters of large cells with dark-coloured contents.

being directed towards the axis, and are seen to be arranged in a single zone at some distance from the centre. They are manifestly simple tubular lacunæ interposed among the cells of the endoderm, and destitute of special walls. They are irregular in size, one of them especially being usually considerably larger than the others; and Agassiz, who was the first to call attention to this difference of size, lays considerable stress upon it, for he regards it as constant, and considers the large channel to represent that which alone constituted the cavity of the *Tubularia* in its young state. I have made many sections of *Tubularia* stems, and have always found the tubes irregular in size, and in most cases one of them considerably surpassing the others, as affirmed by Agassiz. Wright, who first distinctly drew attention to the tubular lacunæ, represents them as of equal size; but his figure must be regarded as merely diagramatic. I am not, however, prepared to assent to Agassiz's view of the origin of the large channel. I believe, on the other hand, that the simple somatic cavity of the young *Tubularia* is represented in the adult by the common chamber at the summit of the stem, into which the longitudinal channels all open. It is only in the free stage of *Tubularia* that its cavity is simple; and immediately after it has become fixed the hydranth is carried upwards by the development of a stem whose cavity exhibits, at the moment it can be detected, the compound character of the adult.

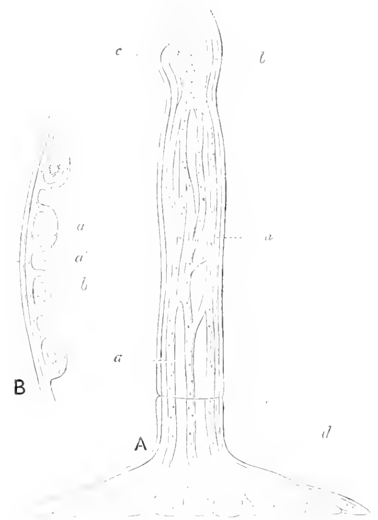
That portion of the endoderm which occupies the axis of the stem consists of large cells of a spherical form, or by mutual pressure more or less polygonal; they are filled with a clear colourless or slightly granular fluid, while the more peripheral portion of the endoderm is composed of small spherical cells containing abundance of minute vermilion-coloured granules; it is in this peripheral portion of the endoderm that the lacunæ are excavated. The walls of the lacunæ are clothed with very long and distinct vibratile cilia.

A structure which in all essential points resembles that just described in *Tubularia indivisa* occurs also in *Corymorpha nutans*, the endoderm of the stem being here, as in *Tubularia*, excavated by longitudinal lacunar canals (Pl. XIX, figs. 1, 6, 7). These canals inosculate here and there with one another; they are much more numerous than in *Tubularia*, but towards the base of the stem they become by mutual coalescence less numerous than in the distal part; they lie just within the ectoderm, and open above into a common cavity in the basal portion of the hydranth. Here the endoderm which forms the floor of the hydranth-cavity rises as a broad conical projection so as to nearly fill the posterior half of the cavity. The axis of this projection is perforated by a narrow canal by which the cavity of the hydranth is continued to the summit of the stem. At this point the canal becomes wider, and receives the longitudinal channels of the stem. The peripheral portion of the endoderm, or that in which the canals are excavated, is composed of small spherical cells with reddish-brown granular contents, while the rest of the endoderm is composed of loose cells with clear colourless contents, and forms a thick pith-like column which occupies the whole axis of the stem. I have not succeeded in detecting cilia in the canals, but, from the very distinct currents which may be witnessed in these canals in the living hydroid, I have no doubt of the presence of cilia here as in *Tubularia*.

The superficial position of the endodermal canals both in *Tubularia* and *Corymorpha* renders them conspicuous without dissection, even to the naked eye, for they give to the stem the appearance of being marked by longitudinal bands from one end to the other.

In *Antennularia antennina* the cœnosarc in the main stems presents also a canaliculated condition, one, however, which differs in some important points from that of *Tubularia* and *Corymorpha*; for, while in the two latter the canals of the stem are mere lacunæ excavated in a common endoderm, the whole cœnosarc is in *Antennularia* broken up into separate tubes, each with its own endoderm and ectoderm, and all surrounded by a common chitinous perisarc (woodcut, fig. 54).

Fig. 54.



Canaliculation of Endoderm in *Antennularia antennina.*

A. Very young hydroid, just after the fixation of the planula and the elevation of the primordial stem. *a*, *a*, the canals of the endoderm, inosculating here and there with one another; *b*, common cavity, formed by the coalescence of the endodermal canals at the summit of the stem; *c*, commencement of a ramulus; *d*, lobed hydrorhizal disc, forming the surface of attachment of the young hydroid; *e*, circular groove, commencement of segmentation in the stem.

B. Part of a transverse section of the adult stem. *a*, ectoderm, and, *b*, endoderm of cœnosarcal canals; *a'*, extension of the ectoderm in the intervals of the canals; *c*, perisarc.

Twenty or more tubes will thus be found in the main stem of a specimen of *Antennularia*. They lie close upon the inner surface of the perisarc, and are connected to one another by an extension of their ectoderm (woodcut, fig. 54 B). In some parts of their course they are straight and parallel; in others, more or less sinuous and reticulated by inosculation. The whole centre of the stem is empty, and has no communication with the somatic cavity, instead of being occupied, as in *Tubularia* and *Corymorpha*, by an endodermal pith-like core, or instead of being, as in most of the Hydroida, occupied by the somatic cavity itself. Very distinct currents may be witnessed in these tubes, especially in the young hydroid, thus affording evidence of the existence of vibratile cilia on their walls.

Endoderm of tentacles.—In the tentacles of the Hydroida, both those of the hydranth and of the medusa, the endoderm usually undergoes a peculiar and important modification. In *Hydra* the tentacles are quite pervious throughout their entire length, while they are lined by a simple continuation of the endoderm of the digestive cavity; but in every other hydroid with which I am acquainted, the endoderm of the tentacles of the hydranth presents a peculiar septate appearance, looking in some cases like a solid core divided by numerous transverse septa into circular discs, and entirely filling up the tube of the tentacles, while in others, though the same septate condition exists, there is still a narrow pervious canal in the axis.

I believe that in all these cases the apparent septa are really the opposed walls of large adjacent endodermal cells which encroach more or less on the cavity of the tentacle, often even to its entire obliteration.

This structure may be well seen in the tentacles of various species of *Corynidæ* (*Coryne pusilla*, Pl. IV, fig. 3, &c.). For some distance from the distal extremity of the tentacle, the cavity is usually entirely obliterated by thin membranous septa which stretch transversely across it. Further towards the base of the tentacle, the septa become less regular, and the obliteration of the tube is now plainly seen to be caused by the large irregular cells of which the endoderm is here composed, and which encroach upon its cavity to such an extent as entirely to fill it; while at a little distance from the base the encroachment of the endodermal cells is usually not so complete, and the cavity of the tentacle, though greatly contracted, still continues pervious, and admits into it fluid with suspended particles from the digestive cavity of the hydranth.

Many of the cells which thus constitute the peculiarly modified endoderm of the tentacle contain a very distinct nucleolated nucleus, round which is generally collected a colourless finely granular protoplasm, which is often kept in connection with the cell-wall by radiating prolongations. A few large coloured granules are also usually contained in the cells. Towards the distal extremity of the tentacle, where the septa are most regular and complete, we generally find a little granular mass collected in the centre of the distal surface of each septum, or else forming a little axile column stretching from septum to septum. These septa, with their intervening chambers, have much the appearance of large cells which stretch entirely across the tube of the tentacle; it is possible, however, that they may be formed by the coalescence of two or more cells from opposite sides, as in the more proximal portions, but here accompanied by the disappearance of their walls in the axis of the tentacle, and the consequent confluence of their cavities.

In some other cases the endodermal cells are not developed to such an extent as to obliterate in any portion the cavity of the tentacle, which thus remains pervious in its entire length; but the large size and regular form of these cells continue to confer on the tentacle a distinctly septate appearance. I have found this condition in the tentacles of *Garveia nutans* (Pl. XII, fig. 6).

In the planoblast also the tentacles usually present the same septate appearance as in the hydranth, the endoderm being frequently so developed as entirely to obliterate the tube. Examples of this may be seen in the marginal tentacles of most medusæ, as, for instance, those which constitute the planoblasts of *Obelia dichotoma*, and of *Podocoryne carnea*, as well as in the tentacles of the free sporosac of *Dicoryne*. Those cases, however, in which the tentacle preserves a complete continuity of its tube are much more common in the medusa than in the hydranth. In the medusa, indeed, it is far from uncommon; we find it, for example, in the marginal tentacles of the medusa of *Syncoryne eximia* (Pl. V, fig. 4), *Gemmaria implexa* (Pl. VII, fig. 4), and *Sarsia strangulata* (woodcut, fig. 17), and, according to Haeckel, in the long extensile tentacles of the *Geryonidæ*.[1]

In the bulb-like expansion which usually exists at the base of the marginal tentacles of the medusæ, at the point where the radiating canal meets the circular canal, the endoderm acquires increased thickness, and often forms lobulated projections which encroach upon the cavity, but never obliterate it (woodcut, fig. 56). These projections are usually rich in cells filled with coloured granules, which, like the coloured granules of the digestive cavity, appear to be secreted in secondary cells developed in the interior of mother-cells.

The endoderm lining the remainder of the gastrovascular canals is, on the other hand, entirely destitute of lobes or ridges. It is very thin, and would seem to have a purely distributive function, the fluid contents of the canals being propelled by vibratile cilia which clothe their walls. These cilia may be well seen in *Syncoryne eximia* (woodcut, fig. 56).

[1] Reichert (loc. cit.) maintains the entire absence of the endoderm in the tentacles of the sertularian and campanularian hydranths, while he regards the septate appearance as produced by simple extensions of his "supporting lamella," which, according to him, forms a layer secreted on the inner surface of the tentacular ectoderm. This view, however, is opposed by the structure, which easily admits of demonstration in the tentacles of many tubularian hydroids.

PHYSIOLOGY OF THE HYDROIDA.

In attempting a classification of the various phenomena of hydroid life, we are at once met by the difficulty of arranging them under definite physiological heads. The low grade of specialisation on which the HYDROIDA stand, renders it often impossible to assign to these phenomena a definite physiological significance, and many of the acts which make up the life of such simple organisms can scarcely claim to be referred to one more than to another of the great classes under which the functions of animals are usually distributed.

Notwithstanding this, however, we shall find it convenient to speak of the vital acts of the HYDROIDA under the following heads :—1. Digestion. 2. Circulation, Nutrition and Growth of the Tissues, and Respiration. 3. Secretion. 4. Contractility. 5. Sensation. 6. Phosphorescence. 7. Reproduction. We must, however, keep in mind that these classes do not all necessarily possess the definiteness which characterises them in the higher and more specialised members of the animal kingdom.

1. *Digestion.*

So far as observation has taught us anything regarding the food of the HYDROIDA, we may conclude that it consists mainly of living animals, though Diatomaceæ and other minute free vegetables contribute also to their subsistence. The patient observations of Trembley and the older naturalists on the fresh-water *Hydra* had long ago shown that animals of considerable size, such as entomostraca, and even aquatic larvæ and worms, are seized by the tentacles of this voracious little hydroid, and carried to the mouth, through which they are borne into the cavity of the body; and subsequent observations have proved that in other HYDROIDA the nature of the food and the capture of the prey are in all essential points similar to what has been noticed in the *Hydra*.

It is in this act that the functions of the thread-cells seem to be mainly called into play; and repeated observations have shown that no sooner do the tentacles come in contact with the living prey, than all power of resistance in the latter is at an end; its efforts to escape seem suddenly paralysed, and it becomes an easy victim to the rapacity of its captor.

If the prey be at this stage released from the grasp of the hydroid and placed under the microscope, all the soft tissues of its surface will be found pierced with discharged thread-cells.

Observers are by no means agreed as to the true functions and mode of action of the thread-cells. By most they are supposed to penetrate the tissues of the prey, and those which, like the larger thread-cells of Hydra, are provided with an apparatus of barbed spines, have been described as plunged beyond the barbs into the soft tissues of the victim. Other observers, and more especially Möbius, reject the idea of penetration, and maintain that the thread-cells arrest the motions of the prey by the mere adhesion of the ejected filament.

I believe, however, that it will be found that there is an actual penetration, but not to the extent that is usually insisted on. If some soft body, such as a worm, be brought into contact with the tentacles of a Hydra, the surface of contact may be seen immediately afterwards to be covered with large discharged thread-cells, many of which will be found with the freed end of the barbed sac inserted into it as far as the roots of the barbs. I have never, however, witnessed a deeper penetration than this, and the barbs themselves were never immersed.

I believe that in such cases the action of the thread-cell consists in the sudden ejection of the barbed sac against the tissues of the prey, which, if these be soft enough, allow the point of the sac to penetrate as far as the roots of the barbs. This act is instantly followed by the ejection of the filament, for which the barbed sac has opened the commencement of a passage, and which now worms its way among the tissues, recalling the mode in which the delicate filaments which form the *mycelium* of certain parasitic fungi penetrate the organic structures infested by them.

It is impossible, however, to believe that such effects as follow the action of the thread-cell can be produced by mere mechanical penetration, and the conclusion is irresistible that the penetration is accompanied by the injection of some potent virus which acts by rapidly destroying the irritability of the living tissues, the tubular filament of the thread-cell as it continues to insinuate itself, affording at the same time a channel by which the special secretion of the cell is conducted into the deeper parts of the tissues of the prey.

In judging of the functions of the thread-cells, however, it must not be forgotten that they also occur in parts which preclude the possibility of their being employed as offensive or defensive organs, as, for instance, when they exist, as they frequently do in great numbers, in that part of the ectoderm which is under cover of the hard chitinous perisarc, or when they are included in the interior of cavities which can have nothing to do with the capture of the prey, as in the sac-like receptacles which occur in the umbrella of *Gemmaria*.

Though we have scarcely yet sufficient data to enable us to determine the exact limits of that part of the somatic cavity on which the function of digestion specially devolves, we shall perhaps be justified in considering as such that portion of it which is included within the hydranth, and which is almost always distinguished by its form and by some special structure of its walls from that which belongs to the cœnosarc; while in the medusa the cavity of the manubrium, or at least its basal portion, must also be regarded in a special sense as devoted to the digestive functions of the free planoblast.

When the food has once passed the mouth and entered the cavity of the hydranth, or that of the manubrium of the medusa, it is there subjected to a process of solution. Of the nature of the solvent we as yet know almost nothing. There can be little doubt, however, that it is secreted from the walls of the cavity; and though it must be more or less diluted with water which has obtained admission through the mouth, its action on the food is powerful and rapid. This process is doubtless aided by the motion to which the contents of the digestive cavity are subjected by the contraction of the walls and the vibration of the cilia which clothe them. The soluble and nutritious parts are speedily separated, and the insoluble and non-nutritious *débris* are ejected through the mouth.[1]

[1] Corda ("Anat. Hydræ fuscæ," in 'Ann. des Sci. Nat.,' 1837) has described the body-cavity of Hydra as communicating with the external medium by an orifice situated at the end opposite to the

The product of this process, consisting of the dissolved and disintegrated nutritious portion of the food, mingled with certain materials which it has received from the walls of the digestive cavity, and diluted with water which has been introduced from without, is propelled from the cavity of the hydranth into that of the cœnosarc, or from the manubrium into the radiating canals of the medusa, in order to be distributed to the several tissues. It thus becomes the *somatic fluid*, to be presently considered in its relations to the circulatory functions.

Examined under the microscope, this fluid is seen to be of a very heterogeneous nature. Its basis is a transparent colourless liquid, and in this solid bodies of various kinds are suspended. These consist partly of disintegrated elements of the food, partly of solid coloured matter which has been secreted by the walls of the somatic cavity, partly of cells, some of which have undoubtedly been detached from these walls, though it is possible that others may have been primarily developed in the fluid, and partly of minute irregular corpuscles, which are possibly some of the effete elements of the tissues.

Beyond this point it is plain that digestion cannot be traced as a specialised function, and its phenomena here become coincident with those of circulation.

2. *Circulation, Nutrition, and Respiration.*

Between the phenomena associated above under the general head of digestion, and those which might with equal justice be claimed by circulation, it is impossible to draw any well-marked line of demarcation. The somatic fluid, whose relations to digestion we have been just considering, has relations quite as intimate with circulation; for though in one aspect we may compare it to the chyme or chyle of the more highly specialised animals, in another it admits of just as close a comparison with the blood.

No trace of a differentiated blood vascular system has been detected in any hydroid. The nearest approach to it is that which is presented by the radiating and circular canals of the medusa, and yet these are simple offsets from the digestive cavity.

The place of the blood is taken by the fluid which pervades the somatic cavity, and which consists of the digested food largely mingled with water which has gained admission by the mouth, as well as with certain materials which have been secreted by the walls of the somatic cavity.

The fluid which thus permeates the somatic cavity and extends through all its ramifications must not be supposed to be in a state of rest. On the contrary, it is subjected to constant motion, which manifests itself in currents more or less regular in their velocity and definite in their direction.[1] In some cases the currents present a remarkable definiteness and regularity.

mouth. I have not been able to confirm this observation; and though Leydig ("Ueber den Bau der Hydren," in 'Müller's Archiv,' 1854) and Hancock ("Notes on a Species of Hydra," in 'Ann. Nat. Hist.,' 1850) support Corda's statement, I cannot avoid believing that the orifice in question is accidental.

[1] Cavolini was the first who distinctly noticed the currents of the somatic fluid in the HYDROIDA. He has described them in a campanularian hydroid (Sprengel's 'Cavolini,' p. 56). They were subse-

This may be well seen in the stems of *Tubularia indivisa*, where the contained fluid is distributed in numerous parallel streams ascending through some of the channels which are excavated in the endoderm of the stem of this hydroid, and descending through others. The ascending streams become confluent at the summit of the stem, and from this point the descending streams issue. Every now and then the direction of the streams is reversed, the fluid flowing down the channels which just before carried ascending streams, and flowing up in those through which the streams had previously descended. Here and there the longitudinal channels communicate with one another by transverse branches, and through these branches the fluid may be seen flowing from one longitudinal channel to another. Occasionally the fluid will remain for a short period at rest in one of the channels, while it continues to flow in its ascending and descending streams in the others. The somatic currents of *Tubularia*, however, are by no means always easily seen, and it is only now and then that a specimen occurs, which, from the transparency of its tissues, and the abundance of floating corpuscles in the somatic fluid, presents conditions favorable for observation.

In *Corymorpha nutans*, the structure of whose stem resembles that of *Tubularia indivisa*, similar definite currents may be witnessed; and in *Antennularia antennina*, whose cœnosarc, as already mentioned, is composed of numerous tubes within a common perisarc, currents of an entirely similar kind may be seen ascending in some of these tubes, descending in others, passing over from one to another by intercommunicating branches, and again resting in others, but ready to start off in a fresh stream upwards or downwards while we continue to watch.

It is rare, however, to find the currents of the somatic fluid presenting the regularity and definiteness which characterise them in the instances just mentioned. In those far more numerous cases in which the somatic cavity is simple instead of being composed of separate and distinct channels, the contained fluid may occasionally be seen in a single broad stream flowing through the axis of the stem or branch, then coming to a state of rest and after a short period of repose, starting off anew in a reversed direction. Most usually, however, the movement in such cases, instead of being in the form of a definite current, consists in an irregular commotion in which the floating corpuscles are whirled about in all directions. Within more limited cavities, such as that of the spadix in the sporosac and of young buds in process of development, the motion of the fluid is generally in circular streams, which may be seen coursing round the walls of the cavity and returning into themselves. These streams in the developing bud usually present great activity. A similar disposition of the streams in circular currents may be witnessed in the cavity of the hydranth; but the motion here ought probably to be referred to digestion rather than to circulation, as it does not seem to have any proper distributional office, being most likely specially connected with the preparation of the aliment.

In the gastrovascular canals of the medusa, the currents are very distinct, the transparency of the surrounding tissues rendering it easy to observe them. In all these canals, whether radiating or circular, they constitute simple streams, which in some of the radiating canals may be seen flowing from the proximal towards the distal end, and in others from the distal towards the proximal, and, as it would seem, reversing themselves every now and then in all these tubes. In the

quently described by Lister, who also detected them in the stem of *Tubularia indivisa* ('Phil. Trans.,' 1834). Since then the currents in the somatic cavity of the HYDROIDA have become familiar to every observer of these animals.

circular canal the fluid may also be seen flowing at one time in one direction, and then again in the opposite.

That the motion of the somatic fluid in all these cases is mainly caused by the impulse of vibratile cilia, there can be but little doubt. Dujardin appears to have witnessed these cilia in the stem of his *Syncoryne decipiens*;[1] and in the stem of *Tubularia indivisa*, where the cilia clothing the lacunar channels and their relation to the currents were first pointed out by Dr. T. S. Wright,[2] they are very distinct, and can be demonstrated with the greatest ease in a transverse section of the stem (Pl. XXIII, fig. 7). By carefully applied pressure, I have succeeded in ejecting the spadix in an inverted state through the proximal end of a detached sporosac of *Tubularia indivisa*, when its internal surface being thus exposed, a rich clothing of very distinct actively vibrating cilia has been brought into view (Pl. XXIII, fig. 10).

It must, however, be admitted that in the greater number of hydroids the existence of endodermal cilia has not been proved by direct observation. In most hydroids the tissues are too opaque to afford a view of the delicate cilia which may clothe the cavities, while sections of the stem will afford none of that aid which we obtain from them in *Tubularia*; for the section is accompanied in most other species by a collapsing of the cavity which would necessarily interfere with the action of the cilia and remove them from observation. In every case where a satisfactory view of any portion of the free surface of the endoderm in the HYDROIDA has been obtained, as, for instance, where the transparency of the tissues is such as to afford no obstacle to a view of the deeper seated parts, this surface is invariably—except in *Hydra*, where cilia appear to be really absent—seen to be clothed with vibratile cilia. Thus, in certain medusæ the cilia may be easily seen vibrating along the walls of the radiating and circular canals.

It is probably, then, a nearly universal fact that the free surface of the endoderm in the HYDROIDA is ciliated, and that the fluid in contact with this surface is kept in motion by the impulse it receives from the cilia.

It must not, however, be overlooked that the contractility of the walls has its share in this motion. The fluid contained within the gastric cavity of the hydranth may, indeed, be frequently seen to be forcibly expelled from this cavity by its contraction into that of the cœnosarc—the mouth of the hydranth being at the same time kept closed—and then again drawn back into the gastric cavity, when the contraction which had expelled it is succeeded by an expansion.

As every portion of the somatic fluid is thus successively brought in contact with the walls of the somatic cavity, it yields to the tissues by a process of direct absorption the nutriment necessary for their growth and maintenance, and receives from them such portions of their substance as in the performance of their vital functions had become effete.

That the formation and growth of the tissues is intimately connected with cell-formation is rendered obvious by attending to the phenomena which accompany rapid growth among the HYDROIDA.

A healthy colony of *Obelia dichotoma* was placed in a jar of sea-water. In a few days most of the hydranths had disappeared, but adventitious branches had begun to be sent out in great profusion from various parts of the surface. These branches elongated themselves with

[1] 'Ann. des Sc. Nat.,' tome iv, 1845, p. 275.

[2] 'Proc. Roy. Ph. Soc. Edinb.,' 1855-56.

astonishing rapidity, in some cases at the rate of three quarters of an inch in thirty-six hours.

The distal extremity of the branch was its growing point, and here it terminated in a slight enlargement which formed a cul de sac, in whose walls both endoderm and ectoderm were distinctly differentiated (woodcut, fig. 55). The somatic fluid penetrated to the extremity of the branch. The ectoderm formed a considerably thicker layer than the endoderm, and was composed of very distinct, nearly spherical cells, with clear granular contents, and with but little intercellular plasma. Numerous slightly curved, cylindrical bodies, resembling undeveloped thread-cells, appeared to lie free in the intercellular plasma, where they were scattered among the true cells.[1] Under the action of acetic acid a distinct nucleus was rendered evident in the ectodermal cells.

FIG. 55.

Growing extremity of an adventitious branch of *Obelia dichotoma*.

a. Ectoderm overlaid by a delicate pellicle of chitine, and composed of distinct cells, where it occupies the growing point; *b*, endoderm; *c*, ectoderm, somewhat removed from the growing point, its cells no longer evident; *d*, some of the cells from the ectoderm of the growing point, treated with acetic acid, more highly magnified, and with thread-cell-like bodies lying scattered among them.

The endoderm of the growing point was also distinctly composed of spherical cells in a very scanty intercellular plasma. The endodermal cells, however, were much smaller than those of the ectoderm, and, instead of the clear contents of the latter, the endodermal cells contained coloured granules.

On following the cells of the ectoderm backwards from the growing point, they were found to become less and less distinct; it was, indeed, plain that they had undergone a metamorphosis, and at a short distance from the extremity no true cells could any longer be detected in the ectoderm, which now presented in a sectional view only an obliquely striated and granular appearance. The endoderm, on the other hand, retained its distinctly cellular structure throughout. The perisarc, which on the proximal part of the branch possessed considerable thickness, showed itself on the growing part as a scarcely perceptible pellicle.

I did not succeed in detecting anything like a process of cell-division in the ectoderm of the growing point, nor could I satisfy myself that the cells became multiplied by endogenous formation of cell-broods within the cavity of the older ones. The appearances were, on the other hand, rather in favour of the direct formation of the cells out of the plasma.

The cells of the endoderm probably originate in the same way, but they appear soon to become ruptured and to discharge their contents into the somatic fluid, which filled the cavity of the growing stem.

In certain other tissues, growth would seem to take place by cell-division. This, at all events, appears to be the case in the epithelium of the umbrella of *Obelia* (see below woodcut, fig. 59, c).

[1] This structure recals that of certain young sponges, with the spiculæ which are to form the skeleton scattered among more or less individualised masses of protoplasm.

The currents described above, as existing in the somatic cavity of the Hydroida, serve not only for the distribution of the nutritive fluids among the tissues—an office in which they admit of comparison with the somatic circulation of the blood in the more specialised members of the animal kingdom—but they also contribute to bring this fluid into more immediate relation with the surrounding medium, and thus subserve the function of *respiration*.

No differentiated respiratory organs occur anywhere among the Hydroida, and the interchange between the nutritious fluid and the surrounding medium must take place through the general surface of the body, more especially through those portions of it which, not being under cover of the chitinous perisarc, are more directly exposed to the conditions under which such interchange may be effected.

The cilia which cover the external surface of the hydroid when in the stage of planula, as well as those which clothe the free sporosac of *Dicoryne*, and those which occur on certain hydroid medusæ not yet traced to a trophosome, such as *Trachynema*, Gegeng., are probably subservient to respiration as well as to locomotion.

3. *Secretion.*

That distinct secretions are found among the Hydroida, and that even special structures are set aside for their elaboration, there cannot now be any doubt.

One of the most marked of these secretions consists of a coloured granular matter which is contained at first in the interior of certain spherical cells, and may afterwards become discharged into the somatic fluid. These cells, as already mentioned, are developed in the endoderm, in which they are frequently so abundant as to form a continuous layer upon the free surface of this membrane. It is in the proper gastric cavity of the hydranth and medusa, in the spadix of the sporosac, and in the bulbous dilatations which generally occur at the bases of the marginal tentacles of the medusa, that they are developed in greatest abundance and perfection; but they are also to be found more or less abundantly in the walls of probably the whole somatic cavity, if we except that portion of the gastrovascular canals of the medusa which is not included within the bulbous dilatations.

In the parts just mentioned as affording the most abundant supply of these cells, they are chiefly borne on the prominent ridges into which the endoderm is thrown in these situations; when they occur in the intervals between the ridges, they are smaller and less numerous.

The granular matter contained in the interior of these cells varies in its colour in different hydroids. In many it presents various shades of brown; in others it is a reddish-brown or light pink, or deeper carmine or vermilion or orange; or occasionally a fine lemon-yellow, as in the hydranth of *Coppinia arcta*, or even a bright emerald green, as in the bulbous bases of the marginal tentacles of certain medusæ. No definite structure can be detected in it; it is entirely composed of minute granules, irregular in form, and usually aggregated into irregularly shaped masses in the interior of the cells. It is to this matter that the colours of the Hydroida, varying as they do in different species, are almost entirely due.

The coloured granular matter is undoubtedly a product of true secretion; and the cells in which it is found must be regarded as true secreting cells. These cells are themselves frequently to be seen as secondary cells in the interior of parent cells, from which they escape by rupture, and then falling into the somatic fluid, are carried along by its currents, until ultimately, by their own rupture, they discharge into it their contents.

We have no facts which may enable us to form a decided opinion as to the purpose served by this secretion. Its being always more or less deeply coloured, and the fact of its being abundantly produced in the digestive cavity, might suggest that it represented the biliary secretion of higher animals. This may be its true nature, but as yet we can assert nothing approaching to certainty on the subject: indeed, considering how widely the cells destined for the secretion of coloured granules are distributed over the walls of the somatic cavity, it would seem not improbable that the import of the coloured matter may be different in different situations; that while some of it may be a product destined for further use in the economy of the hydroid, more of it may be simply excretive, taking no further part in the vital phenomena, and intended solely for elimination from the system.

The fluid which acts so powerfully as a solvent on the food which has passed into the digestive cavity, must certainly be also regarded as a secretion. We are ignorant of its exact source, but it is in all probability derived, like the coloured matter, from cells developed in the walls of the cavity.[1]

Under the head of specific secretion must also probably be classed the fluid contents of the thread-cells.

That the remarkable green matter which is contained in the endodermal cells of *Hydra viridis* is a special product of these cells there can be no doubt. Its very definite structure, however, would seem to take it out of the class of ordinary secretions, and place it rather in the same group of products as spermatozoa and thread-cells.

The researches of Cohn[2] have led him to believe that the green colouring matter of Hydra is identical with that of *Euglena*, and with that of *Loxodes*, *Stentor*, and certain other green *Infusoria;* and, further, that in all these cases it is indistinguishable from the chlorophylle granules of certain *Algæ*, especially of *Vaucheria*. He has shown that the green granules in these animals, as well as in a green *Planaria* which he has also examined, present precisely the same appearances under the action of sulphuric acid as those which we witness in the chlorophylle of plants when subjected to the same treatment; for instead of remaining unchanged, or merely becoming charred, the granules, when brought into contact with the acid, pass in a very characteristic way from verdigris-green to a more intense bluish-green, and at last, in solution, become almost blue.

From these facts Cohn concludes that the green matter in the organisms mentioned, at least in *Euglena* and the green ciliate *Infusoria*, performs a function similar to that of the chlorophylle of plants, and he regards it as destined for the excretion of oxygen.

The chitinous perisarc which, to a greater or less extent, invests the surface of almost every hydroid, is perhaps rather a product of metamorphosis of tissue than of true secretion, the most external portions of the ectoderm becoming converted into the perisarc, which increases in thickness by successive additions to the inner surface, these additions giving a distinctly

[1] The cells described by Haeckel as arranged in peculiar leaf-like groups in the stomach-walls for certain medusæ belonging to the family of the *Geryonidæ*, would seem to be destined for the elaboration of some special secretion.

[2] Cohn, "Beitr. zur Entwckel. der Infusorien," 'Zeit. f. Wiss. Zool.,' vol. iii, 1851.

laminated condition to the otherwise absolutely structureless perisarc. To the same class of products belongs the gelatinous-looking investment which envelopes the acrocyst in *Sertularia pumila*, &c. (see p. 50), and in which a distinctly laminated character may frequently be detected.

4. *Contractility.*

The existence of a fibrillated tissue in the HYDROIDA has been already mentioned; and there can be no doubt that this tissue is endowed with contractility, and is the proper seat of the more energetic motions performed by these animals. The act by which the hydranth becomes suddenly retracted when touched is evidently due to the contraction of the longitudinal fibres which are developed on the inner surface of the ectoderm; and the rhythmical and exquisitely graceful movements of the medusæ have their seat in the contractile fibres which are developed on the concave surface of the umbrella and in the velum, and are antagonised by the elasticity of the gelatinous substance which constitutes the chief mass of the umbrella.

It is, indeed, in the motions of the medusæ that we find contractility manifesting itself in its highest degree of intensity among the HYDROIDA. In these beautiful zooids the contraction of the sub-umbrellar fibres necessarily diminishes the cavity of the umbrella, and by thus expelling in a jet a portion of the water which had filled it in its expanded state, causes the propulsion of the medusa in an opposite direction, or that in which the convexity of the umbrella is turned forward, while the relaxation of the fibres immediately following their contraction permits the elasticity of the umbrella to come into play, so that its cavity instantly resumes its original capacity, and receives within it a fresh supply of water, to be again expelled as a propelling force by the energetic contraction of the fibres. The part played here by the velum would seem to consist chiefly in controlling the diameter of the aperture through which the jet of water is propelled from the umbrella cavity.

But contractility is by no means confined to the fibrillated tissue. There are many parts of the HYDROIDA in which no trace of fibres can be detected, and which are yet eminently contractile. Thus the broad four-lobed lip of the medusa of *Obelia geniculata* is remarkable for its mobility and its power of constantly changing its form while under observation, and yet it consists exclusively of a single layer of differentiated masses of protoplasm (membraneless cells) without the slightest trace of fibres.

Ecker has shown that the body of *Hydra viridis* is to a great extent composed of a contractile, semifluid homogeneous substance, agreeing in all essential points with the sarcode matter of the lowest animals. Ecker, however, is wrong in denying a cellular structure to *Hydra*, for the sarcode is not only differentiated into distinct cell-masses, but these masses are included each—in most cases along with certain granular products—within a proper cell-wall. By the rupture of the cell-wall the protoplasm can be liberated under the microscope; and Ecker has seen it then undergoing evident contraction, forming isolated masses, which continually change their shape like an *Amœba*.

There can be little doubt that many of the motions of the HYDROIDA are due to the contractility of this homogeneous sarcode; and while we may refer the sudden retraction of the hydranth when touched to the action of the fibrillated tissue, its subsequent slow extension would seem to be the result of the contractility of the sarcode, probably combined with the general elasticity of the tissues.

I have already shown that the substance which fills the nematophores of the *Plumularidæ* is mainly composed of a similar sarcode, which here, however, is not confined in cells; and it can, therefore, extend itself beyond the surface of the hydroid in the form of long pseudopodia, which will occasionally even branch exactly as in certain *Rhizopoda* (see woodcuts, figs. 50, 51). The remarkable capsules filled with thread-cells, which are borne along the marginal tentacles of the medusa of *Gemmaria implexa* (Pl. VII, fig. 3, 4), are supported on peduncles of extraordinary extensibility. In these peduncles we have also an example of true sarcode identical with that of the *Rhizopoda*. Strethill Wright has also shown that those filiform processes of the ectoderm of the HYDROIDA, which he calls "palpocils," are composed of a true rhizopodal sarcode; and these processes are probably offsets of a very thin sarcode layer, which, as already mentioned, can be seen, in certain cases, to extend over the surface of the hydranth.

Under the head of contractility the phenomena of ciliary motion must also be included. Vibratile cilia, as we have already seen, exist in almost every case on the walls of the somatic cavity, and mainly contribute to the production of the currents so well known in the nutritive fluids of the HYDROIDA; while the planula or early locomotive stage of most hydroids, as well as certain hydroid medusæ (*Trachynema*) and the free sporosac of *Dicoryne conferta*, are provided with an external covering of vibratile cilia.

5. *Sensation.*

Of late years several observers have believed themselves successful in demonstrating a nervous system in the HYDROIDA, while others have refused to admit the existence of a differentiated nervous system in these animals, and consider the arguments which have been adduced in favour of its presence as resting upon imperfect or incorrectly interpreted observations.

The advocates for the existence of a specialised nervous system in the HYDROIDA all agree in regarding as its principal part an apparent filament with ganglion-like enlargements, which may be seen running in the form of a ring round the margin of the medusa just below the circular canal. Agassiz maintains the existence of such a ring-like cord, and assigns to it the function of a nerve-ring, in *Sarsia*, *Tiaropsis*, *Staurophora*, and *Bougainvillia*; M'Crady in *Eucheilota*; Fritz Müller in *Tamoya*, a genus belonging to the family of the *Charybdæidæ*, as well as in *Liriope* and *Cunina*, true hydroids;[1] and Leuckhart in a medusa which he refers to Gegenbaur's genus *Eucope*; while Hensen also admits the presence of a nerve-ring in the *Eucope* of Gegenbaur. But by far the most complete description we possess is that by Haeckel,[2] who has studied the structures in question

[1] The hydroid structure of the *Œginidæ*, in which *Cunina* is included, must follow, from the remarkable observations of Haeckel on the structure of *Cunina* and on its genetic relations with the Geryonidan Medusæ.

[2] Haeckel, op. cit.

with great care in certain medusæ belonging to the family of the *Geryonidæ*, more especially *Glossocodon* (*Liriope*) *eurybia* and *Carmarina hastata*, where it would appear that they are very conspicuous, and well fitted for examination.

According to Haeckel the nervous system in the *Geryonidæ* consists of a very slender ring-like cord, which runs round the margin of the umbrella immediately below the circular canal, and under each marginal vesicle swells into a ganglion. From these ganglia filaments are sent off, one along the course of each radial canal as far as the stomach, and one to each of the tentacles, while another penetrates the marginal vesicle in order to undergo within it a peculiar distribution. In the system thus constituted he believes that he has succeeded in demonstrating nerve-elements. The nerve-cells of the nervous ring are contained in the ganglia only; in the intervening portions the ring presents merely a longitudinally striated appearance.

While with Haeckel's very detailed description we should hardly be justified in denying the existence of a marginal nerve-cord with ganglia in the *Geryonidæ*, I am by no means prepared to attribute a similar significance to the cord-like structure which may be seen running round the margin of the umbrella in other medusæ (Pl. XVI, fig. 8, and woodcuts, figs. 58 and 59). I have in several cases carefully studied this part of the medusa, and have arrived at the conviction that in all these the apparent cord is only the ectodermal layer, which lies immediately upon the distal side of the circular canal, and constitutes the extreme margin of the umbrella, presenting, when viewed along the plane of the codonostome, the appearance of a chord. In the medusa of *Campanularia*, which Gegenbaur refers to his genus *Eucope*, and in that of *Obelia*, which he includes in the same genus,[1] I have no doubt as to this being the true interpretation of the supposed nerve-cord, while the structures assumed to be ganglia are only thickenings of the ectoderm at the points which give attachment to the *lithocysts* or sense-capsules, to be presently described.

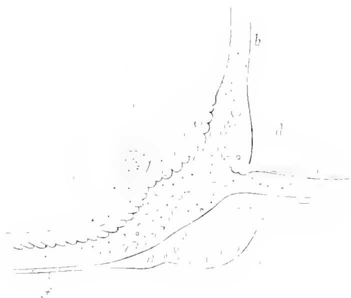
Besides the structures to which the significance of a nervous system has been thus assigned, certain bodies which have been long known and regarded by common consent as organs of sense, hold a prominent place in many hydroids. They occur only in the medusæ, and are of two kinds—the *ocellus* and the *lithocyst*.

The Ocellus.—The ocellus consists of a little mass of pigment, forming a well-defined coloured spot, in some species black, in others vermilion or deep carmine. In most cases (Pl. V, fig. 3, Pl. VI, fig. 3, and Pl. IX, fig. 8) no other structure can be detected in the ocellus; but sometimes (Pl. XVII, fig. 5, and Pl. XVIII, fig. 6) a transparent, refracting body may be seen immersed in the pigment mass. The ocellus is always situated in the walls of the bulbous dilatation which exists at the root of the marginal tentacle of the medusa (woodcut, fig. 56), where it lies very superficially, being imbedded exclusively in the ectoderm, while a

[1] The genus *Eucope* was founded by Gegenbaur for certain small medusæ which are known to be the planoblasts of campanularian hydroids. He subdivides his genus into a deep-belled and a shallow-belled section—sections, however, which differ from one another by characters which are at least of generic value. The deep-belled forms are the planoblasts of the true *Campanulariæ*, while those with shallow bells are the planoblasts of another campanularian genus (*Laomedea* of authors, in part), and had already been described by Péron and Lesueur, under the generic name of *Obelia*. *Eucope*, as a generic appellation, must therefore be suppressed in favour of the older names of *Campanularia* and *Obelia*, by which the deep-belled and shallow-belled forms must be respectively designated.

thin layer of the latter passes over it so as to separate it from direct contact with the surrounding water. In *Tyaropsis* alone does a similar definite pigment mass occupy a different position. In this genus it is situated not at the root of a tentacle, but at the base of a lythocyst, in the interval between two neighbouring tentacles (woodcut, fig. 57). I cannot, however, regard the pigment-shot in *Tyaropsis* as the equivalent of the ocellus in other medusæ; for besides its connection with the lithocyst rather than the tentacle, it is imbedded in a thickening of the endoderm of the circular canal instead of being, as in the true ocellus, an exclusively ectodermal structure.

FIG. 56.



Part of the umbrella-margin, with basal bulb of marginal tentacle, in *Syncoryne eximia*.

a. Umbrella wall: *b*, distal extremity of a radiating canal;—vibratile cilia may be seen clothing its walls; *c*, part of circular canal; *d*, endoderm of bullous dilatation of base of marginal tentacle;—it is thrown into prominent lobes, which project into the cavity of the bulb; *e*, cushion-like thickening of ectoderm loaded with thread-cells; *f*. marginal tentacle; *g*, ocellus, imbedded in a thickening of the ectoderm.

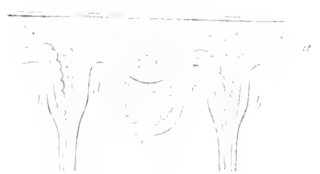
When the pigment of which the ocellus is composed is examined under a high power of the microscope, it is seen to possess a more definite structure than the granular coloured matter which is secreted in the walls of the somatic cavity. The ocellus is, in fact, composed of an aggregation of very minute cells, each filled with a homogeneous coloured matter. Such, at least, is the structure of the ocellus in *Syncoryne eximia*, and it is probable that in other cases a similar structure may be demonstrated.

As just said, a transparent body, capable of refracting the light, may be sometimes seen immersed in the pigment. A very distinct refracting body, of a lenticular shape, has been described by Quatrefage as imbedded in the outer side of the pigment in *Eleutheria*. In the nearly allied *Clavatella* I have found a minute, spherical, transparent, and refracting body imbedded in the same way in the pigment of the ocellus (Pl. XVIII, fig. 5); and Krohn and Claparède had already made a similar observation. It is, however, here of soft consistence; it seems to be easily broken down, and I have occasionally failed in detecting any trace of it. A similar refracting lens-like body may be seen in the ocellus of *Cladonema* (Pl. XVII, fig. 6). In every other case with which I am acquainted the ocellus consists merely of a mass of pigment-cells, without any structure which can serve as a refracting medium, unless the transparent layer of ectoderm which is continued in front of it may be regarded as contributing to the functions of the ocellus by its refractive action on the rays of light. In *Eleutheria* and *Clavatella*, indeed, the ectoderm presents at this spot an abruptly prominent convex surface, which Quatrefage has compared in *Eleutheria* to a cornea.

We have no means of forming anything like a certain conclusion as to the proper function of the ocellus. The universal presence of a definite pigment, and the occasional occurrence of a refractile, lens-like body, have suggested a comparison with an organ of vision, and against the justice of this comparison no sufficient argument has been yet adduced.

The Lithocyst.—Like the ocellus, the lithocyst is invariably developed on the margin of the umbrella. It consists of a transparent, mostly spherical capsule, within which are contained one or more transparent refractile concretions generally of a spherical or oval form. In *Cunina* alone among the HYDROIDA the concretions are, according to Haeckel, in the form of crystals, the usual condition of the analogous bodies in the *Discophora* or steganophthalmic medusæ. In most cases there is but one of these bodies in each capsule. Sometimes, however, they are more numerous. In *Tima Bairdii* the number varies from four to twenty in different lithocysts of the same specimen. In *Tyaropsis* they are arranged in a regular crescent parallel to the distal wall of the capsule, as Agassiz has pointed out in a North American species of this genus, and as I have myself found in a *Tyaropsis* from the Scottish coast (woodcut, fig. 57), in which I have counted about thirteen concretions in each capsule.

FIG. 57.



Part of the umbrella-margin of *Tyaropsis scotica*.

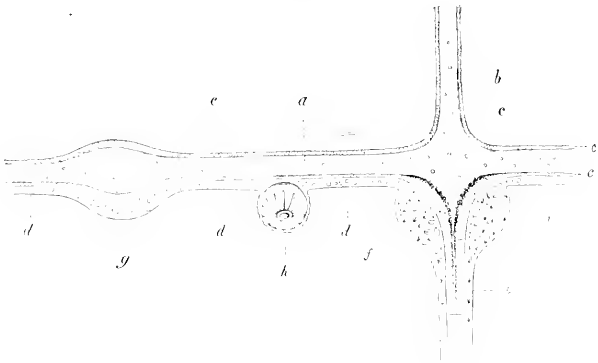
a, Circular canal; *b*, *b*, marginal tentacles; *c*, lithocyst; *d*, ectoderm of distal side of circular canal; *e*, endoderm; *f*, projection of the ectoderm, lying at the inner side of the lithocyst; *g*, ocelliform spot, imbedded in the endoderm of the circular canal.

The concretions offer resistance to pressure; and, according to Gegenbaur, would seem to consist of carbonate of lime in an organic basis, which retains the form of the original body after the mineral matter has been removed by acid. The mineral constituent is, according to Haeckel, a phosphate of lime in the *Geryonidæ*. At least, it here dissolves in acids without effervescence. The concretions, in every case, are quite motionless, and never lie free in the capsule.

A careful study of the lithocysts in two very common hydroids—*Campanularia Johnstoni* and *Obelia* (*Laomedea*) *geniculata*—has rendered apparent the following facts, which may probably be regarded as representing, in all essential points, the usual structure of these bodies among the HYDROIDA.

In *Campanularia Johnstoni* there are eight lithocysts which alternate with the eight marginal tentacles of the medusa; each lithocyst (woodcut, fig. 58*h*) is immersed for a little way in the cord-like structure, which forms the extreme margin of the umbrella, and which sends a very delicate extension of its substance over the whole of the free surface of the lithocyst. It consists of a spherical transparent and structureless vesicle or capsule, the greater part of whose cavity is occupied by a soft spherical pulp, in whose distal pole, or that opposite to the point of attachment of the vesicle, there exists a deep well-defined excavation; and within this, but not entirely filling it, is the spherical highly refractile concretion. In the pulp itself I could detect no trace of structure, but when seen in profile it has a slightly wavy outline, possibly occasioned by a special layer which intervenes between it and the walls of the capsule. Its surface is marked by twelve or fifteen delicate striæ, which take a meridional course at exactly equal distances from one another. Towards the distal pole they all terminate distinctly on the margin of the excavation, and may be thence traced to within a short distance of the opposite pole, though I have never been able to follow them exactly to it. The striæ generally appear light-coloured when contrasted with the darker intervening spaces. It is often difficult to detect any trace of them, but with a high power and carefully adjusted illumination they frequently appear with great distinctness, more especially under the action of dilute acetic acid.[1]

FIG. 58.



Part of the Umbrella-margin in the Medusa of *Campanularia Johnstoni.*

a, cavity of circular canal; *b*, cavity of a radiating canal; *c*, *c*, *c*, *c*, endodermal lining of radiating and circular canals; *d*, *d*, *d*, *d*, ectoderm forming the extreme margin of the umbrella; *e*, ectoderm of marginal tentacle; *f*, thickened ectoderm at the base of the tentacle loaded with thread-cells and directly continuous with *d*, the ectoderm of the umbrella-margin; *g*, marginal ectoderm thickened where it lies over the spot from which a new tentacle is to spring; *h*, lithocyst.

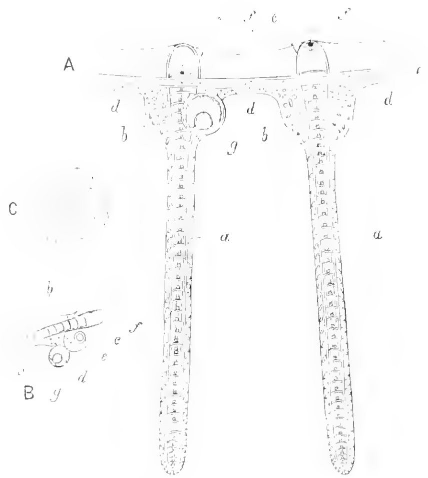
In *Obelia geniculata*, the lithocysts are also eight in number, two being situated in each of the four interradial spaces (woodcut, fig. 59 A *g*, and B *g*). They are sessile on the cord-like margin of the umbrella,and are placed each at the subumbrellar side of the base of a tentacle, but not exactly in its meridian plane. The structure of the lithocyst resembles that just described in *Campanularia Johnstoni*, consisting, like it, of a spherical capsule with a contained pulp, which nearly fills it, and which is excavated at the distal pole of the capsule into a cavity in which is the spherical refracting concretion. I could, however, obtain no distinct evidence of the meridional striæ visible in the lithocyst of *C. Johnstoni*.[2]

[1] Busk appears to have noticed these striæ, for in a paper which he read before the Microscopical Society of London ('Trans. Mic. Soc. Lond.,' vol. iii, p. 22), and which gives the most complete account of the lithocyst we had possessed up to the time of its publication, the author describes "an indistinctly fibrous, radiating appearance," which might sometimes be detected in the more external parts of the contents of the lithocyst in a *Thaumantias*-like medusa.

[2] Keferstein and Ehlers ('Zoolog. Beiträge,' p. 88, pl. xiii, fig. 1) describe the *Eucope polystyla* of Gegenbaur, which is, however, really an *Obelia*. They give a good figure of the lithocyst, but they mistake the cavity in which the concretion is contained for a peduncle projecting into the capsule from its distal wall, and carrying the concretion on its summit. A similar mistake seems also to have been made by Fr. Müller ("Ueber die Randbläschen der Hydroidenquallen," in Max Schultze's 'Arch. f. Mic. Anat.,' 1865, vol. i, p. 143), in his account of the lithocyst of an allied Medusa.

In most cases no definite structure can be detected in the walls of the external capsule. In an undescribed species of *Tyaropsis*, however (*Tyaropsis scotica*, woodcut, fig. 57), these walls are composed of very distinct prismatic cells, lined with a finely granular layer, which immediately invests the pulp and the zone of concretions imbedded in its surface, and I have noticed a similar structure in another medusa allied to *Thaumantias*. Gegenbaur has pointed out the existence of a layer of polygonal cells, which lines the capsule in one of the *Geryonidæ*, an observation which has been confirmed by Haeckel in other members of this family; and in the medusæ of *Campanularia* and *Obelia* described above there is indication of a special lining of the capsule.

FIG. 59.



Medusa of *Obelia geniculata*.

A. Part of the umbrella-margin. *a*, *a*, marginal tentacles; *b*, *b*' thickened ectoderm at the base of the marginal tentacles; *c*, *c*, large cell forming the proximal extremity of the marginal tentacle where it is plunged into the gelatinous substance of the umbrella; *d*, *d*, *d*, ectoderm forming the extreme margin of the umbrella; *e*, circular canal; *f*, *f*, gelatinous substance of the umbrella; *g*, lithocyst.

B. Meridional section of umbrella-margin. *a*, marginal tentacle; *b*, thickened ectoderm at base of marginal tentacle; *c*, large cell forming the proximal extremity of marginal tentacle; *d*, ectoderm of extreme margin of umbrella; *e*, circular canal in transverse section; *f*, gelatinous substance of umbrella; *g*, lithocyst.

C. Structure of epithelium clothing the inner surface of the umbrella. In several of the cells the nuclei have undergone division.

Hensen, in his remarkable memoir on the auditory organ of the Decapod Crustacea, describes the lithocyst of a medusa, which he refers to Gegenbaur's genus *Eucope*, and maintains that the concretion is connected to the walls of the capsule by a bundle of very fine hairs ("auditory hairs").[1] This observation of Hensen, however, has not been confirmed by other investigators, and I consider it almost certain that the meridional striæ described above have given rise to the appearance which Hensen has mistaken for hairs.[2]

[1] "Studien über das Gehörorgan der Decapoden," 'Zeit. für Wissensch. Zool.,' vol. xiii, p. 355, note.

[2] The lithocyst has been studied with great care by Haeckel (op. cit.) in *Glossocodon eurybia* and *Carmarina hastata*, Geryonidan Medusæ which, from their large size, offer special facilities to the observer, though they belong to a peculiar type, and their lithocysts, as described by Haeckel, present features which differ in many points from the structure which, as we have already seen, these bodies present in *Campanularia* and *Obelia*.

In the Medusæ which form the subject of Haeckel's observations the lithocyst is completely included within the gelatinous substance of the umbrella-margin. It is described as a transparent sphere seated on the upper side of a ganglion of the nerve-ring. Its walls are formed of a homogeneous membrane lined with a pavement epithelium, and it is filled with what appears to be a watery fluid, into which projects from the upper free wall of the capsule a clear spherical body, attached to the wall by means of a broad short stalk, and containing within it one or more small, concentrically laminated concretions.

Within the capsule, on its base, there is seated a cushion-like body, apparently in immediate con-

The lithocysts are almost always freely exposed to the surrounding water upon the margin of the umbrella. In *Glossocodon* and *Carmarina*, however, they are entirely included within the gelatinous substance of the umbrella. They are usually sessile, but are occasionally (*Cunina*) borne upon a distinct peduncle; they generally occur in the interval between two marginal tentacles. In *Obelia*, however, they are situated on the inner side of the base of a tentacle.[1]

The distribution of the lithocysts on the umbrella margin is at first always symmetrical, and their number is equal to or a multiple of that of the radiating canals. It is only in certain cases in which the lithocysts become very numerous, as, for example, in *Tima*, that this numerical law ceases to be apparent.

We know as little of the function of the lithocyst as we do of that of the ocellus. Consisting as it does of a capsule and contained concretions, it presents a structure which has been compared with that of certain organs which are met with in the mollusca and in the crustacea, and which have in both these groups been generally regarded as organs of hearing, and a similar function has from analogy been attributed to the lithocyst. The analogy, however, is by no means so close as to justify us in attributing an auditory function to the organs in question, while their structure would seem to indicate a relation to light at least as intimate as to sound.[2]

nection with the ganglion of the nerve-ring. It is composed of roundish and fusiform cells, and Haeckel regards it as a nervous ganglion. On each side it is prolonged into a flat, longitudinally striated, band-like cord, which is evidently composed of close parallel fibres, and which he considers to be a nerve of sense. These two sense-nerves, after passing up like meridian lines on the walls of the capsule, unite at the opposite pole. Here the fine fibres which compose them appear to become interwoven into a cord, which, after forming the stalk of the spherical body which immediately encloses the concretions, passes into its interior. Haeckel regards this body as a second internal ganglion. It appears to be a round vesicle, containing within it a mass of small, closely aggregated cells. In the midst of these cells are the concretions, consisting of a calcified organic basis, the organic matter being apparently united with phosphate of lime. He is unable to satisfy himself as to the mode in which the fibres of the sense-nerves terminate within the spherical body, though he believes it probable that their extremities are in connexion with the cells existing in the interior of this body.

Haeckel's interpretation of the various structures which he thus finds in the interior of the lithocyst, and regards as ganglia and nerve-cords, may be open to criticism, though it must be admitted that it is not easy to offer any very satisfactory view of them. The two supposed sense-nerves which he has observed running in two opposite meridians on the inner side of the wall of the capsule will suggest a comparison with the meridional striæ described above, as apparent on the central pulp of the lithocyst in *Campanularia*.

[1] In *Oceania octona* and *O. turrita*, Forbes ('Monograph') describes a cavity at the base of each tentacle, just below the ocellus, and having within it a vibrating mass. He regards this cavity as a lithocyst, with its contained concretion. A recent opportunity of examining the *O. turrita* of Forbes has convinced me that what Forbes took for a lithocyst is only a dilatation of the gastrovascular system, with its contents set in motion by the vibratile cilia of the walls, a suspicion which had already been entertained by Busk and by Gegenbaur.

[2] The visual functions of the lithocyst, though maintained by Agassiz, Fr. Müller, and partly also by Haeckel, who is inclined to attribute to them a double function of sight and hearing, has been by no one so well supported as by Busk ("On the Anatomy of a Species of Thaumantias," 'Trans. Mic. Soc.

The two forms of sense-bodies now described are never associated in the same species, and the case of *Tyaropsis*, as already shown, affords no exception. It has been already stated, as a nearly universal rule, that the ocelli are confined to the true sexual medusa or gonocheme while the lithocysts are found only in the blastocheme. Exceptions to this rule, however, are afforded by *Thaumantias*, as limited by Gegenbaur, which, though a blastocheme, has ocelli instead of lithocysts, and by *Staurophora* and *Laodicea*, which are also blastochemes, though, according to Agassiz, the ocellus takes the place in them of the lithocyst. On the other hand, *Goodsirea*, Wright, has, according to Wright's observation,[1] lithocysts instead of ocelli, though it is a true gonocheme. *Melicertum*, another blastocheme, is, according to Agassiz, also very exceptional, for neither lithocysts nor ocelli are found in it.

The ocellus, however, is by no means so constantly present in the gonocheme as the lithocyst is in the blastocheme, many planoblasts, with the other characters of the gonocheme, having no definite pigment spot, though the bulbous expansion at the base of the tentacles, with its contained coloured matter, has in such cases been frequently confounded with a true ocellus.

Touch.—Analogy would lead us to regard it as probable that sensitiveness to touch resides in all parts of the surface of the HYDROIDA—such parts, at least, as are not under cover of a thick perisarc. It would seem, however, that this sensitiveness is in a special degree conferred upon the tentacles of both hydranth and medusa. The slightest contact of the tentacles of the hydranth with a foreign body not destined to be appropriated as food, will frequently be followed by the instant contraction of the entire hydranth, accompanied, in the calyptoblastic hydroids, by retraction within the hydrotheca, an action which is plainly subservient to the safety of the animal by causing its withdrawal from sources of injury. The ordinary contact, however, of pabulum with the tentacle, excites only the prehensile functions of one or more tentacles, and is not accompanied by any general contraction of the hydranth. In like manner the marginal tentacles of the medusæ instantly contract on being touched. We are not, however, obliged to conclude that these acts are necessarily accompanied by consciousness on the part of the hydroid. Like many other apparently conscious acts in the animal economy, they may be purely reflex and automatic.

Corda and Wright have described as organs of touch the minute bristle-like bodies to which the latter has given the name of palpocils (see above, p. 107). Haeckel[2] has also described as organs of touch certain long fine and stiff hairs ("Tastborsten"), which he has observed in *Cunina*, and which Gegenbaur[3] and Keferstein and Ehlers[4] have observed in *Ægineta*; they are developed from the epithelium lying over the ganglion-like swelling on which the lithocyst is seated in these medusæ;

Lond.,' vol. iii, p. 22), who adduces in favour of this view the action of the lithocyst on polarized light, when the concretion exhibits a well-defined black cross, indicating, as he believes, a gradually decreasing density from the centre to the circumference, and pointing to a close resemblance between these bodies and the crystalline lens of higher animals. Evidence of the sensibility of the hydroid planoblasts to light is found in their habit of congregating on the light side of the jar in which they may be confined. I have noticed, on the other hand, that the planulæ of *Plumularia pinnata*, in which, however, nothing like sense organs exist, avoid the light, always crowding towards the dark side of the jar.

[1] 'Edinb. New Phil. Journ.,' July, 1859.

[2] 'Die Familie der Rüsselquallen,' p. 137.

[3] 'Versuch eines Systemes der Medusen,' p. 266.

[4] 'Zoologische Beiträge,' p. 94.

while Häckel has found similar hairs arranged in three verticils upon the knob-like extremity of the tentacle in another medusa, *Rhopalonema umbilicatum*. It is probable that in attributing to these various structures a specially developed sense of touch, their true function has been assigned to them; but it must, at the same time, be admitted that we have no direct evidence of their real purport in the economy of the animal.

6. *Phosphorescence.*

Among the most remarkable faculties possessed by the Hydroida is the power with which many of them are endowed of emitting light—a power which, like contractility and sensation, ought, perhaps, to find its place among the functions of irritability, as it appears to be always manifested in obedience to the action of a stimulus.

If a healthy colony of *Obelia dichotoma*, for example, be irritated in the dark by being roughly touched, a beautiful pale-white light will be seen for an instant to flash along the branches. Here the power of emitting light would seem to reside exclusively in the trophosome, and I have sought for it in vain in the free planoblasts of this hydroid, where one might, *à priori*, expect to find it.

On the other hand, in species of *Thaumantias* and allied forms which I have met with swimming in the open sea, and which are almost certainly planoblasts liberated from some trophosome as yet unknown, the luminosity was very striking and beautiful. In these medusæ, when an individual confined in one of my jars was touched in the dark, the whole umbrella-margin became instantly lighted up by a multitude of luminous points. The luminosity was entirely confined to the margin of the umbrella, and, indeed, might be seen to have its exclusive seat in the bulbous bases of the marginal tentacles.[1] These phosphorescent hydroid planoblasts must be regarded as one of the chief sources of the luminosity of the sea.

In some of the most brilliantly phosphorescent hydroid trophosomes, the luminosity presents a singular intermittence, the light appearing, when the hydroid is touched, to *palpitate* in a very beautiful way over the surface. Its duration, however, is very transitory; within a few seconds it will have entirely vanished, and will then need a repetition of the stimulus to call it forth. After a few such repetitions the power seems to exhaust itself, and rest for some time is needed before it can be again excited.

The vapour of alcohol exerts a very marked influence on the emission of the light. On exposing a campanularian trophosome to alcoholic vapour, given off at a temperature of about 70° F., I was surprised to find that not only was a brilliant luminosity called forth, but that the light had acquired a persistence very different from its usual transitory manifestation. It continued, indeed, for about five minutes while held over the vapour, after which, though still exposed to the vapour, it gradually faded away.

It must be here borne in mind, however, that the action of the stimulus in the experiment

[1] Busk ('Trans. Mic. Soc. Lond.,' vol. iii, p. 22) has described the luminosity of a Thaumantias-like medusa, in which he also found the seat of the light to be confined to the marginal tentacular bulbs.

with the alcohol is continuous, while the mechanical stimulus exerts itself only for a moment. A stimulus presenting a closer parallelism with that of the alcohol is afforded by contact with atmospheric air. I have always found that the hydroid, when suddenly removed from the water into the air, becomes brilliantly luminous at the moment of the change of medium; the luminosity here, however, as in the case of simple mechanical stimulus, lasts only for a few seconds, notwithstanding the continuous action of the atmosphere on the animal. After its disappearance the vapour of alcohol will again call it forth, accompanied by the persistence which characterises the application of this stimulus.

Many hydroids, however, are destitute of phosphorescence. It does not exist in the fresh-water *Hydra*, and I have never witnessed it in any gymnoblastic form; while among the *Calyptoblastea* it would seem that only some are endowed with it. Observations, however, are still wanting on this point, and phosphorescence will doubtless yet be found in species in which it is not at present known to exist.

Of the immediate source of the phosphorescence we know scarcely anything, and though in some other phosphorescent animals it would seem to reside in a special luminous secretion we have no evidence of such a secretion in the HYDROIDA. Its dependence here on the operation of a stimulus would remove it from simple physical luminosity, such as may result from a process of slow combustion or from insolation. It may, it is true, be asserted that the immediate result of the stimulus is to excite the formation of a luminous secretion, but in the absence of all evidence of any such secretion this explanation cannot be accepted. The luminosity would here seem rather to be, like electricity in other cases, the direct accompaniment of certain vital actions.[1]

7. *Reproduction.*

The reproductive faculty, whose exercise gives rise to the calling into existence of a new being, belongs properly to the department of Physiology, while development, or the successive changes of form which this being undergoes, is a subject of Morphology, and has been already treated of in its proper place under that head.

Reproduction in the HYDROIDA may be either sexual or non-sexual; the sexual showing itself in the production and fertilization of the ovum, the non-sexual in the production of buds and in fission.

[1] Some observations which I have made on the luminosity of *Beroe* have brought out the somewhat unexpected result that the faculty of emitting light is not possessed by these animals at all times during the twenty-four hours. It does not exist in the presence of daylight, and *a previous seclusion of the animal for some time in darkness* is always necessary for its manifestation (see 'Proc. Roy. Soc. Edinb.,' 1862, p. 519). I have no reason to believe that this is the case with the HYDROIDA, though I have made no observations which can here be regarded as decisive. It certainly is not the case with *Noctiluca*, one of the most vividly luminous of animals, and one well fitted for observation.

a. Sexual Reproduction—Generation

Comparison of the Sexes in the Hydroida.—The existence of differentiated sex in the HYDROIDA was first announced by Ehrenberg,[1] who maintained that the so-called "egg-capsules" in *Coryne*, *Sertularia*, &c., had the significance of special fertile animals, to which he gave the name of females, while he regarded the ordinary hydranths as the sterile individuals of the colony.

With this announcement we may date a well-marked era in the history of progressive discovery among the HYDROIDA; for it is to the happy conception of Ehrenberg that we must refer the more philosophic views which within the last few years have so greatly advanced our knowledge of the structure, functions, and relations of these animals.

The celebrated German micrologist, however, did not grasp the full meaning of the facts of which he had thus so nearly given us the exact interpretation; for he regarded the central column (blastostyle) of the gonangium in *Sertularia* as the equivalent of the central diverticulum (spadix) in the gonophore of *Coryne*, while he viewed the gonophores borne on the sides of the blastostyle in *Sertularia* as merely eggs equivalent to the true eggs contained in the gonophore of *Coryne*.

The doctrine of the sexual differentiation of the HYDROIDA was confirmed by Lovén in a remarkable memoir, originally published in the 'Transactions of the Royal Swedish Academy' for 1835, and thence translated into Wiegmann's 'Archiv.'[2] In this memoir Lovén gives an account of those singular extracapsular medusiform gonophores which are described above (p. 57) under the name of "meconidia;" he found them in a Campanularian hydroid (*Gonothyrea Lovéni*, Allm.), and recognised in them their true sexual function. He also describes the occurrence of medusi-form gonophores in two species of *Syncoryne*; and having observed that in the gonophores of one of these species the cavity of the umbrella was filled with ova, he distinguishes them from mere organs, and regards the gonophores in both instances as special female animals.[3]

Naturalists had now not only become familiar with the presence of true ova in the HYDROIDA, but they saw in the portions of the colony set aside for their production something more than mere organs. No one, however, had as yet discovered any trace of spermatozoa; Ehrenberg at this time makes no mention of a male element, while Lovén calls the nutritive polypites male, and in this view of their nature falls behind Ehrenberg, who more truly names them sterile or sexless individuals.

[1] 'Corallenthiere, Abhandl. der Königl. Akad. der Wiss. zu Berlin,' 1832.

[2] 'Beiträge zur Kentniss der Gattungen *Campanularia* und *Syncoryne*. Wiegm. Arch.,' 1837. Erster Band, S. 239.

[3] It may here be noticed that Wagner had already (Isis, 1833, § 256, tab. xi) found medusa-like gonophores, filled with ova in a hydroid which he names *Coryne aculeata*, apparently a species of *Podocoryne*; but, not being aware of the doctrine of Ehrenberg only just announced, the exact significance of these bodies escaped him.

The doctrine of the sexuality of the HYDROIDA now waited only for the discovery of the male element in order to receive its complete development. This discovery was made by Ehrenberg, who, in 1838, pointed out the real nature of certain conical tubercles which at particular seasons are developed on the body of the freshwater hydra, and had been by previous observers regarded as a peculiar disease to which this animal was supposed to be subject, but which were now shown by Ehrenberg[1] to be true spermatophorous capsules, while a further and important step in this direction was made by Krohn, who a few years afterwards announced that he had, in the *Pennaria Cavolinii*, Ehren., found certain receptacles similar in form to the ovigerous ones long ago described by Cavolini in the same remarkable hydroid, but containing spermatozoa instead of ova. Similar observations were made on *Tubularia indivisa* and on *Eudendrium racemosum*, as well as on *Aglaophenia pluma* and the *Sertularia* (*Eudendrium?*) *missenensis* of Cavolini, in all of which Krohn succeeded in detecting spermatozoa.[2]

It is now certain that every species of hydroid gives origin to male and female zooids (or, in case of such medusæ as may be directly developed from the egg, to male and female sexually generated individuals), one destined for the production of ova, the other for that of spermatozoa. The separation of the sexes in distinct generative zooids, or in distinct individuals of a sexually generated offspring, is thus absolute and universal among the HYDROIDA. In by far the greater number of cases the separation is carried even further than this; for we scarcely ever meet with male and female gonophores in the same colony. As an almost universal rule, then, the HYDROIDA are diœcious; in other words, every colony is unisexual.[3]

Some few cases of a monœcious condition, however, occur. This has been noticed by many observers in the freshwater *Hydræ*,[4] where, indeed, it is the most usual condition. I have found it also in *Plumularia pinnata*, which sometimes carries on the same stem both male and female gonophores, and Hincks has observed it in some other sertularian hydroids.[5] In *Dicoryne conferta* too there may generally be found, among the dense forest of stems with which this hydroid invests the surface of univalve shells, some stems carrying male and others female gonophores. Each stem, however, carries gonophores of one sex only, though it would seem that both male and female stems are united by the creeping stolon into a common colony. In *Hydractinia*, on the other hand, whose habit is entirely similar to that of *Dicoryne*, we never meet with the two sexes in a common colony; perhaps even never investing the same shell.

Origin of the Generative Elements.—Throughout the whole of the HYDROIDA the generative elements originate between the endoderm and ectoderm, and, with one exceptional condition to be presently described, are always formed in the walls of an organ strictly homologous with the manubrium of a gymnophthalmic medusa.

[1] 'Mittheil. aus den Verhandl. der Gesellsch. naturf. Freunde in Berlin,' 1838.

[2] Krohn, "Einige Bemerkungen und Beobachtungen über die Geschlechtverhältnisse bei den Sertularinen," 'Müller's Archiv,' Jahrg. 1843, S. 174.

[3] Krohn had already noticed that, in all the species examined by him, the male and female gonophores were borne on separate colonies (loc. cit., p. 181).

[4] See especially Prof. Allen Thomson "On the Coexistence of Ovigerous Capsules and Spermatozoa in the same Individuals of *Hydra viridis*," in 'Proc. Roy. Soc. Edin.,' No. 30, 1845-47.

[5] 'Quarterly Journal of Science,' July, 1865, p. 409, note.

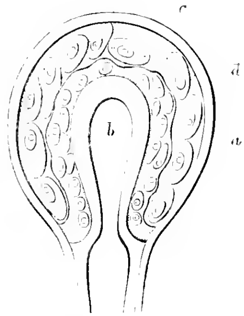
This organ forms the axile diverticulum in the young adelocodonic gonophore, and the manubrium of the sexual medusa, while it is represented by the entire sexual zooid which buds from the radiating canals in the blastocheme or non-sexual medusa.

It is not at first easy to say whether the generative elements have their proper origin in the ectoderm or endoderm of this body, as in most cases they can be merely seen filling the space between these two membranes, which become more and more separated from one another as the included mass of ova or spermatozoa increases in volume.

From some favorable observations, however, which I have succeeded in making on certain species of hydroids, I have convinced myself that the true origin of the ova and spermatozoa is to be found in the endoderm, while the ectoderm serves merely as a confining and protecting sac until such time as the generative elements acquire sufficient maturity to allow of their liberation, which always takes place by simple rupture or absorption of the ectodermal sac.

Thus, in the gonophores of the male colonies of *Sertularia polyzonias* the spermatogenous tissue may be seen filling the entire space between the long cylindrical axile spadix and the surrounding walls of the gonophore. In most specimens it may be easily seen that the spermatogenous mass is far from being of uniform maturity throughout; for while towards the axis of the gonophore it is still very immature, the mother-cells being here distinctly visible with the ultimate spermatic cells within them, we find that towards the periphery it consists of free active spermatozoa. The youngest portion of the mass is thus that which is still in contact with the spadix or endodermal portion of the gonophore, while the oldest portion is situated externally, being in contact with the confining ectoderm—a condition which would be scarcely possible if the ectoderm, rather than the endoderm, gave origin to the spermatic cells.

Fig. 60.



Young Sporosac of *Coryne pusilla*, showing certain early stages in the formation of the ova.

a, Outer wall (perigonium) of the sporosac; *b*, cavity of spadix; *c*, plasma, investing the spadix, and having imbedded in it the germinal vesicles of the future ova; within the germinal vesicles are seen the germinal spot and the *punctum germanitivum*; *d*, fully formed ova, in each of which a portion of the common plasma has become differentiated as a vitellus round the germinal vesicle.

A state of things exactly parallel to this may be seen in the female gonophores of *Coryne pusilla*, in which, moreover, the actual formation of the ova may be satisfactorily traced. At an early period in the development of these gonophores, the large thick spadix may be seen to be surrounded by a granular plasma, throughout which numerous minute nucleated cells are scattered (woodcut, fig. 60). These cells I regard as the germinal vesicles and spots of the future ova, round which no distinctly differentiated vitellus can as yet be detected. In a more mature stage of the gonophore, while the same peculiar tissue continues to invest the spadix, the peripheral portion of this tissue may be seen to be thrown off in the form of undoubted ova, consisting each of a germinal vesicle and spot precisely similar to those observed in the more central portion of the mass, but now with a portion of the common plasma differentiated round each germinal spot in the form of a a very definite vitellus. When the gonophore has attained complete maturity, the whole of the plasmatic mass, with its immersed nucleated cells, has become metamorphosed into fully formed ova.

I have spoken above of an exception to the all but universal fact that the generative elements originate between the ectoderm and endoderm of a body homologous with the manubrium of a naked-eyed medusa. The exception referred to consists in the origination of ova in the blastostyle, as may be seen in *Sertularia pumila* and one or two other species of *Sertularia*.

In *Sertularia pumila* a solitary gonophore of the ordinary form, and containing in the usual way ova or spermatozoa, originates, as in other cases, by a bud from a blastostyle. In the female colonies, however, nucleated spherical bodies, in no way distinguishable from young ova, are found in the walls of the blastostyle itself, between whose ectoderm and endoderm they seem to lie (woodcut, fig. 21, *k*). I have not succeeded in satisfactorily tracing the destination of these bodies; but I have reason to believe that the true gonophores bud forth from that part of the blastostyle in which the nucleated bodies occur, and that these, as young ova, pass from the blastostyle into the budding gonophore, where they would then naturally occupy their normal position between the endoderm and ectoderm of an organ representing the manubrium of a medusa, destined to undergo there a further development before being discharged into the acrocyst, which, as we have already seen, exists in this species. Each gonophore, after having performed its duty as a receptacle, in which certain intermediate stages of development take place, would seem to disappear, and be succeeded by another, which in a similar way receives its young ova from the blastostyle on which it buds.[1]

b. Non-sexual Reproduction.

Gemmation.—As already said, non-sexual or agamic reproduction may manifest itself in the HYDROIDA either by budding or by fission. There is scarcely any part of the external surface of a hydroid which may not give origin to a bud, though the actual conditions which determine the formation of this bud are entirely unknown. Buds capable of becoming developed into one or other of the various forms of zooids, which make up the hydroid colony, may be emitted by the hydranth, by the hydrocaulus, or by the hydrorhiza. In the gonosome we find that not only does the blastostyle give origin to buds destined to take part in the generative functions, but that the medusæ themselves have the power of emitting buds from various parts of their surface. The form and development of these buds have already been considered in the morphological section of the present Monograph.

As an almost universal fact the bud, from whatever part of the hydroid it is emitted, has its somatic cavity in open communication with that of the budder, so that the common somatic fluid passes freely from the one into the other. Cases, however, have been recorded (see above, p. 82) in which certain Æginidan medusæ would seem to give origin to buds from the *internal* surface of the manubrium. It is possible that there may be here some error of observation, and, though

[1] Bodies, undoubtedly of the same nature as those here described, but without any indication of a nucleus, are figured by Agassiz in an American species, which he regards as identical with the *Sertularia pumila* of Europe (op. cit., pl. xxxii, fig. 9). They had also been already described by Lindström (op. cit.).

we owe the statement to able and trustworthy inquirers, it is yet to be desired that we had further verification of a fact so much at variance with the phenomena of gemmation as presented elsewhere among the HYDROIDA.

It is rarely that the medusa has been noticed to emit buds simultaneously with the production of ova or spermatozoa. Instances, however, are on record in which the sexually mature medusa has also multiplied itself by budding. This has been observed by Busch[1] in a medusa which he refers to the *Sarsia prolifera* of Forbes, and in which the basal bulbs of the tentacles gave origin to medusa-buds, which were coexistent with the presence of generative elements in the walls of the manubrium; by Krohn[2] in the medusa of *Clavatella*, which he has seen to be loaded with ova at the same time that medusa-buds were emitted from the margin of its umbrella; and by Sars,[3] who in a blastocheme (*Thaumantias multicirratus*, Sars) saw medusæ budding from the radiating canals simultaneously with the existence of the convoluted generative pouches.

No multiplication by budding has ever been noticed in the sporosac, a zooid which, it is to be borne in mind, is almost from its first appearance engaged in the production or protection of the generative elements.

Fission.—Though budding thus constitutes a highly characteristic and all but universal phenomenon among the HYDROIDA, multiplication by spontaneous fission is, on the other hand, rare and exceptional. Kölliker[4] observed a process of true fissiparous multiplication in a medusa (*Stomobrachium mirabile*, Köll.) obtained in abundance at Messina. The fission always commenced by a vertical division of the manubrium, which thus became doubled; and this stage of the process was followed by a similar division of the umbrella, separating the animal into two independent halves. The process, however, did not stop here, but was followed by a further division of each of the two first-formed segments into two others, by a fission at right angles to the direction of the first; while Kölliker's observations led him still further to conclude that the process does not terminate with even the second cleavage, but, on the contrary, that it still goes on, the animal continuing to multiply itself by frequent acts of fission.

Developed generative bodies were not observed in *Stomobrachium mirabile*, and Kölliker is of opinion that this medusa is only the young of another (*Mesonema cærulescens*, Köll.) found in the same seas, and in which no division takes place, but in which well-developed generative sacs occur along the course of the radiating canals.

But besides this case of fissiparous multiplication in the medusa I am enabled to give a very well-marked and interesting one which I met with in the trophosome of an undescribed campanularian hydroid (woodcut, fig. 61), to which I have assigned the name *Schizocladium ramosum*.[5]

I have not as yet met with this hydroid more than once. It is a profusely branched form, with its trophosome having much resemblance to that of *Obelia dichotoma*; but as no gonosome

[1] Busch, 'Beobacht. über Anat. u. Entwick. einiger wirbellosen Seethiere,' p. 1, pl. i, fig. 1.

[2] Krohn, 'Wiegmann's Archiv,' 1861. In the gemmiferous specimens of the *Clavatella* medusa examined by myself, there were no visible generative elements.

[3] Sars, 'Bescrivelser.'

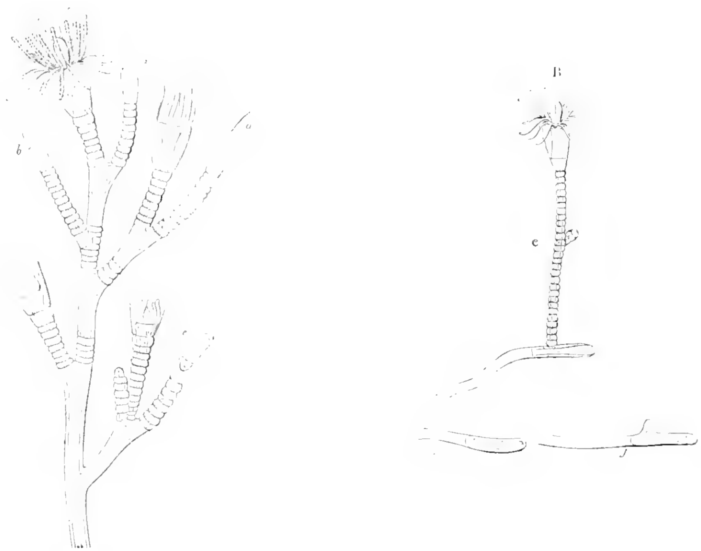
[4] 'Zoologische Beiträge, 1861.'

[5] "On a Mode of Reproduction by Spontaneous Fission in the Hydroida." 'Reports of Brit. Assoc. for the Advancement of Science,' 1870.

was present in any of the specimens collected, its exact systematic position cannot now be more than provisionally assigned to it.[1]

Besides the ramuli which here, as in the hydroids generally, support the hydranths, others are developed in abundance from all parts of the hydrocaulus. These (A, *a*) commence just like

FIG. 61



Schizocladium ramosum, showing reproduction by spontaneous fission.

A. Part of an adult colony magnified about six diameters. *a*, One of the fissiparous ramuli, still entirely invested by the chitinous perisarc; *b*, a fissiparous ramulus, in which the contained cœnosarc has extended itself beyond the distal extremity through the ruptured perisarc; a constriction (the commencement of fission) has begun to show itself in the cœnosarc of the ramulus where still covered by the perisarc; *c*, the fission is completed, and the separated portion is escaping from the distal extremity of the ramulus; *d*, the separated portion has entirely disengaged itself, and has become a free frustule in the surrounding water.

B. Gemmation of the hydroid from the free fission frustule. *f*, The free frustule, after having excreted a mucous tube, from which it has partly withdrawn itself; *g*, a bud has begun to be emitted from the side of the frustule; *e*, the bud has become developed into a hydranth with its hydrotheca and hydrocaulus, and the young trophosome has begun to complicate itself by the emission of a branch.

the ordinary ramuli as offshoots from the hydrocaulus, and consist, as usual, of a continuation of the cœnosarc invested by a chitinous perisarc. Unlike the ordinary branchlets, however, they never carry a hydranth, but are destined for the multiplication of the colony by a process of spontaneous fission.

After the entire ramulus has attained some length, the contained cœnosarc continues to

[1] It is quite possible that in *Schizocladium ramosum* spontaneous fission never occurs simultaneously with true sexual generation.

elongate itself. In doing so it ruptures the delicate pellicle of chitine which closes the extremity of the ramulus, and extends itself quite naked into the surrounding water.

It is now that the process of fission commences. A constriction takes place in the cœnosarc at some distance below its distal extremity, and in the part still covered by the chitinous perisarc (*b*). The constriction rapidly deepens, and ultimately cuts off a piece (*c*), which slips entirely out of the perisarcal tube and becomes a free zooid (*d*), while the surface of disseveration soon heals over, and the axial cavity of the free frustule becomes here as completely closed as at the opposite end

The detached segment is now about the $\frac{3}{100}$ of an inch in length, and strikingly resembles a planula in all points except in the total absence of vibratile cilia. It attaches itself by a mucous excretion from its surface to the walls of the vessel, and exhibits slight and very sluggish changes of form. It now slightly advances along the surface of support, withdrawing itself from the first-formed portion of the excretion, which remains behind as a tube of great tenuity, adhering to the sides of the vessel (*f*).

In tracing the further history of the frustule it was found that this never directly developes a mouth or becomes transformed into a hydranth. After a time a bud springs from its side (*g*), and it is from this bud alone that the first hydranth of the new colony is developed.

The bud which thus becomes developed into the primordial hydranth remains attached to the fission-frustule, which forms for it a sort of hydrorhiza, but which would seem ultimately to perish and give place to true hydrorhizal filaments. In the mean time the primary bud emits others (*e*), and a complex branching colony is the result.

The fission-frustule thus admits of a comparison with the free medusiform element of other hydroids, with which it agrees in never becoming directly developed into a hydriform trophosome, but from which it differs in the very important fact of taking no part in the true generation of the hydroid, and in giving origin to a new colony only by a non-sexual multiplication.

The fissiparous multiplication of *Schizocladium* would seem to throw light on the nature of certain bodies which made their appearance in a jar containing living specimens of *Corymorpha nutans* (see Plate XIX, figs. 12—14). These bodies presented a close resemblance to the fission-frustule of *Schizocladium*, and were seen to become developed into hydranths, which it is almost certain ultimately repeat the form of the adult *Corymorpha*. Their origin was, at the time I noticed them, very enigmatical, but I now regard it as highly probable that they are produced by a process of spontaneous fission from the filaments which are emitted towards the base of the stem in the *Corymorpha*. They would seem, however, to differ from the fission-frustules of *Schizocladium* in becoming *directly* developed into a trophosome.

The decapitation and successive renewal of the hydranths, referred to above (p. 69) as occurring in various species of *Tubularia*, may be compared with the phenomenon of fissiparous multiplication just described. In the decapitation of *Tubularia*, however, the separated hydranth is not destined to undergo any further development; it has matured its sexual buds, and has accomplished all the objects of its existence before being cast off, and it then perishes, to be replaced by another.

The decapitation of *Tubularia* admits of a still closer comparison with the formation and detachment of discs (*ephyræ*) from the hydriform stage (*scyphostoma*) of *Aurelia* and other *Discophora*. Here, however, the discs into which the *scyphostoma* breaks up by a process of transverse division which has its equivalent in the budding, by which the sexual zooids are formed from the hydriform trophosome of the Hydroida, are destined to undergo further development and enjoy an independent existence like that of the hydroid planoblasts. But notwithstanding this difference the analogy is still close and interesting; for the more simultaneous occurrence of the transverse constrictions which result in the formation of a pile of discs before their ultimate detachment in the *scyphostoma* has but little significance; while, as we have already seen, the hydranths successively produced and detached from the stem in *Tubularia*, are formed not by a process of budding, but by one of metamorphosis which shows itself in growth with change of form in the distal extremity of the stem in this hydroid,—a mode very similar to that by which the successive terminal discs or *ephyræ* are developed from the *scyphostoma*.

[illegible]

DISTRIBUTION.

1. Distribution in Space.

The data from which an adequate knowledge of the Geographical Distribution of the Hydroida may be derived are as yet very imperfect, and our assertions regarding the horizontal and vertical extension of the group in the present seas of the globe cannot be regarded as possessing more than a provisional value, liable to modifications as additional facts come to our knowledge; while—if we except the graptolites, whose hydroid relations will be presently discussed—we know almost nothing of the geographical distribution of hydroids in former periods of the earth's history. Indeed, the localities which have yielded the very few fossil hydroids—not being graptolites—hitherto discovered cannot be viewed as representing, even approximately, the former distribution in space of the species which have thus come down to us, and the following remarks on the distribution of the Hydroida in space are therefore confined to the existing forms of the order.

a. Horizontal Distribution.

In a complete exposition of the horizontal distribution of the Hydroida our statements ought to embrace not only the fixed elements of the hydrosoma, but also the free planoblasts. It is true that a large number of planoblasts still remain untraced to their hydriform trophosomes, but our want of knowledge in this respect can scarcely afford grounds for rejecting the medusa from our general survey of hydroid distribution, more especially when we bear in mind the probability that the planoblasts, notwithstanding the pelagic habits of these free-swimming buds, never wander far from the rooted trophosomes in which they originate; and it is only because our positive knowledge of the distribution of the planoblasts is so very deficient that our assertions regarding hydroid distribution must be understood as applying chiefly to the rooted trophosome.

But even though we take all the facts which have come to our knowledge regarding the distribution of both trophosome and planoblast, we are still far from possessing the data necessary for a satisfactory determination of the geographical distribution of the Hydroida. In a great many important geographical areas we know absolutely nothing of the state of hydroid life, while from many others the facts which have come to us are so few that they are quite inadequate as the basis of a generalisation.

It is upon the coasts of the British Isles that the most numerous and complete observations have been made, and next to these in importance must be mentioned the north-west shores of the continent of Europe, the Atlantic shores of North America, and the Mediterranean Sea; while others of considerable value have come to us from the Pacific shores of North America, and from Australia, New Zealand, and South Africa.

Several hydroid trophosomes have been recently obtained from deep dredgings in the western parts of the Gulf Stream, while dredgings at great depths in the more eastern areas of the North Atlantic have yielded others of much interest; and others still have been found tenanting the great North Atlantic seaweed meadow, where, borne upon the floating weeds of the Sorgasso Sea, they lead almost the pelagic life of the planoblast.[1]

Some scanty observations have come to us from the Pacific and Atlantic shores of South America, from the Falkland Isles, from Madeira, from the Islands of the East Indian Archipelago, and from Kerguellau's Land, and the Auckland Islands; while we have somewhat fuller ones from the West Indies. From all these localities we have evidence of the occurrence of hydroid life, though from none have we data sufficient for the determination of definite hydroid provinces.

We have hardly yet sufficient information to enable us to assign any special physiognomical facies to the hydroid faunas of special zones, though the beautiful plumularian group represented by the genus *Aglaophenia* may be considered as especially characteristic of intertropical and warmer temperate seas, where it acquires a far greater development than in the colder waters of the higher latitudes; and it may perhaps also be asserted that the largest hydroid forms are as a rule confined to the warmer seas, while those of temperate and colder latitudes consist for the most part of humbler and less conspicuous species.

Under the name of *Plumularia angulosa* Dana[2] mentions a hydroid from the East Indies, which attains a height of three feet, while Semper[3] has described a gigantic plumularian hydroid from the Pelew Islands, where it forms submarine forests nearly equalling in height that of a man, and with the base of the stems more than an inch in thickness. It is armed with formidable stinging cells, and the incautious bather will have reason to repent his too rash incursions within the precincts of this marvellous grove when he finds himself suffering for hours afterwards a sense of intolerable burning excited by the envenomed darts to which he has unwittingly exposed himself.

Nothing which can be compared with this has been found in any of our northern or temperate seas, where, however, *Aglaophenia myriophyllum* may attain a height of between two and three feet, and where *Tubularia* and *Corymorpha* present forms which strike us by the large size and conspicuous beauty of their hydranths.

The genera of the Hydroida would appear to be far less rigidly confined within limited areas of distribution than we know to be the case with those of other nearly allied groups, such as the coral-forming *Actinozoa*.

In a collection from New Zealand, which was placed in my hands for determination by Mr. Busk, and which consists of twenty-five different species of calyptoblastic hydroids referable to seven genera, I cannot find more than two generic forms (both new) which are not also British. Among thirty-one species from Australia, collected during the voyage of the "Rattlesnake," referable to seven genera, and determined by Busk,[4] five of these genera are, as pointed out by Busk, represented by British species, while of the remaining two (*Pasythea*, Lamx., and *Idia*, Lamx.), *Pasythea*, though not British, is according to Lamouroux, a form belonging to the

[1] Since the above was written the Hydroida obtained during the exploration of the Gulf Stream by the United States Coast Survey have been entrusted to me for determination. So far as I have as yet been able to examine them I find them full of interest. The collection is a very large one, and gives promise of a most important addition to our knowledge of hydroid zoology.

[2] Dana, "Structure and Classification of Zoophytes."

[3] Semper, 'Zeitschrift f. w. Zool.,' Bd. xiii, p. 560.

[4] Busk, in the Appendix to the 'Voyage of the Rattlesnake,' p. 385.

Northern Hemisphere, having been met with in the North Atlantic, though its exact locality is doubtful, as Lamouroux's specimens were found on floating seaweed. To the genera peculiar to Australia must also be added the genus *Lineolaria* of Hincks.[1]

Again, in a collection containing sixteen species of calyptoblastic hydroids from the Pacific coast of North America, and examined by Busk and myself, besides one undescribed genus, there is not another in the collection which is not also British; while twelve species determined by Alexander Agassiz,[2] Andrew Murray,[3] and Trask,[4] from the same shores, belong all to British genera.

A collection of twenty-five species of *Calyptoblastea* from South Africa, given to me by Mr. Busk for examination, are also all referable to British genera.

While almost all the generic forms known to us as occurring in other latitudes than our own are thus widely distributed over the globe, this is by no means the case with the species. The species of hydroids are as a rule confined within determinate and limited areas. Thus of the twenty-five species composing the New Zealand collection just mentioned, three only, namely, the cosmopolitan *Sertularella polyzonias*, with its nearly allied *Sertularella Gayii*, and the equally cosmopolitan *Sertularia pumila*, have been recorded from European seas; while among the thirty-one species collected by the "Rattlesnake" in Australian seas, Busk has detected only three European species, namely, *Sertularia operculata*, *Lafoëa dumosa*, and *Laomedea volubilis;* the last of which he regards as doubtful. Of the remaining species of this collection three only, as pointed out by Busk, occur beyond the limits even of the Australian seas, namely, *Sertularia elongata*, Lamx., which has been also collected in New Zealand, *Sertularella divaricata*, Busk, in the Straits of Magellan, and *Aglaophenia Macgillivrayi*, Busk, in the Philippine Islands. To these, however, must be added the *Sertularella bispinosa*, Gray, which is also a New Zealand species, while it has been collected by Dr. Hooker in the Auckland Islands, and an *Aglaophenia* (*Aglaophenia formosa*, Busk), obtained from Australia by Dr. Landsborough, and which I have found in the collections from New Zealand and from South Africa; while Mr. Hincks records as Australian the *Plumularia obliqua* of our own seas.

Among the hydroids referred to above from the Pacific coast of North America, there are only two which can with any probability be regarded as also European. One of these is *Sertularia pumila*, found in California by Dr. Scouler, and contained in Mr. Busk's collection. The specimen is destitute of gonangia, but its trophosome is indistinguishable from that of our British form. The other is *Lafoëa dumosa*, forming part of the same collection, and also obtained in California. This is also destitute of gonangia, but so are all the European examples of this species hitherto examined.

Indeed, the limitation of groups of hydroid species to definite areas is strikingly illustrated by the marked difference between the hydroid fauna of Australia and that of New Zealand. Among all the hydroids hitherto examined from these two regions, only three species, *Sertularia elongata*, Lamx., *Sertularella bispinosa*, Gray, and *Aglaophenia formosa*, Busk, are common to both. Perhaps when a greater number of Australian and New Zealand species shall have

[1] Hincks, in 'Ann. Nat. Hist.,' 1861.
[2] Al. Agassiz, 'Illustrated Catal.'
[3] A. Murray, 'Ann. Nat. Hist.,' vol. v, 3rd ser., p. 250.
[4] Trask, 'Proc. Cal. Acad.,' 1857.

become known, other points of agreement will be found; but it is not likely that the percentage of species common to the two will be much altered; and this will appear all the more remarkable when we bear in mind that a very large proportion of Australian *Polyzoa* are, as ascertained by Busk, common to that country and New Zealand.

Even within the region of the British seas a few species occur which are not only exclusively British, but which are either absolutely confined to the Northern or the Southern shores of the British Isles, or have at least the metropolis of their distribution on one or other of these shores. Among these we may cite, as examples of Northern forms, *Syncoryne eximia*, *Syncoryne pulchella*, *Endendrium annulatum*, *Tubularia bellis*, *Halecium labrosum*, and *Sertularia fusca*; while *Coryne vaginata*, *Perigonimus serpens*, *Hydranthea margarica*, *Ophioides mirabilis*, and *Aglaophenia pennatula* may be cited as especially belonging to the Southern shores of our islands. It is not improbable, however, that further observations will show that many species have a much wider range than what our present knowledge would justify us in attributing to them.

There is, however, one region which affords a remarkable exception to that limitation of species within definite areas which is here insisted on. I have examined a collection of twenty-five species of calyptoblastic hydroids from South Africa in Mr. Busk's possession, and find them not only all referable to British genera, but with no less than ten of the species indistinguishable from hydroids occurring on the British shores. These ten species are *Sertularia pumila*, *Sertularia abietina*, *Sertularella polyzonias*, *Diphasia attenuata*, *Diphasia pinnata*, *Antennularia antennina*, var.,[1] *Aglaophenia tubulifera*, *Filellum serpens*, *Lafoëa pygmea*, and *Lafoëa parvula*;[2] while another British species, *Sertularia operculata*, has also been recorded by Busk from the same seas.

Among the ten hydroids, however, which I have thus identified with British species, the specimens referred to *Sertularella polyzonias* and *Diphasia pinnata* are the only ones in which the gonosome is present; but as the trophosomes of the others are indistinguishable from those of the species to which I have referred them, we are justified for the present in assuming the identifications as correct.

Admitting the correctness of this determination, the proportion of South African species identical with British ones is quite exceptional, and unexpectedly large; so much so that I have little hesitation in explaining the correspondence between the two faunas by referring it to the transporting agency of the large number of European ships which frequent our South African

[1] This *Antennularia*, though branched, appears to come nearer to *Antennularia antennina* than to *Antennularia ramosa*. The short intervening internode which is characteristic of *Antennularia antennina* is here occasionally present in the ramuli, though more frequently absent; while the ramuli themselves agree with those of *Antennularia antennina* in being more distant than in *Antennularia ramosa*. The form is plainly intermediate between *Antennularia antennina* and *Antennularia ramosa*, and would seem to shake the validity of the latter as a true species.

[2] Though I believe I am right in the determination of these two species of *Lafoëa*, it must not be forgotten that the smaller species of *Lafoëa* are very obscure, and by no means easily distinguished from one another. No gonosome having as yet been found in any of them, we are, in the absence of the hydranths which may possibly afford diagnostic features, forced to characterise them from what are in many cases very slight differences in the form of the hydrothecæ—differences which have scarcely the constancy necessary for a specific character.

colonies, and to whose bottoms the hydroids may adhere. It is interesting, and confirmatory of this view, to find the specimens of *Sertularia abietina* infested in precisely the same way as British ones with *Spirorbis communis* and *Filellum serpens*, both quite characteristic dwellers on the specimens of *Sertularia abietina* which occurs in such abundance round the British shores.

It is an interesting and significant fact that the distribution of the most widely disseminated species is not to be accounted for by any locomotive faculty or pelagic habits of their sexual buds, for the most cosmopolitan hydroids never produce planoblasts at all, their sexual buds being in the form of fixed sporosacs.

Indeed the hydroid medusæ are much more local in their distribution than what one might at first be led to suspect, and it is highly probable that the planoblasts, notwithstanding their powers of locomotion, never, unless drifted by winds or currents, wander far from their fixed trophosomes. I can find no evidence that any one of the hydroid medusæ enumerated by Forbes in his Monograph of British Naked-eyed Medusæ has been met with beyond the province distinguished below as the BOREO-CELTIC. Several species of hydroid medusæ have been observed by Mertens in the North Pacific and other seas during his voyage round the world, while none of them have been as yet recorded from localities at a distance from those in which this excellent observer had noticed them. A similar localization may be affirmed of the species which Péron and Lesueur as well as other circumnavigatory voyagers have noticed in intertropical and other seas traversed by them; while those which Gegenbaur has so fully described from the Mediterranean appear to be similarly limited in their distribution.

There can be little doubt that some facts in hydroid distribution must be attributed to the agency of man, and that hydroid trophosomes are not unfrequently carried to a distance while attached to the bottoms of ships and to floating timber. The exceptional correspondence between the hydroid faunas of South Africa and Britain has been just accounted for in this way. It is possible that *Cordylophora lacustris* owes its introduction into our docks, canals, and rivers to a migration of this kind, which would have its exact parallel in the case of *Dreissena polymorpha*, a mollusc which had been undoubtedly introduced into this country in a similar way, and is now by no means sparingly distributed through the brackish and fresh waters of the British Isles.

What has been just asserted regarding the wide distribution of generic forms must be regarded as referring only to the calyptoblastic hydroids, for if we except the collections made by the North American zoologists on their own shores, it is only the calyptoblastic species which have been collected from distant regions of the globe in sufficient numbers to justify generalisations as to their distribution, or—with very few exceptions—in a sufficiently good state of preservation to render possible a satisfactory determination of them.

Even among the calyptoblastic hydroids we are almost confined to the *Sertularinæ* for facts on which to base any reliable conclusions as to distribution. Almost all the specimens of hydroids which have been brought to us from other parts of the world than our own latitudes have either been picked up dead from the seashore, or if obtained in a living state by means of the dredge, have been brought to this country in a dried condition. Now no gymnoblastic hydroid can under such circumstances retain any characters of value; and even among the calyptoblastic species the *Campanularinæ*, with their delicate and easily detached hydrothecæ, are in their dried state often little better fitted than the dried *Gymnoblastea* for satisfactory determination. Until, therefore, collectors make it a point to secure fresh specimens and put them at once into spirits, or determine them on the spot, our data for the Geographical Distribution of all but the *Sertularinæ*, with their firm, chitinous, persistent hydrothecæ, must continue very defective.

It is, indeed, by no means improbable that the distributional relations of the *Gymnoblastea* are in many respects very different from those of the *Calyptoblastea*, and that not only the species, but a large number of the genera of the gymnoblastic hydroids are confined within limited areas of distribution. Numerous hydroid medusæ have been noticed by navigators in tropical and other distant seas, and though these have not received the attention they deserve, there is reason to believe that among them are many generically different from any which frequent our own latitudes. It is probable, as we have already said, that these medusæ do not spontaneously migrate far from the rooted trophosomes in which they originate; and if so their presence would indicate not only the existence of these trophosomes in the seas frequented by the medusæ, but their limitation within definite areas corresponding to those of the medusæ.[1]

Now, with the exception of such few as may have originated directly from the egg, it is almost certain that all these medusæ are the planoblasts of either gymnoblastic or campanularian trophosomes,—the two groups of which, as has been said, collections from other countries, have hitherto afforded us such few and imperfect examples.

That a more complete knowledge of the gymnoblastic hydroids of other parts of the world would result in the discovery of numerous generic forms, limited in their distribution to definite areas, is rendered further probable by the fact that in almost the only region beyond the European seas where they have been subjected to a scientific study, many generic forms, entirely different from those of Europe, have been established. I refer to the researches of the American naturalists, more especially to those of the two Agassizs, and of Clark, McCrady, and Stimpson, which have resulted in the discovery of seven genera of gymnoblastic hydroid trophosomes inhabiting the Atlantic shores of North America, and unknown upon the eastern side of the Atlantic.

But few facts regarding the distribution of the *Eleutheroblastea* are known to us. The freshwater genus *Hydra*, the only generic representative of this group, appears to be very widely distributed, for it is not only spread throughout nearly the whole extent of Europe, but it has been recorded from North America and from Northern Africa. The extra-European examples of *Hydra*, however, require further examination before their difference from European species or their identity with them can be asserted with confidence.

Though the species of calyptoblastic hydroids have been proved to be on the whole allocated to definite localities, a few would appear to be widely distributed. *Sertularia polyzonias*, a very abundant British species, is also one of the most common sertularians of the Mediterranean, where I have found it ranging from Naples to Nice; while, according to the observations and identifications of Agassiz, Busk, Hincks, and others, it occurs upon the Atlantic shores of the United States, and on the shores of Greenland, Norway, Madeira, South Africa, the Red Sea, and the Falkland Islands; and I have also determined this species among hydroids collected in New Zealand. *Plumularia obliqua*, another British species, has, as already stated, been recorded by Hincks from Australia. South Africa and Australia are given by Busk as localities for *Sertularia operculata*, another abundant British species, while Hincks appears to have also identified it among hydroids from Patagonia, the Falkland Islands, the Auckland Islands, New Zealand, and Kerguellan's Land.

[1] The occurrence of hydroid medusæ at a great distance from the nearest land is probably due to the drifting action of winds and currents.

A trophosome (without gonangia) collected by Dr. Harvey at the Cape of Good Hope, and now in Mr. Busk's collection, is, as I have already said, indistinguishable from that of our common *Sertularia pumila*, while this species with its gonangia occurs in the New Zealand collection already referred to, and—judging from the trophosome, for no gonangia are present—it also occurs, as stated above, among some hydroids obtained by Dr. Scouler in California. Indeed, *Sertularia pumila* and *Laföëa dumosa* appear to be the only species yet discovered common to the Atlantic and Pacific shores.

If these determinations be accepted, *Sertularella polyzonias*, *Sertularia operculata*, and *Sertularia pumila* have quite a cosmopolitan range. Besides those now mentioned, including the exceptionally large number of European species which occur also in South Africa, some others have been recorded from other parts of the Southern Hemisphere, but the evidence of identity does not appear to me sufficient for acceptance. We should bear in mind too that in many cases the specimens brought to us from abroad are entirely destitute of their gonosome, and without this important element of identification our determinations, though we may fairly assume their correctness, are scarcely otherwise than provisional, even though the trophosomes may present a complete agreement.

The parts of the world from which the most abundant data have been obtained for the establishment of definite provinces of hydroid distribution are found in the North Atlantic and its great eastern offset, the Mediterranean.

When we compare the hydroids of the British seas with those which have been recorded from the Scandinavian shores as far even as the North Cape, and from the shores of Belgium and the Atlantic shores of France and Spain, we find such a uniformity in the hydroid fauna of the whole of this coast-range that its division into distinct hydroid provinces cannot be thought of. The same group of forms, with but little variation, may be also traced westward across the North Atlantic, by the Faröe islands, Iceland, Greenland, Labrador, Newfoundland, and Nova Scotia. On the coast of the State of Maine a decided change begins to show itself by the introduction of many species unknown on the eastern side of the Atlantic, and the difference becomes still more marked as we proceed southwards along the Atlantic shores of the United States, until in South Carolina and Florida—judging from the species enumerated by McCrady and Agassiz—not a single hydroid has been found which can be referred to a species known to inhabit the eastern shores of the Atlantic.[1]

Within the range now mentioned two distinct hydroid faunas may be distinguished. One of these may be followed along the whole of the western shores of Europe round to the North American shores by Greenland and along the coasts of the intervening islands, until it attains its south-western limit a little to the south of Nova Scotia.

A comparison of the hydroid dwellers in this northern, north-eastern, and north-western Atlantic area with those which have been recorded from the Atlantic shores of North America, between the State of Maine and the southern point of Florida, shows that though there is a considerable number of species common to the two, there are yet so many forms which are special to this more southern area, that we are justified in regarding this portion of the Atlantic shores of

[1] Alexander Agassiz has given a very full list of North American hydroids, including both the fixed trophosomes and such free hydroid medusæ as have not yet been traced to their trophosomes. 'Illust. Catal. North American Acalephæ,' p. 222.

North America as another province of hydroid distribution distinct from that of the northern, north-eastern, and north-western shores of the Atlantic.

Again, the hydroid fauna of the Mediterranean has many special forms, and differs so much from those of the other two regions, that we are compelled to raise it also to the rank of an independent province.

Three definite provinces of hydroid distribution may thus be regarded as well established in the great North Atlantic area. These may be designated as the Boreo-Celtic, Northern Atlanto-American, and Mediterranean.

The West Indies will probably constitute a fourth, the hydroids of the West Indian seas being, so far as we know, very distinct; the species, however, with which we are acquainted from this locality are not yet sufficiently numerous to justify us in regarding a West Indian province as fully established.

The data we have from other parts of the world are also very imperfect. Among these the Pacific shores of North America, New Zealand, Australia, and South Africa are the regions from which we have obtained the most abundant information; and though we are as yet far from knowing as much of their hydroid faunas as could be desired, I believe we are justified in regarding all but South Africa, whose present hydroid fauna would appear to be a spurious one, originating largely in artificial immigration—as so many distinct provinces of hydroid distribution. In the North Pacific Ocean especially, we would seem to have a singularly well-marked area, for we have seen that, with the exception of *Sertularia pumila* and *Lafoëa dumosa*—species which may have been easily carried on the bottoms of ships—not a single species inhabiting this region has yet been proved to occur in any other part of the world.

The exact limits of this North Pacific Province cannot yet be assigned. It would seem, judging from the species which I find common to the two, to extend at least from the North of Vancouver's Island to the South of California. We know nothing of the hydroids of the Asiatic shores of the Pacific, but, arguing from the greater continuity of the coast line by which the North Pacific Ocean is encircled, we may well believe that there is a greater agreement in their hydroid faunas between the two sides of the North Pacific than between the two sides of the North Atlantic.

Besides the three Provinces enumerated above as determined with sufficient certainty in the North Atlantic, four others may thus with good reason be indicated as probable, namely, the West Indian, the North Pacific, the Australian, and the New Zealand.

The generalisations now given are the utmost that we are justified in founding on the facts before us. Wherever in other parts of the world hydroid trophosomes have been met with, it is only one or two species that have been collected or recorded from any one region—an amount of material quite inadequate for the indication of definite provinces.

b. Vertical Distribution.

General considerations.—The vertical or bathymetric distribution of the Hydroida has, like their horizontal distribution, been very imperfectly investigated, and beyond the North Atlantic area we have scarcely any available data.

Until quite recently we should have deemed it sufficient to express the vertical distribution of the HYDROIDA by referring every species to some one or more of the bathymetrical zones of Forbes; and for all that regards the tidal shores of our own latitudes, down to a depth of about one hundred fathoms, the zones of depth, as laid down by Forbes, will be found convenient.

The recent deep-sea explorations, however, have shown how entirely Forbes's views must be modified in all that regards the deeper regions of the sea. His zero of submarine life has not yet been found, and has probably no existence, for there is no distance from the surface to which the sounding line or dredge has reached—even though the enormous depth of more than two thousand four hundred fathoms has been explored by them—where living beings are not now known to dwell.

It is plain, too, that exactly equivalent regions are not necessarily demonstrable in all seas, and that zones situated at the same depth from the surface in different seas may present physical characters so very different as to determine in each an entirely different fauna and flora.

If this difference could be discovered from known data; if, as in the case of the zones of altitude in the distribution of terrestrial life, we could take the latitude as a factor, which, with the distance from the sea level, would express the conditions which determine the peopling of each zone, we should find the marine zones as full of interest and significance for the laws of distribution as we know to be the case with the zones of altitude. In the case of the sea, however, so many disturbing operations come into play that general assertions can scarcely be ventured on.

The higher regions of the sea, as may be expected, participate largely on the effects of superficial currents, and in local climatic and tidal influences. We are not, however, to suppose that the deeper regions are withdrawn from disturbing influences; we now know that the distribution of heat in the deeper sea regions is very irregular, being in many cases under the influence of local conditions which cannot be determined by any *à priori* reasoning; such, for instance, as the submarine currents, which have determined the deep cold area demonstrated by the "Lightning" and "Porcupine" explorers in the North Atlantic.

It is such facts as these which greatly take away from the value of definite bathymetrical zones as a form in which the submarine distribution of animals may be expressed. When applied to locally limited faunas they are very convenient; but in comparing the faunas of seas far apart, we must be careful not to give them too much value, or regard as equivalent what have really little relation with one another.

Indeed, the recent investigations in the animal life of the deep sea have only shown how very far we yet are from a knowledge of the laws of the bathymetrical distribution of animals. A number of facts of great interest have been accumulated, but these, so far from being in favour of a definite distribution in depth of marine animals, only extend the known range of forms to which our earlier imperfect knowledge had assigned a much more confined and definite limit.

There can be no doubt, however, that while many animal species have been now proved to extend through almost all depths hitherto explored, there are some whose bathymetrical distribution is more limited, and every explorer of marine life knows that there are both shallow water and deep water forms. Some species, indeed, may be allocated to very definite zones, and when we assign to each zone the species which have hitherto been found in it, determining the few which have not yet been met with beyond its limits, and indicate moreover certain relations between the animal and vegetable life of the sea, we shall have said almost as much as our knowledge of the distribution of animals in depth will justify.

In the phenomena connected with submarine vegetation, indeed, we shall find conditions which exert an obvious influence on the distribution of animals. It is certain that in the range of marine life a much more direct and intimate relation exists between depth and vegetation than between depth and the presence of animal life. With the deeper regions vegetation has nothing to do. We know that the higher forms of marine plant life entirely cease at a comparatively slight depth, and even the lower forms disappear long before the deepest regions yet explored have been reached, while no limit has yet been found to the extension downwards of living animals; even the *Diatomaceæ* and other protophytal forms giving place in the deeper regions to their protozoal representatives.

Now, one of the most marked elements in determining the animal life of submarine zones will naturally be sought for in the abundance or paucity of their vegetation; for this affords food to the vegetable feeders which in their turn supply the carnivorous tribes, while both find in its more or less luxuriant development mechanical support and shelter.

Though the HYDROIDA, less probably than many other groups of marine animals, are dependent on the surrounding vegetation, it must yet be admitted that in the region of submarine vegetation, and in that which stretches down beyond it, we have thus the limits of two natural zones of depth, and there can be no doubt that these present us with two sets of conditions which go far to determine the bathymetrical distribution of animals.

But in order to express with sufficient accuracy the distribution of animals in depth, a more minute division is needed, and it will be found convenient to divide the entire depth into several definite zones. Of these the higher ones will be each characterised not only by its fauna, but by the form of vegetation which is special to it; while below we have a vast plantless region stretching downwards into depths which until lately were regarded as unfathomable.

The zones which lie between high water mark and the lowest level of spring tides, and constitute the Litoral and upper part of the Laminarian zone of Forbes, are, at least along the tidal shores of our own latitudes, where they are loaded with a profuse marine vegetation, very rich in hydroid life. In this region two distinct physical habitats must be distinguished, each exerting its special influence on litoral life, and each characterised by a more or less definite hydroid fauna.

One of these consists of the ground which during the ebb becomes exposed to the air retaining only so much moisture as may be prevented from evaporating by the clothing of sea-weed and the projecting ridges of rock. The other is formed by the rock pools,—reservoirs of water of greater or less extent which are left behind by the retreat of the tide.

Again, in the deeper regions the physical condition of the bottom, whether rocky or covered with large stones, or sandy or shelly, or overspread with ooze or mud, will exercise an important influence on the distribution of the HYDROIDA and of other marine animals.

Among the positive facts which the scientific exploration of the deep sea has established with regard to the distribution of the *Hydroida*, one of the most important is that the range in depth of hydroid life is not surpassed by the known range of any other group of the animal kingdom. For while some species occur rooted to the rocks and seaweeds close to high-water mark—not to mention the pelagic planoblasts whose life is spent on the very surface of the open sea amid all the influences of the atmosphere and of the light and heat of the sun—there is evidence of the existence of others at a depth of nearly three miles from the surface, the "Porcupine" explorers having brought up fragments of a hydroid from a depth of 2435 fathoms, the greatest at which dredging has ever been accomplished.[1]

Even single species of hydroids are distinguished by the great extent of their bathymetrical range. Thus *Sertularella polyzonias*, a species also remarkable for its very wide horizontal area, ranges in vertical distribution from a zone between tide-marks to a depth of 374 fathoms, from which specimens were brought up during the expedition of the "Porcupine." *Hydrallmania falcata* was obtained during the same expedition from a depth of 542 fathoms, though it is a common species in the "Coralline zone" of Forbes, which corresponds to a depth of between fifteen and fifty fathoms, while *Thuiaria articulata* was brought up from 632 fathoms, though frequenting a depth of less than fifty fathoms round our shores.

Many species which have not yet been obtained elsewhere were brought up from great depths by the dredges of the "Porcupine." Among these is a *Diphasia* from a depth of 632 fathoms, while a plumularidan, which must be referred to a new genus, was brought up by the same haul of the dredge. Two new species of *Thuiaria* were dredged from a depth of 640 fathoms, and a *Lafoëa* from 345 fathoms. A *Sertularella*, nearly allied to *S. Gayii*, of which it may perhaps be regarded as only a variety, ranged from 290 to 605 fathoms. It is a fact, by no means without interest, that in every case hitherto observed, these deep-water hydroids belong to forms which produce fixed sporosacs instead of planoblasts.[2]

The cold area lying between Shetland and the Faroe Isles, which is overflowed by a deep icy current from the polar seas, and whose discovery by the "Porcupine" explorers constitutes one of the most important additions to our knowledge of the physical geography of the North Atlantic, is not without a deep sea hydroid fauna, although its bottom varies from the freezing point of freshwater to nearly two and a half degrees of Fahrenheit below it. The two new species of *Thuiaria* already alluded to were obtained from it where the temperature of the bottom is as low as 30° Fahr., while from the same area the new plumularian genus, with the new species of *Diphasia* and *Lafoëa*, also referred to above, were obtained in water whose temperature varied in different places from 30°·5 Fahr. to 29°·8 Fahr.[3]

[1] The record of this fact is contained in the Report of the "Porcupine" Expedition, where, from a depth of 2435 fathoms, in lat. 47° 38′ N., long. 12° 08′ W., the dredge is stated to have brought up "two fragments of a hydroid zoophyte." ("Preliminary Report of the Scientific Exploration of the Deep Sea in H.M. Surveying Vessel 'Porcupine,' during the Summer of 1869."—'Proc. Roy. Soc.,' Nov., 1869, p. 429.) The specimens seem unfortunately to have been lost, so that no special determination of the hydroid obtained from this great depth has been possible.

[2] A special report, which I have prepared on the hydroids collected during the expedition of the "Porcupine," will appear in the general Report of the Expedition.

[3] In connection with deep dredging we must here refer to the researches of Sars, who, before the English exploration of the deep sea was undertaken, dredged round the Scandinavian shores in depths which, however, never exceeded 450 fathoms. In these dredgings he obtained, from a depth of 300 fathoms, two hydroids, *Campanularia verticellata*, Linn., and a new genus and species, *Lafoëina tenuis*, Sars. (See Sars in "Videnskabs-Selskabs Forhandlinger," for 1868, p. 246. Translated in 'Ann. Nat. Hist.' for June, 1869, p. 423.)

The late exploration of the Gulf Stream, undertaken by the United States Coast Survey, must also be referred to. In this expedition very important additions were made to our knowledge of the fauna of the sea bottom in the western part of the Gulf Stream, though no dredgings which can be

The great majority of the Hydroida, however, belong to much shallower water, where they are chiefly distributed through the great belt of submarine vegetation already referred to. This belt, as stated above, extends downwards through a region divisible into definite zones of depth. In the systematic part of the present work I have given, so far as it was possible to determine them, the bathymetrical areas occupied by the various species described. These I have endeavoured to express in bathymetrical zones based on those of Forbes—a method which will apply sufficiently well to the Atlantic shores of Europe and of North America. It is less applicable to the Mediterranean, where the Litoral and Laminarian zones, which take so very important a part in the hydroid distribution of our own shores, can scarcely be said to exist,[1] while from other parts of the world the data we have received are so scanty that scarcely anything can be asserted regarding the depths inhabited by such few hydroid species as have been found there.

Bathymetrical zones and their characteristic hydroids.—In order to convey some idea of the leading facts connected with the distribution of the Hydroida in depth, it may be well to take a glance at the most striking features presented by each of those zones which, in the systematic portion of the present work, will be referred to in recording the bathymetrical range of the species there described. They are, with some modifications, identical with the zones of depth, as originally laid down by Oersted for the Danish coast, and afterwards extended to greater depths and otherwise developed by Forbes. Our survey will embrace their leading physical and botanical characters and the most striking features of their hydroid faunas as presented round the shores of the British Islands. From what we have already said, however, we must avoid giving too much weight to the influence of these zones on distribution, for few species are absolutely confined within the limits of any one of them.

The depth-regions which we shall here distinguish are six in number, namely,

I. The Surface Zone. II. The Litoral Zone. III. The Laminarian Zone. IV. The Coralline Zone. V. The Deepwater Zone. VI. The Abyssal Zone.

I. *The Surface Zone.*—This, though an exceedingly important depth-region, has been very generally ignored as a special zone in the bathymetrical range of marine life. It is formed by the stratum of water which reaches from the surface of the sea to a depth of two or three feet, and has nothing to do with the subjacent ground. It is exposed to the direct action of the sun and of the atmosphere, and is, more than any of the other zones, under the influence of latitude and

compared in depth to those of the "Porcupine" explorers were attempted. Some of the hydroids obtained have been examined by Mr. de Pourtales, who describes five new species, namely, an *Antennularia*, three species of *Halecium*, and a *Tubularia*; none of these, however, came from a depth greater than 270 fathoms. (See "Contributions to the Fauna of the Gulf Stream at Great Depths." By L. F. de Pourtales, Assist. U.S. Coast Survey, Bul. Mus. Comp. Zoology, at Harvard College.)

I am myself engaged on the remainder of the hydroids collected during this important expedition, and hope to be soon able to make known the results of my examination.

[1] It may be supposed that the species which inhabit the region between the high and low water lines on coasts where there is a well-marked tide range are fully represented on coasts where the tide range is but slight, with this difference only, that in the former case they are spread over a wide belt, in the latter condensed within a narrow one. Experience, however, shows that this is not the case, and that shores with a narrow tide range have but a poor litoral fauna.

climate. While the explorations of the dredge have revealed to us the fauna of other zones, this has yielded up its treasures to the towing net.

The hydroid fauna of the Surface Zone consists of the multitudes of planoblasts which have been liberated from the fixed trophosomes of other zones, and of such hydroid medusæ as may have been directly developed from the egg, all finding here conditions suited to their love of sunlight and their great powers of locomotion.

A few trophosomes, however, which root themselves to floating seaweeds, may perhaps be regarded as belonging to the fauna of the Surface Zone, just as some exceptionally formed planoblasts would seem to frequent other zones. To the latter belong *Clavatella* and *Eleutheria*, which are found creeping over the seaweeds and nullipores of rock-pools in the Litoral Zone, and probably also *Cladonema*, which, besides its power of swimming like other medusæ, has also the faculty of mooring itself to fixed bodies.[1]

The Surface Zone is not without its plant-life, but its flora is a floating one—the gulf-weed of the Sargasso Sea (*Sargassum bacciferum*), and the lower Algæ—*Oscillatoriæ* and *Diatomaceæ*, which often accumulate in such quantities, even round our own shores, as to impart their colours to the sea for many square leagues.

With the hydroids of this zone is associated a rich pelagic fauna of *Radiolariæ* and other *Protozoa*, of discophorous medusæ, and of siphonophores and ctenophores, as well as of pelagic molluscs—pteropods and heteropods; and pelagic *Annulosa*—*Sagitta* and *Tomopteris;* and the larval forms of echinoderms and annelidans, and of molluscs, which in their adult state creep over the ground or moor themselves to the rocks. Certain fishes, too, must be included in it, for many species have their habitual abode in the Surface Zone, and pursue their prey in this highest region of the sea. It is the zone of sunshine, the region where life becomes intensified, and where beings whose organisation specially fits them for the enjoyment of the more exciting influences of the external world find a congenial dwelling-place. It is the zone, too, where phosphorescent animals congregate in countless multitudes, and light up at night with their mysterious fires the dark surface of the sea.

II. *The Litoral Zone.*—The Litoral Zone constitutes round our shores a well-marked belt. It extends through the entire space which exists between the flood and the ebb levels of ordinary tides. Among the hydroids which occur in it are some of those species which are the most decidedly limited in their bathymetrical range. Of the various species which constitute its hydroid fauna some will be found rooted to the moist rocks which have been left uncovered by the retiring tide, or may be seen spreading over the fronds of the olive-coloured Algæ—*Fucus vesiculosus*, *F. nodosus*, and *F. serratus*—which form the chief features in the vegetation of the zone; while others have their favourite abode in the rock pools with which this zone usually abounds, and in which they are associated with hundreds of living beings belonging to very different groups, all finding like the hydroids a congenial abode in the clear waters of the rock-pool.

The greater part of the species, however, which are peculiar to this zone, are not found in the

[1] The curious hydroid forms, *Nemopsis* and *Acaulis*, have been taken by the towing net in this zone; but these, as we have already seen, are probably only the detached hydranths of trophosomes rooted to the bottom of some of the deeper zones.

rock-pools, but in that portion of the belt which is left uncovered during the ebb, and where they meet with conditions entirely different from those which are present in the deeper zones from which the sea never retires.

Among the hydroids which contribute more especially to characterise the Litoral Zone may be mentioned the following:

Clava squamata, Coryne pusilla, Clavatella prolifera, Laomedea flexuosa, Gonothyræa Loveni, Sertularia pumila.

Of these, *Clavatella prolifera* is confined to the rock pools, occurring in the smaller pools which are situated near the level of high-water neap tides; while the others attach themselves to the moist rocks or to the surface of the seaweeds which are left exposed during the ebb.

III. *The Laminarian Zone.*—This zone embraces the average range of that portion of the shore which is uncovered only at spring tides. It is the favorite abode of numerous hydroids, and since the sea ebbs from it as in the Litoral Zone, it presents both rock pools which at all times retain a supply of water, and stretches of shore from which the sea entirely retreats.

Unlike the Litoral Zone, however, it is only during spring tides that this zone becomes exposed. Instead, therefore, of being laid bare to the atmosphere twice in every twenty-four hours, there are two intervals of nearly a fortnight in each month, during which the sea never leaves it, and even then—since it forms only a narrow band at the extreme limit of low water—it is but for a short time at each ebb that it continues exposed. Its conditions are thus different from those of the Litoral Zone, and as may be expected, it possesses a different fauna.

The fauna of the Laminarian Zone is a very rich one. This region is the abode of such species as cannot endure the long and repeated exposure to the atmosphere to which those of the Litoral Zone are subject, and which yet suffer no injury from such short withdrawal of the water as they experience after each of the long intervals which intervene between every access of spring tides.

The species which frequent the rock pools are here, as in the case of those with a similar habitat in the Litoral Zone, less decidedly limited to one bathymetrical area than are those which attach themselves to exposed rocks and seaweeds. The *Laminaria digitata*, associated with Rhodomenias and other red and purple Algæ, botanically characterises this zone round the shores of the British Islands, and of the other more northern parts of Europe, and some of the most distinctive hydroids of the region may be seen congregating round the roots and stems, or spreading over the broad fronds of this grand seaweed. In the Mediterranean, with its almost tideless shores, the place of the *Laminaria* is taken chiefly by beautiful *Cystoseiræ*, whose narrow heath-like ramifications give support and shelter to hydroids of other species than those of our northern laminarian fauna.

The following species may be cited as among the most characteristic hydroids of the Laminarian Zone of Britain:

Tubularia larynx, Tubularia indivisa, Tubularia bellis, Coryne vaginata, Syncoryne eximia, Myriothela arctica, Obelia geniculata, Campanularia Johnstoni, Sertularia operculata, Sertularella rugosa, Aglaophenia pluma.

IV. *The Coralline Zone.*—This zone extends from the lowest level of spring tides to a depth of about fifty fathoms from the surface, and is never exposed in any state of the tide. Its bottom varies much, and affords appropriate habitats for correspondingly varied forms of life.

In some places it is rocky, in others sandy or muddy, or covered with detached blocks or with old shells. It possesses but a scanty vegetation, and this consists chiefly of the red algæ. Hydroid life, however, would seem to attain here its maximum of development. The sandy and muddy bottoms possess but few species, while our knowledge of the hydroid tenants of the rocky ground is still deficient, in consequence of the difficulties here experienced in exploration by the dredge, and our acquaintance with them is chiefly derived from such as have been brought up entangled in the lines of the fishermen. All the more minute forms which attach themselves to the rocks must necessarily escape this mode of capture, and it is highly probable that the rocky bottoms of the coralline and other deeper zones abound with an unknown hydroid fauna, the source probably of many of those free-swimming planoblasts which have not yet been traced to their trophosomes.

The stony and shelly bottoms, on the other hand, offer great facilities for the use of the dredge, and from none of the zones has such an abundant hydroid fauna been procured.

The following species may be enumerated as among the most characteristic:

Corymorpha nutans, *Hydractinia echinata*, *Eudendrium ramosum*, *Perigonimus serpens*, *Perigonimus minutus*, *Bougainvillia ramosa*, *Dicoryne conferta*, *Obelia longissima*, *Laomedea volubilis*, *Laomedea verticillata*, *Coppinia arcta*, *Lafoëa dumosa*, *Halecium halecinum*, *Sertularella polyzonias*, *Sertularia filicula*, *Sertularia argentea*, *Sertularia abietina*, *Diphasia tamarisca*, *Thuiaria thuja*, *Hydrallmania falcata*, *Antennularia antennina*, *Plumularia setacea*, *Plumularia pinnata*.

V. *The Deepwater Zone.*—The Deepwater Zone extends from the lower limit of the Coralline Zone to a depth of about 100 fathoms from the surface. The Hydroida, as we have just seen, had attained their maximum of development in the Coralline Zone, and we now find them begin to decline in variety of form and in multitude of individuals. The plant-life, with the exception of *Diatomaceæ* and some nullipores, has disappeared. There is the same variety of ground in this zone as in the Coralline, but the muddy bottoms with their scanty hydroid life are more frequent. For our knowledge of the species frequenting the rocky bottoms of the Deepwater Zone we are also mainly indebted to the long lines of the fishermen.

Most of the species, however, which occur in this zone have also been found in others.

The following are deepwater species, and will give a fair notion of the character of the hydroid fauna of the zone:

Tubularia simplex, *Tubularia attenuata*, *Merone cornucopiæ*, *Lafoëa fruticosa*, *Grammaria abietina*, *Halecium muricatum*, *Halecium labrosum*, *Sertularella Gayii*, *Sertularella tricuspidata*, *Diphasia pinaster*, *Thuiaria thuja*, *Thuiaria articulata*, *Aglaophenia myriophyllum*, *Plumularia catharina*, *Plumularia frutescens*.

VI. *The Abyssal Zone.*—This zone commences at the lower limit of the Deepwater Zone, and extends to the greatest oceanic depth yet determined. Our knowledge of its faunas is of quite recent acquisition. We are mainly indebted for it to the deep-sea dredgings which have been lately carried on in the North Atlantic, and which have formed so important an era in zoological research. Its bottom would seem to vary like that of the two preceding zones, though great tracts of fine mud loaded with *Globigerinæ* and other protozoal forms, would seem to constitute the most widely extended and characteristic grounds. With the exception of *Diatomaceæ*, plants are entirely absent; and even the *Diatomaceæ* disappear in the lowest regions of the zone.

The hydroids which tenant the Abyssal Zone include some highly interesting forms unknown in the others. Among them are most of the new species discovered by the "Porcupine" explorers. It is an interesting fact, however, in the bathymetrical distribution of the HYDROIDA that several species which frequent much higher zones extend downwards into this. Thus *Laomedea verticellata* has been obtained from the Abyssal Zone at a depth of 300 fathoms, *Sertularella polyzonias* at a depth of 374 fathoms, while *Hydrallmania falcata* has been brought up from a depth of 542 fathoms, and *Thuiaria articulata* from a depth of 632 fathoms.

The following species have not yet been found in any zone above the Abyssal.

Lafoëa halecioides, Lafoëina tenuis, Diphasia coronifera, Thuiaria flexilis, Thuiaria laxa, Thuiaria salicornia, Plumularia ramulifera, Gonocladium plumosum.[1]

Deep Lacustrine Fauna.—In connection with the bathymetrical distribution of the HYDROIDA, the recent researches of Dr. Forel on the deep fauna of the Lake of Geneva must be mentioned. He has found the mud of this lake at a depth of even 300 metres by no means destitute of animal life. The species occurring at this depth belong to the groups of *Insecta* (larvæ), *Arachnida, Crustacea,* and worms. At a depth, however, of 75 metres (250 feet) a much richer fauna was found, for in addition to the groups represented in the deeper zone there occurred here *Mollusca, Cœlenterata* and *Infusoria,* the *Cœlenterata* being represented by a *Hydra.*[2]

2. DISTRIBUTION IN TIME.[3]

Among the extinct forms which have been referred to the HYDROIDA are the graptolites of the Silurian period, and though there is much which is still obscure and enigmatical in these remarkable bodies, our present knowledge of them points towards the HYDROIDA as their probable allies.

Admitting the hydroid affinities of the graptolites, it is among these remarkable fossils that we must seek for the chief evidence of the existence of HYDROIDA in former ages of the world, for the association of the rugose and tabulate corals with the HYDROIDA, which has been insisted on by Agassiz, has not yet received the verification which is necessary for its acceptance, while the number of other fossils which have been on good grounds referred to the HYDROIDA is very small.

We shall presently consider the well-established instances of ancient hydroid life, and shall discuss the nature of graptolites and their probable points of contact with the HYDROIDA; but it will be best to notice first certain fossils which have, without, as I believe, sufficient evidence, been adduced as former representatives of this order.

[1] The new species here enumerated will be described in my Report on the Hydroida of the "Porcupine" Expedition.

[2] F. A. Forel, "L'Étude de la Faune profonde du Lac Leman," 'Bull. de la Soc. Vaudoise de Sci. Nat.,' vol. x, p. 217.

[3] To Mr. Etheridge, Palæontologist to the Geological Survey of Great Britain, I must here express my thanks for his kindness in looking over the proofs of this section before they were finally sent to press.

Fossils referred to the Hydroida on insufficient grounds.—The genus *Oldhamia* had been founded by Edward Forbes[1] for the reception of certain enigmatical impressions which occur as almost the sole evidence of life in rocks of the Cambrian age. They are not only absolutely special to this period, but are extremely limited in their geographical distribution, having been hitherto found only in a narrow area composed of these rocks in the counties of Wicklow and Dublin.

They present two well-marked modifications of form. In one of these (*Oldhamia antiqua*) there is a distinct stem, which gives off, at short intervals on alternate sides, fan-shaped clusters of somewhat dichotomously divided branches. In the other form (*Oldhamia radiata*) the stem is absent, and the branches radiate from a common centre.

The branches present an obscurely moniliform or nodulose appearance, which has been supposed to indicate the remains of hydrothecæ, and the fossil has accordingly been referred to the HYDROIDA, with the *Sertularia argentea* as its nearest living representative. Oval-shaped bodies have, moreover, been described as present on the branches in some rare instances, and in these it is believed that we have the remains of gonangia.[2]

I must, however, confess my inability to recognise hydroid characters in these obscure impressions. The structure which has been taken for hydrothecæ is never so well marked as to justify this interpretation; and though I have examined a great number of specimens, I have never met with anything which can be regarded as gonangia.

Whatever be the nature of *Oldhamia*, then, I am not prepared to place it among the HYDROIDA. Forbes believed that its affinities must be sought for among the *Polyzoa*, and this view has at least as much in its favour as the other, while that which would regard *Oldhamia* as a vegetable impression seems as tenable as either.[3] Indeed, there are some facts which seem to militate even against its organic origin, such as the undoubted extension observable, in many specimens, of the impression through numerous successive laminæ of the bed in which it occurs.

Under the name of *Corynoides calicularis* Dr. Nicholson has described certain bodies which he has found associated with graptolites in the Silurian shales of Dumfriesshire.[4] They are small, flattened, narrow, wedge-shaped bodies, from one third to a half an inch in length, and measuring about half a line in diameter at their broader end, from which a few short, irregular processes diverge. Towards the opposite end they taper away to a fine point, or, according to Dr. Nicholson, they sometimes terminate here in a double point. In the specimens examined by myself, however, this double termination was not observed. They certainly never show any evidence of attachment. Dr. Nicholson refers them to the tubularian hydroids, and finds their nearest ally in the living genus *Corymorpha*.

[1] Edward Forbes, "On Oldhamia, a New Genus of Silurian Fossils," 'Journ. Geol. Soc. of Dublin,' 1848.

[2] See J. Kinnahan in 'Trans. Roy. Irish Acad.,' 1859, p. 517. Mr. Kinnahan's paper contains the best account we possess of *Oldhamia*, and is illustrated with excellent and characteristic figures. Under the name of *O. discreta* he describes a third form, which, however, is hardly distinct enough to be accepted as a separate species. He strongly advocates the hydroid nature of the fossil, comparing it to the living *Sertularia argentea*.

[3] Schimper ('Traité de Paléontologie végétale,' 1869) regards *Oldhamia* as a plant, and places it among the *Nullipores*.

[4] Nicholson, in 'Geological Magazine' for 1867, vol. iv, p. 108, pl. vii, figs. 9—11.

I am unable, however, to participate in this view. Through the kindness of Mr. Carruthers, of the British Museum, I have been enabled to examine numerous specimens of *Corynoides*, and in none can I find evidence sufficiently clear to lead me to believe in their hydroid affinities. Dr. Nicholson is probably right in regarding them as originally consisting of a corneous (or rather chitinous) material, while they may also have been tubular, though we are without any of that evidence of their tubular conformation which we find so complete in the graptolites. If their affinities be with the tubularian hydroids, the wide end cannot represent a hydrotheca, as supposed by Dr. Nicholson, while under no circumstances can they have as their representative *Corymorpha*, which is entirely destitute of a proper chitinous perisarc. If the wide end represents a distal dilatation of the perisarcal tube, then the processes from it are without parallel in any known hydroid; while if the narrow pointed end be the distal one, there could have been no hydranth developed in them.

Dr. Nicholson's discovery of *Corynoides* forms an interesting contribution to the palæontology of the Silurian Rocks; its relation with the Hydroida may be possible, but other characters than those as yet detected in these little, flattened, wedge-shaped bodies are needed before we can assign to them, with any probability, hydroid affinities.

MM. Duncan and Jenkins have given us a very interesting memoir on a remarkable little organism from the lower shales of the Carboniferous Limestone of Scotland.[1] The authors name it *Palæocoryne*, and regard it as a tubularian hydroid.

It consists of a little calcareous cylindrical column, about one tenth of an inch in height, attached by a dactylose base, and surmounted by an expansion in the form of a reversed cone, the margin of whose wide end is extended into several radiating arms, which, like the rest of the fossil, are entirely calcareous. Both column and arms are beautifully ornamented by flutings and regularly disposed puncta.

The arms are tubular, and open into the summit of the column, which is also traversed by an axial cavity, while the base, with its root-like prolongations, presents, on section, an irregularly chambered structure.

Two species of *Palæocoryne* are described by the authors, and from their very clear description and the excellent figures which accompany it, there is no difficulty in arriving at an adequate conception of the form and essential points of structure of these singular fossils. I regret, however, my inability to recognise the hydroid affinities of *Palæocoryne*. The completely calcified condition of the entire fossil—both base, stem, and arms—and the certainty that it could never have been otherwise, the peculiar ornamentation of its surface, and the chambered structure of its base, are all directly opposed to its alleged relation with the Hydroida. The authors of the memoir believe that they can find in the living tubularian genus *Bimeria* features which resemble some of the most anomalous of the characters of *Palæocoryne*. They see, especially in the extension of the perisarc over a part of the tentacles and hypostome of *Bimeria* a condition which has its parallel in the calcareous arms ("tentacles") and summit of the column in the fossil. But this partial investment of the tentacles and hypostome in *Bimeria* is flexible and chitinous, and a considerable portion of the tentacle remains quite free from it, while in *Palæocoryne* the thick calcareous walls of the radiating arms are all but closed at their distal extremity, where they exhibit at most

[1] P. Martin Duncan and H. M. Jenkins, "On *Palæocoryne*, a Genus of Tubularine *Hydrozoa* from the Carboniferous Formation," 'Phil. Trans.,' 1869, p. 693, pl. lxvi.

but indications of a minute foramen, quite insufficient for the transmission of a comparatively thick tentacle like that of any known hydroid.

On the whole, though the authors have done good service to Palæontology by making us acquainted with this remarkable little tenant of Carboniferous seas, I cannot accept their views of its affinities, and I believe that we must seek for these with the *Rhizopoda* rather than with the HYDROIDA.

Fossils, exclusive of the graptolites, which have been correctly referred to hydroid trophosomes.—Of the hydroid nature, however, of certain other fossils which have been detected in various geological formations there can be no doubt. Instances are known of the chitinous basis of *Hydractinia* having been preserved in a fossil state. Under the name of *Cellepora echinata* M. Michelin has described a fossil from the sub-apennine group of Asti, and from the superior Fallunian of Bordeaux and Dax.[1] M. Fischer has drawn attention to the fact that the *Cellepora echinata* of Michelin is really a *Hydractinia* encrusting a *Murex* or a *Nassa*, while he has himself added another fossil *Hydractinia* from the Upper Greensand of Mans.[2] This he found in the collection of M. Alc. d'Orbigny, where it encrusted numerous specimens of *Natica tuberculata*, d'Orbig., from that formation. M. Fischer has assigned to this species the name of *Hydractinia cretacea*, while to Michelin's species he has given that of *Hydractinia Michelini*.

To the two examples thus noticed by Michelin and Fischer I am enabled to add a third from the Coralline Crag of Norfolk and Suffolk. It occurs among some Coralline Crag fossils in the collection of the British Museum, where it encrusts two specimens of *Purpura lapillus*, one from Orford, in Norfolk, and the other from Redgrave, in Suffolk. It covers with a continuous crust the shell over which it spreads, and has a minutely alveolar structure, with its surface thickly set with short blunt spines. The original chitine is entirely replaced by carbonate of lime. There cannot be the slightest doubt of its being a true *Hydractinia*, and, indeed, it is impossible to find any characters which can separate it from the living *Hydractinia echinata*. From the mere fossilised basis, however, which is, of course, all that has come down to us, we should not be justified in absolutely asserting its identity with the living hydroid.

M. Fischer gives no specific description of the specimens to which he assigns two distinguishing names, and it is probable that no characters of diagnostic value can be detected sufficient to distinguish them from one another or from the Coralline Crag specimens, or even from our living *Hydractinia echinata*. It is by far most likely that such characters would be found if an opportunity existed of examining in the fossils the soft parts now entirely lost, more especially when we bear in mind that they lived at such distant intervals of time as those which separated from one another the cretaceous, meiocene, pleiocene, and existing epochs.

If, under these circumstances, we should be justified in assigning to the Coralline Crag species a distinguishing name when no available characters can be found on which a diagnosis can be based, this may be derived from its geological position, and the purely provisional designation of *Hydractinia pleiocena* may be given to it.

Among fossil hydroids *Sertularella polyzonaas*, one of the most abundant and most widely distributed species of the present seas, has been cited from the later Pleistocene deposits of Ayrshire.[3]

[1] Michelin, 'Icon. Zooph.,' p. 74, pl. xv, fig. 4.

[2] Fischer, 'Bull. de la Soc. Géol. de France,' 2 sér., tome xxiv. p. 689.

[3] Morris, 'Catal. Brit. Fossils,' p. 63.

I have sought in vain, however, for the evidence on which this citation rests, though there is no *à priori* reason why the case should not be accepted as authentic.[1]

Fossil Hydroid Medusæ.—If we except the graptolites, which will be afterwards considered, the instances now mentioned are the only ones yet known of any portion of an undoubted hydriform trophosome having been preserved in a fossil state. Among the most interesting evidence, however, of ancient hydroid life, is that afforded by the discovery of fossil hydroid medusæ.

Several medusæ—some true hydroid or gymnophthalmic forms, and others belonging to the *Discophora* or steganophthalmic group—are now known to exist as fossils. These are all of Jurassic age, having been found only in the lithographic slates of Solenhofen and Eichstädt, and it is to Haeckel that we are indebted for most of our knowledge regarding them.

In 1845 a fossil medusa was exhibited by Frischmann, at a meeting of the Nuremberg Association of Naturalists, and was soon afterwards briefly described by Beyrich under the name of *Acalepha deperdita*.[2] Haeckel[3] has since subjected this fossil to a careful examination, and, under the name of *Craspedites deperdita*, has given a figure and full description of it. He regards it as a hydroid medusa, and refers it to the family of the *Trachynemidæ*. He afterwards[4] alters the generic name from *Craspedites* to *Trachynemites*.

The fossil belongs to the white or upper Jurassic formation of Eichstädt, in Bavaria, and is one of the most perfect impressions of medusæ known. Four specimens of it have been found, and are distributed among the museums of Munich, Carlsrhue, and Berlin. The largest specimen has a diameter of two inches seven lines, and presents the form of a disc bounded by a circular furrow, and showing another furrow internal to this, concentric with it, and separated from it by a distance of five lines. From eight equally distant points of the inner circle there run eight straight radial furrows towards the centre, without, however, reaching it. Each radial furrow is deeper and wider in the middle of its length than at either end, so that the convex cast on the obverse slab has each radiating line projecting almost in the form of a lanceolate leaf.

The obvious interpretation of these appearances leads Haeckel to view the central area into which the radiating furrows do not extend as corresponding to the place of the manubrium and

[1] It is quite possible that the *Websteria crisioides* of Milne-Edwards is a hydroid. Under this name M. Milne-Edwards ('British Fossil Corals,' part i, p. 43, tab vii, figs. 5, 5*a*) has described a fragment of a fossil discovered by Mr. Frederick Edwards in the London Clay of Hampstead. He regards it, though with some doubt, as an actinozoon, referring it to the family of the *Gorgonidæ*.

Judging from M. Milne-Edwards's figure and description, the resemblance of *Websteria crisioides* to a sertularian hydroid, notwithstanding obscure indications of a central axis, is considerable, certainly greater than to a gorgonidan. I have endeavoured, in vain, however, to obtain a sight of the original and only specimen yet found. This seems to have been lost, and without an actual inspection I should scarcely feel justified in expressing an opinion as to its affinities.

M. Pictet ('Traité de Paléontologie') is also disposed to believe in the possible hydroid nature of *Websteria*.

[2] It would seem, however, that the first notice of this fossil was given in 1835 by Fr. S. Leuckart, who correctly referred it to the impression of a medusa. See Rud. Leuckart, in 'Wieg. Arch.,' 1870, Band. ii, Seit 279.

[3] 'Zeit. f. Wissens. Zool.,' 1865, vol. xv, p. 506, tab. 39, fig. I.

[4] Id., vol. xix, p. 560.

mouth, and the eight radiating furrows as the remains of the radiating canals.[1] The inner of the two concentric circles is regarded by Haeckel as the circular canal, and the outer as the periphery of the umbrella, which has become compressed by the conditions to which it had been exposed after death. The dilatations at the middle points of the radiating canals would represent the generative appendages of these canals. The umbrella margin is even, showing no trace of a division into lobes.

The living genus to which Haeckel regards the fossil as most nearly allied is *Rhopalonema*. This, when viewed from the summit, presents quite the same essential relations of form as the fossil, having eight radiating canals, each carrying at its middle point a sexual sac; and this view is further strengthened by the fact that in *Rhopalonema* the radiating canals are, according to Haeckel, supported by a double cartilaginous band, specially fitted to leave behind a well-marked impression, while the umbrella itself in the *Trachynemidæ*, to which *Rhopalonema* belongs, possesses an almost cartilaginous consistence, and is thus peculiarly adapted for preservation in a fossil state.

The large size of *Trachynemites deperditus*, when compared with any living Trachynemidan, is remarkable, the largest known living Trachynemidan measuring little more than a quarter of an inch in diameter, while the fossil has a diameter of more than two and a half inches.

The only other hydroid medusa which has been determined with sufficient certainty from its fossil impression has been referred by Haeckel, to whom we are indebted for our knowledge of it, to the family of the *Æginidæ*.[2] The impression, which is very distinct and sharp, occurs on a slab of the lithographic slate of Solenhofen, forming part of the collection in the Palæontological Museum at Munich. It exhibits both umbrella and marginal tentacles. The umbrella is one inch and a half in diameter, with eight marginal lobes. The marginal tentacles are admirably preserved. These are eight in number, and can be traced to the intervals between the marginal lobes of the umbrella. They are eight inches in length, cylindrical, and about a quarter of an inch thick for the greater part of their length, when they begin to taper to a point at their distal extremity. They are traversed in their entire length by a reddish-brown line, which there is every reason to interpret as the remains of an axial canal. From the peculiar way in which the tentacles lie in the fossil, and the stiff curves into which they are thrown, it appears that in the living animal they must have possessed considerable rigidity, a condition which is very characteristic of the marginal tentacles in the living *Æginidæ*. Indeed, both umbrella and tentacles in the *Æginidæ* possess for the most part a cartilaginous consistence, which renders them particularly well fitted to come down to us in a fossil state.

If we follow in the fossil the direction of the axes of the tentacles, when prolonged towards the summit of the umbrella, we may distinguish eight small pit-like depressions at a distance of a little more than a quarter of an inch from the margin. These appear to be the impressions of the eight sexual sacs. No trace exists of mouth or stomach, or of the lateral gastric pouches which characterise the living *Æginidæ*.

Haeckel assigns to this fossil the name of *Palægina gigantea*. In referring it to the family of

[1] Rud. Leuckart, however ('Wiegmann's Archiv,' 1870, Band ii, Seit 280), asserts, from an actual inspection of the Carlsruhe specimen, that the eight radiating furrows regarded by Haeckel as impressions of the radiating canals, are in this specimen approximated to one another in pairs, and thus throw doubt upon the validity of Haeckel's determination.

[2] Haeckel, 'Zeit. f. Wissensch. Zool.,' vol. xix, p. 540, tab. 40.

the *Æginidæ* he appears to have good grounds. Its enormous size, however, when compared with living representatives of this family, constitutes a striking feature in its physiognomy.

Several other fossil impressions of medusæ have been described by Haeckel, though none of these can with anything like certainty be referred to the HYDROIDA. Some of them are preserved with great distinctness, and are undoubtedly referable to the *Discophora* or steganophthalmic medusæ, while some others are so imperfectly preserved as to render it impossible to determine their systematic position, though in some, at least, the evidence is in favour of their hydroid rather than their discophorous affinities.

It will be seen that the only two fossil hydroid medusæ which have been satisfactorily determined appear to belong, one to the *Trachynemidæ*, and the other to the *Æginidæ*, families characterised by certain anomalous features which distinguish them from the ordinary hydroid medusæ.

Graptolites.—Among the extinct forms of life few possess more interest than these remarkable fossils, absolutely confined, as they are, to one great section of the palæozoic rocks, where their vast abundance, wide geographical distribution, and easy recognition, render them of special value to the practical geologist.

The graptolites are now by most palæontologists referred to the HYDROIDA, and their living representatives are sought for among the calyptoblastic genera of this order. While, however, I am unable to recognise their hydroid relations from the point of view from which palæontologists have generally agreed to regard them, I believe that their affinities with the HYDROIDA are too decided to justify their omission from any complete exposition of the palæontological history of this group of the animal kingdom.

The typical form of a graptolite is that of a narrow tube, straight or more or less curved, emitting from one side a series of hollow denticles, through which the cavity of the tube opens externally, and having a solid slender rod imbedded in the walls of the opposite side. This type form ("monoprionidian") is represented by the genus *Graptolites* proper, where the denticles or tubular offsets from the common canal are in contact with one another at their bases and usually for a greater or less extent of their length, and by the genus *Rastrites*, where they are separated from one another by considerable intervals.

But we may conceive of two such graptolites being united back to back, and the resulting form will then present two series of tubular offsets, one on one side of the main tube and the other on the side diametrically opposite, while the solid rod will now occupy the axis, holding just such a position as it would do if it had been formed by the union of the two rods of the component halves.

This form ("diprionidian") is represented by such genera as *Diplograptus*, where the tubular offsets stand out more or less free from the sides of the main tube, and by *Climacograptus*, where they are adnate to one another, so as to appear entirely immersed in its walls.

Some other forms also exist, such as *Dicranograptus*, in which the graptolite, with a double row of denticles, after continuing its course for a time, divides into its component halves, which then diverge from the basal portion as two branches, constructed each on the single-rowed type. Branched single-rowed forms (*Cladograptus*, *Dichograptus*) also occur. In *Dichograptus* primary branches radiate from a common point at the proximal end, where they are connected by a web-like disc, apparently composed of a double membrane of the same nature as that which forms the walls of the branches.[1]

[1] See Hall, 'Graptolites of the Quebec Group.'

There are also some anomalous forms (*Retiolites*, *Phyllograptus*), whose structure has not yet been determined with sufficient certainty to admit of a satisfactory association with the true graptolites; but the essential features in the morphology of the graptolites, as well as their more important modifications, are expressed in the genera already cited.

There is sufficient evidence to show that the graptolites were flexible, and that the solid parts, which are all that have come down to us, were of a horny or chitinous consistence. There is also evidence to show that, though some obscure forms (*Dendrograptus*), associated on insufficient grounds with the graptolites, were apparently rooted, the true graptolites were never directly attached to any other bodies, as we know to be the case with the hydroid trophosomes and most of the corals and *Polyzoa* of the present day.

We are absolutely ignorant of the original contents of the main tube and of its lateral offsets, and we know just as little of other soft parts which may have accompanied the chitinous skeleton, so that in attempting to assign to the graptolites their position in the system of Nature we are driven to analogy by no means close as our sole guide.

The resemblance of the forms just described to the trophosome of a calyptoblastic hydroid —sertularian or plumularian—after the disappearance of all the soft parts, is sufficiently obvious. And it is this resemblance between the fossil graptolite and the recent chitinous skeletons of the sertularian and plumularian hydroids, which has induced modern palæontologists to refer the fossil to the order HYDROIDA, regarding the lateral offsets as hydrothecæ, and the main tube as the chitinous perisarc of the hydrocaulus.[1]

We shall presently consider whether the exact points of contact between the graptolites and hydroids have been indicated in this comparison.

The fact which most obviously opposes itself to an acceptance of the hydroid affinities of graptolites is found in the presence of the rod or "solid axis," which constitutes an essential feature in the structure of the graptolite. This rod was apparently of the same chitinous material as that which formed the rest of the firm skeleton of the graptolite. It is frequently continued for some distance beyond the distal or growing end, while its opposite or proximal end usually terminates in a minute spine ("radicle" of Hall), occasionally continued into a long slender filament, like that of the distal end. It grows with the growth of the graptolite, as can be easily proved by following the progress of the graptolite from its younger stages, and it is difficult to explain its increase of length and thickness without regarding it, like the proper perisarc, as an

[1] The sertularian affinities of the graptolites have been strongly insisted on by Hall, who has greatly advanced our knowledge of these fossils in his classical work, 'Graptolites of the Quebec Group,' which forms one of the memoirs of the Geological Survey of Canada. On the structure and principal modifications of graptolites, the works of Barrande ('Graptolites de Bohême') and of Geinitz should also be consulted. The sertularian affinities of graptolites have also been defended by Mr. Wm. Carruthers, of the Botanical Department, British Museum, and I know of no one who has worked out this question with so much care and completeness. See especially his "Revision of the British Graptolites," in the 'Geological Magazine,' vol. v. The same view is advocated by Dr. J. Alleyn Nicholson, who has also paid special attention to the British graptolites, and has contributed some valuable facts to our knowledge of them.

I must here express my thanks to Mr. Carruthers for the liberal way in which he has placed at my disposal his large collection of graptolites, and for the aid which I have derived from his extensive acquaintance with the literature of the subject.

excretion from the cœnosarc. It is sometimes found in the single-rowed graptolites to have become detached from the test or chitinous perisarc, leaving behind it a furrow in which it had lain; this furrow being in the more perfect state of the fossil converted into a tube by a thin extension over it of the test.

Though the rod would thus form an extremely exceptional structure, its presence can hardly be regarded as offering an insurmountable obstacle to the admission of the graptolites into immediate relation with the HYDROIDA. Until lately a similar structure would have quite as justly excluded from the *Polyzoa* any animal which possessed it. The discovery, however, of the living polyzoal genus *Rhabdopleura* shows that a rod quite like that of the graptolite in all points, except in its not being continued beyond the cell-bearing portion, might be developed in an animal possessing in all other respects a typical polyzoal structure.[1]

It is true that the extension of the rod in the fossil beyond the limits of the proper hydrocaulus appears to increase the difficulty of reconciling its presence with the hydroid affinities of the graptolite. I believe, however, that this is, after all, not so anomalous a fact as at first sight it may appear, and that there is reason to believe that the cœnosarc invested by a proper perisarc was originally continued along what now appears as a free extension of the rod. Its distal extension would then correspond to what had been the young growing portion of the graptolite, as yet destitute of denticles, and with its periderm so delicate as to be incapable of preservation in the fossil, so that the thin perisarc has perished along with the soft cœnosarc it included, its thicker rod-like portion being the only part preserved.

This view is borne out by the fact that in the very young stage of the graptolite a distal extension of the body along the rudimental rod, and beyond the incipient denticles, may be noticed; while it is further confirmed by an observation by Dr. Nicholson,[2] who tells us that in some specimens of *Diplograptus pristis* he has seen the common canal without denticles continued on each side of the prolonged rod.

The continuation of the rod beyond the denticle-bearing portion at the proximal end of the graptolite may also have been accompanied by an extension of the cœnosarc and its enveloping perisarc in this direction, the rod alone remaining in the fossil. To this view an observation of Mr. Carruthers[3] gives support, for he has noticed the prolongation of the rod at the proximal end of *Climacograptus scalaris* frequently invested for a short distance by a sheath.

If this explanation be accepted, the continuation of the rod as a naked filament beyond the denticle-bearing portion of the graptolite need no longer surprise us. A comparison of the rod to the chitinous spines which bristle over the surface of *Hydractinia* may also here suggest itself; but these spines are not only invested by a cœnosarcal layer, but are permeated by canals which are lined by cœnosarc, while in other respects the approximation of the graptolites to *Hydractinia* offers too many difficulties to allow of its being attempted.

The lateral spines often present at the proximal end of the graptolite seem to be of a different nature from that of the rod, and would rather appear to be referable to the same group of structures as the chitinous spines and variously formed processes by which the hydrothecæ and other parts of the perisarc of living hydroids are not unfrequently ornamented.

[1] Allman, "On *Rhabdopleura*," in 'Quarterly Journal of Micros. Science,' Jan., 1869, p. 57, pl. viii.

[2] 'Geological Mag.,' vol. iv, 1867, p. 261, note.

[3] Carruthers, in 'Intellectual Observer' for June, 1867, p. 370.

It has been already said that the advocates of the hydroid nature of graptolites regard their denticles or hollow lateral offsets as hydrothecæ. If this be really the nature of the denticles, the mode in which their cavity opens into that of the main tube is exceptional, for in the living hydroids the point of communication between the hydrotheca and tube of the hydrocaulus is more or less constricted, or even provided with an imperfect diaphragm, so that the hydrothecæ become proper chambers, completely differentiated from the common perisarcal tube. Now, the denticles of the graptolite have their cavity uninterruptedly continuous with that of the main tube, there being no diaphragm or constriction of any kind at the point where the one passes into the other.[1]

There is, however, another view of the denticles which will meet this difficulty. The remarkable bodies known as nematophores, and which are characteristic of the *Plumularidæ*, have been already described. Among these nematophores there is one form which consists of simple chitinous offsets from the main tube of the hydroid filled with the protoplasmic matter which constitutes the characteristic contents of all the nematophores. The mesial and lateral nematophores of *Aglaophenia* are of this nature, and a comparison of them with the denticles of a graptolite will show how complete is the resemblance, as may be seen by a reference to woodcut fig. 51, p. 117, which represents the nematophores connected with the hydrotheca of *Aglaophenia pluma*. It has been already shown that the tooth-like processes which project from the edges of the hollow leaflets, which form the walls of the corbula in *Aglaophenia*, are bodies of an entirely similar kind, and the resemblance between these and the tooth-like processes of many graptolites is complete (see woodcut, fig. 30 *f*, p. 60).

Now, it is not alone in general form that the nematophores of *Aglaophenia* resemble the denticles of a graptolite. The mode in which their chitinous sheaths are seen to open into the common canal of the perisarc after the destruction of all the soft parts, is entirely similar to the mode of communication between the denticles and the common canal in the fossil—in those cases at least in which the graptolite has afforded facilities for examination such as to leave no doubt as to the structure of the parts in question—and quite different from that in which the proximal extremity of the hydrotheca is connected with the common tube of the chitinous perisarc in the existing hydroid.

I cannot help believing that this is the true view to take of the morphology of graptolites. If so, the graptolites would admit of an approximation through an unexpected channel with the *Plumularidæ*. They would then be morphologically plumularidans in which the development of hydrothecæ had been suppressed by the great development of the nematophores, probably the mesial ones; while, on the other hand, the existing plumularidan, with well-developed hydrocecæ, would present in its nematophores the last traces of the structure of its ancient representative, the graptolite.[2]

[1] M'Coy ('Brit. Pal. Foss.') speaks of a septum at the base of the denticles in certain graptolites, but subsequent observations have not tended to confirm this statement.

[2] Among the undescribed species in the collections of the United States Coast Survey is a plumularidan in which that part of the stem which lies at the proximal side of the pinna-bearing portion—and is accordingly destitute of hydrothecæ—carries along its length a single row of fixed nematophores separated from one another by regular intervals, and appearing to take the place of hydrothecæ. This part of the hydroid, if detached from the pinnate portion, might—except for the much greater thickness of the common canal in the living than in the extinct form—almost be taken for a recent *Rastrites*.

Whether the denticles of the graptolites gave lodgment to hydranths, or were filled with simple protoplasm, as we know to be the case with the nematophores of the living *Plumularidæ*, it is of course impossible to say. If we give analogy its full weight, and extend the resemblance between the denticles of the graptolites and the nematophores of the plumularidans to the nature of their contents, we should then have lodged in the graptolite-denticles, not hydranths, but simple masses of protoplasm, capable of emitting pseudopodial prolongations on which would devolve the duties of conveying nutriment to the colony. The graptolites would thus manifest relations, not merely to the HYDROIDA, but would exhibit others at least as strong to the Rhizopoda. Indeed, but a step would be needed to convert such an organism into a true rhizopod, which might then be compared to an association of such rhizopodal forms as *Gromia*, united into a composite colony by a common tube filled with a common mass of protoplasm.

A very general feature in the mode of growth of graptolites is found in the fact that while the entire graptolite continues to increase in length, the denticles which are situated towards the proximal end remain of smaller size than those which succeed them, while after thus increasing in size they again often diminish towards the distal end, the broadest part of the graptolite being consequently in this case towards the middle.

Now, I know of nothing like this among the living HYDROIDA, while, on the other hand, the nematophores vary in form in one and the same colony, and are sometimes found more or less arrested or otherwise modified towards the proximal end of the branch.

In support of the hydroid nature of graptolites, the occurrence of generative capsules in these fossils has been recently adduced, and as this is a matter of great importance in the present question we shall here consider the evidence on which it rests.

Hall has described and figured in one of the double-rowed graptolites (*Diplograptus*) certain appendages of an irregularly triangular shape, having one angle continued into a narrow band by which they become attached to the body of the graptolite. They are arranged with considerable regularity in two opposite rows, which extend for some length along the sides of the graptolite. These appendages are compared by Hall to the gonangia of a calyptoblastic hydroid.[1]

I am indebted to Mr. Etheridge for an opportunity of examining a British specimen of a *Diplograptus* which carries bodies of undoubtedly the same nature as those of Hall, and to Mr. J. Hopkinson, who had previously examined this specimen and determined its nature, for the inspection of an excellent enlarged drawing of it intended for publication.[2] Now, after a full consideration of Hall's description and a careful examination of Mr. Etheridge's specimen, while I admit the probability of the appendages in question belonging to the generative system, I am unable to satisfy myself that they are the remains of gonangia. Indeed, they do not appear to me to be capsular bodies at all, but rather hollow laminæ, though the way in which they are occasionally folded over on themselves may give them the deceptive appearance of having been capsules.

The regularity of their disposition, and the close resemblance between those of the American specimens and those of the British, will not allow us to regard them as mere parasitical or accidental growths, and I believe that their connection with the gonosomal system of the graptolite may be considered as probable. If so, then it remains for us to determine the parts which represent them

[1] Hall, 'Graptolites of the Quebec Group,' p. 32, pl. B, figs. 6—11.

[2] Mr. Hopkinson's description of the specimen has since been published. See 'Ann. Nat. Hist.' for May, 1871.

in the living hydroid, and these I believe will be found in the leaflets which compose the corbulæ in *Aglaophenia*. (See woodcut, fig. 30, p. 60.)

The two rows, then, of appendages in the graptolite would, according to this view, represent a corbula, and the gonangia, if such had existed, would have been borne upon the front of the graptolite along the bases of the appendages. We should hardly, however, expect to find any remains of gonangia in the fossil, for in all living hydroids which have their gonangia protected by corbulæ these gonangia are as delicate and perishable as the naked generative sacs in the *Gymnoblastea*.

The corbulæ of the graptolites were probably open ones, like those of the living *Aglaophenia myriophyllum*, and of several species from extra-European seas, a condition which indicates a low stage of differentiation, and represents a form through which the closed corbula of *Aglaophenia pluma*, &c., passes in the course of its development. (See woodcut, fig. 30, A, B, C, D. p. 60.)

The view here adopted of the nature of these supposed generative capsules in the graptolite receives important support from the fact that in every case where they have been satisfactorily observed the denticles of the graptolite become suppressed in that part of the fossil which carries the appendages,[1] a fact quite in accordance with what we know of the corbulæ in the living hydroids, for in these the hydrothecæ with their accompanying nematophores are replaced by the leaflets of the corbula, while the naked gonangia of other hydroids are never accompanied by an atrophy or other alteration of the hydrothecæ or neighbouring parts.

In both the American and British specimens the appendages in question seem to have been supported by a framework of branched chitinous filaments which remain behind after the destruction of the intervening membrane. The existence of these filaments probably depends on the same morphological conditions as those which determine the presence of the chitinous axial rod, and it must be admitted that we have no known analogy for them in any living hydroid, unless the internal narrow chitinous lamina which passes like a midrib through the corbula-leaflet (woodcut, fig. 30, A, *e*) admits of being compared with them.

This comparison of the appendages of Hall with the corbula-leaflets of an *Aglaophenia* is in harmony with the view here advocated as to the nature of the denticles of the graptolite which we have compared to the nematophores of an *Aglaophenia*. I believe the corbulæ of the living *Aglaophenia* to consist essentially of a special and excessive development of the nematophores, so that the graptolite not only in its trophosome but also in its gonosome would thus present us with an instance of the great development of the nematophoral system at the expense of the hydranthal.[2]

[1] Hall notices a case (*loc. cit.*, p. 33, pl. B, fig. 9) which he regards as one in which the appendages are present in a graptolite which still retains its denticles. This, however, is by no means a well-marked instance, and one might be permitted to doubt the identity of the structures here figured with the appendages previously described by him.

[2] This view of the morphology of the corbulæ seems placed beyond doubt by their formation in an undescribed *Aglaophenia* from the deep-sea dredgings of the United States Coast Survey. The leaflets which form the walls of the large and beautiful open corbulæ of this hydroid are mainly composed of the greatly enlarged and transformed nematophores which in the unaltered ramulus lie in front of the hydrothecæ. The hydrothecæ of the parts which become transformed into corbulæ are not here actually suppressed, but remain of somewhat smaller size, affording the clue to the morphology of the entire organ; and it can be plainly seen that it is the mesial nematophore of each of these arrested hydrothecæ, which

If these views be accepted we shall have nearly the entire graptolite in those instances in which the appendages of Hall have been noticed converted into a corbula, a state of things which naturally follows from the simple unbranched form of the fossil. The graptolite has, in fact, become greatly changed in form, and modified for a special reproductive function in a way which reminds us of the so-called fertile fronds of certain ferns as distinguished from the so-called sterile fronds.

It is true that the great rarity of these peculiarly modified graptolites is opposed to what we know of living hydroids, for among these we are not acquainted with a single trophosome which we are not justified in believing destined at some period of its life to develope a gonosome. A case, however, bearing some analogy to those of the graptolites would be afforded by fossil ferns, for we know how rare a thing it is to find among the vast multitudes of individuals with which the coal-measures abound specimens bearing fructification.

While the graptolites would thus seem to contrast with living hydroids in their rarely developing a gonosome, it is interesting to see them contrasting also in another respect, namely, in their free if not floating habit. And here we are reminded of the gulf-weed of the Sargasso Sea, for throughout the thousands of square miles over which the floating meadows of this remarkable plant extends no one has yet succeeded in finding a single specimen in fructification, though the fructification of closely allied species, which grow attached to rocks like ordinary seaweeds and like the rooted trophosomes of the hydroids, is well known.

Certain bodies found associated with graptolites in the Silurian shales of Dumfriesshire have been described by Dr. Nicholson, who regards them as the "ovarian vesicles" of the graptolites, and as proving the hydroid nature of these fossils.[1] He describes them as "oval, bell-shaped, pyriform, or rounded, provided with a mucro at one extremity, and surrounded entirely by a filiform border, resembling in texture the axis of a graptolite." They attain a length of nearly half an inch.

He has found them not only free, but in many cases attached to the graptolite, not, however, to any constant point, for some spring "from the common canal, others from the apex of a cellule, and others from the under surface of a cellule, the last two modes being the most frequent."

The largest of these capsules which he has seen attached did not measure more than a tenth of an inch in diameter, and Dr. Nicholson believes that at this stage they become detached,

has become enormously developed and flattened out so as to form the leaflet of the corbula-walls, while at the same time it becomes complicated by carrying along one edge a row of small tooth-like nematophores, as in the corbula-leaflet of *Aglaophenia pluma*, &c. The hydrothecæ, with their nematophores, which in the untransformed ramulus constitute a single series along the front of the ramulus, are, in order to form the walls of the corbula, thrown alternately from side to side.

In the description of the corbula of *Aglaophenia pluma* given above (p. 61), I regarded the gonangia as representing the hydrothecæ of the untransformed branch, and as taking the place of these hydrothecæ in the corbula. I am now compelled to modify this view, and to regard the gonangia as independent structures, just as in those plumularidans which are destitute of corbulæ. If any representative of the hydrothecæ had existed it would have been found, not on the floor of the corbula, but in its walls.

[1] Nicholson, in 'Geological Magazine,' vol. iv, 1867, p. 259, pl. ii.

and then attain the large size he has observed in the specimens found free in the shale, for he has there found them in all stages of growth, from small rounded bodies, not larger than a pin's head, to bodies of nearly half an inch in length.

Whatever these bodies may be, it is plain that Dr. Nicholson's account of them is irreconcilable with the supposition that they represent either the gonangia or the gonophores of a hydroid; for, apart from their supposed development after detachment from the colony, their origin from the walls of the denticle is alone decisive on this point. Indeed, their connection with the graptolite appears to be purely accidental.

Hall has called attention to the occurrence in the same beds which contain the graptolites of minute free bodies, which he regards as the young or "germs" of the graptolites.[1] In their earliest form they would appear to consist of a little chitinous oblong sac traversed longitudinally by a slender chitinous filament, which is continued for a little way at both ends beyond the sac, while at one end it is accompanied by two minute lateral spine-like processes.

This early form has been traced through more advanced stages, in which it has been seen to become more and more elongated, to develop denticles along its length, and finally to attain a form in all essential points identical with that of an adult graptolite.

Others slightly differing in shape from those described by Hall have been also obtained. Indeed, these young graptolites—for there is no doubt that Hall is right in his interpretation of their nature—are now well known. They are by no means uncommon in graptolitic shales, in some examples of which I have seen them abounding in countless multitudes.

Hall believes that he finds evidence of their having been contained within the so-called reproductive vesicles of the graptolite. From his account of their relation to these, however, I can recognise nothing but accidental proximity; while if we admit that he has grounds for this belief, we should then have, in the advancement of the embryo to a stage in which it has become covered by a chitinous perisarc previous to liberation, a state of things quite at variance with all we know of the reproductive phenomena of living hydroids.

But little remains to be said regarding other views which have been from time to time advanced as to the affinities of graptolites. These fossils have been compared to the chambered shell of a cephalopod, a view, however, which in the present state of our knowledge of them need not now detain us for a moment. They have also been compared to the sclerobasic *Actinozoa*, and their nearest living allies have been sought for in *Virgularia* and *Pennatula*. It is plain, however, that the resemblance here is of the most superficial kind, and that the internal solid smooth axis of a *Virgularia* or a *Pennatula* has nothing in common with the membranous test of the graptolite, whose axial canal and tubular offsets point to totally different affinities.

They have also been compared to the internal solid skeleton of larval echinoderms, an approximation which has nothing in its favour, and which the occurrence of irregularly-branched graptolites which have been continuously followed in the shale even for several feet will alone render impossible.

Their alleged polyzoal affinities have much more claim on our acceptance. Indeed, were it not for the discovery of the graptolite gonosome (corbulæ?) we should have nearly as much to say for this view as for that which would refer them to the HYDROIDA, more especially as the

[1] Hall, op. cit., p. 33, pl. B, figs. 12—19.

discovery of *Rhabdopleura* renders us acquainted with a polyzoon in whose test is developed a chitinous rod in almost all respects like that of the graptolites.[1]

The graptolites are exclusively of Silurian age. They occur first in Lower Silurian beds, and unless we include among them the anomalous genus *Dendrograptus*, which has been obtained from the Potsdam formation of North America—the probable equivalent of our Lingula Flags—their lower limit will be the summit of the Lingula Flags, from which they range into the Ludlow of the Upper Silurian.[2]

The diprionidian, or double-rowed forms occur in great abundance in the Lower Silurian Rocks, where they are associated with monoprionidian or single-rowed forms. Graptolites become much more rare in the Upper Silurian, where they are represented exclusively by some monoprionidian species.[3]

The following table will show the geological formations which have afforded evidence of the former existence of the HYDROIDA.

	Lower Silurian.	Upper Silurian.	Jurassic.	Cretaceous.	Miocene.	Pliocene.	Pleistocene.	Living.
Gymnoblastic trophosome (Hydractinia) .	...	...	...	×	×	×	...	×
Calyptoblastic trophosome (Sertularella) .	...	...	...	...	...	...	×?	×
Hydroid Medusæ (Trachynemidæ and Æginidæ)	...	...	×	...	...	...	...	×
Monoprionidian Graptolites . .	×	×						
Diprionidian Graptolites[4] .	×							

[1] The comparison of the rod of *Rhabdopleura* to that of a graptolite has already been made by Dr. Nicholson ('Manual of Zoology'), though he adopts the more generally accepted view which sees in the denticles of a graptolite the hydrothecæ of a hydroid.

[2] The curious *Fenestella*-like genus *Dictyonema* has been referred to the *Graptolitidæ* by Hall. It ranges from the Lower Silurian into the Middle Devonian; but whatever may be the nature of this remarkable fossil, it is almost certainly not a graptolite. Schimper ('Traité de Paléontologie végétale') places *Dictyonema* along with *Oldhamia* among the nullipores.

[3] If *Retiolites*, Bar., be a true graptolite we must then carry the Diprionidian forms into the Upper Silurian, for this genus occurs in the Llandovery and Upper Wenlock formations. *Retiolites*, however, is an exceedingly anomalous form, and departs in so many respects from the typical Graptolites as to render the propriety of associating it with those fossils extremely doubtful in the present state of our knowledge.

[4] See preceding note.

This table will, of course, not be regarded as representing the actual distribution in time of the HYDROIDA. It is only an expression of the principal facts in the present state of our knowledge of hydroid palæontology, and it will be at once seen how very few these are. From by far the greater number of formations we have no evidence of the existence of hydroid life, while, if we except the graptolites, the examples which have come to us from any formation whatever are very few, the vast majority of hydroid families being as yet unable to claim any fossil representative. This, however, we can scarcely hesitate to refer to the defects of the record rather than to the absence of hydroid life in past epochs of the globe.[1]

[1] After the above pages on the palæontological distribution of the HYDROIDA had been printed I became acquainted with R. Richter's paper "Aus den Thüringischen Schiefergebirge," published in the 'Zeitschrift der Deutschen Geologischen Gesellschaft,' xxiii Band, 1 Heft, 1871.

The author here describes the graptolites of the Upper Silurian strata of Thuringia, but the paper is chiefly occupied with a dissertation on the structure and affinities of graptolites in general. It contains some valuable original observations, and, as the views advanced differ in certain points from those of other German and of the British and American observers, I have thought it necessary to refer to them here.

He describes the test as composed of two laminæ, an inner thick one—usually marked by oblique striæ—and an outer thinner one, the latter being itself composed of two thin lamellæ, which repeat the striated condition of the former when such is present. If this be really the nature of the graptolite test, the condition in which the Thuringian specimens have come down to us must be exceptionally fitted for the detection of structure, as no evidence in favour of this view seems obtainable from any British or American specimens.

He describes as an "organ of attachment" or "foot" the part named "basalstück" by Geinitz, and "radicle" by Hall, and he gives a figure of it as it has appeared to him in *Graptolites priodon*. It is here, as in other monoprionidian species, described as a hollow elongated cone with rounded base, and like the rest of the fossil composed of two membrauous laminæ. The common canal of the graptolite springs from one side of it at a point not far removed from its thicker end, the pointed end of the foot being, as a rule, thrown back on the dorsal side of the canal. Here, again, the views of the author find no support in any British specimens I have examined.

Having noticed that certain monoprionidian graptolites occur sometimes curved towards the side of the rod, or "dorsal" side, sometimes towards that of the denticles, or "ventral" side, he concludes that these species must have possessed the faculty of spontaneously bending themselves from side to side.

He has never witnessed anything which can be compared with the structures referred by the American and British observers to the generative system of the graptolite, but he has seen in the same rocks with the graptolites great quantities of spherical corpuscles of from 0·1 to 0·3 mm. in diameter, and apparently surrounded by a double membrane. He does not offer any opinion as to the import of these bodies, but along with them he finds also, in great abundance, slender conical bodies, resembling in all respects, except that the pointed end was continued into an extremely fine whip-like filament, that part of the graptolite which he had already distinguished as the "foot." He regards these as the earliest stage of the graptolite. They appear to be the bodies referred to in the text as first described by Hall under the designation of graptolite "germs;" Richter believes that he has seen the stem of the future graptolite originating as a bud from a point near their thicker end.

In such forms as *Rastrites*, in which the long distant spine-like processes are usually regarded as the denticles with terminal orifice, he considers these processes as a mere armature of the true denticles, which, according to Richter, scarcely project beyond the common canal, and have the orifice situated in the axil of the spine.

As to the mode of life of the graptolites, he believes that by the aid of the "foot," which he regards as possessing a certain amount of spontaneous mobility, they were enabled to bore into the sea-bed of clay or mud, and there maintain an erect position.

After comparing them with the *Pennatulidæ*, *Hydroida*, and *Polyzoa*, he concludes that they are most nearly related to these last, and refers to Leuckart as advocating in a letter to himself the polyzoal nature of the graptolites. He adduces the rod in *Rhabdopleura* as affording evidence of this view, and (though the resemblance seems to have escaped him) he might also have compared the peculiar striæ which he has described as usually present in the graptolites with those which exist in the adherent portion of the tube in *Rhabdopleura* (see 'Mic. Journ.,' vol. xi, New Series, pl. viii, fig. 4), to which it must be admitted they present a very striking similarity. I am unable, however, to find in Richter's arguments any grounds for accepting the polyzoal affinities of graptolites, while in his comparison of the two laminæ of the graptolite test to the ectocyst and endocyst of a *Polyzoon* it is plain that he has formed an erroneous conception of the nature of the fleshy organized endocyst which constitutes the essential part of the body-walls of a *Polyzoon*.

The paper concludes with an enumeration of the graptolites which occur in the Upper Silurian strata (Nereitenschichten und Tentaculitenschiefern) of Thuringia, with descriptions of the new species. Among the forms described as new by far the most remarkable is one which carries three vertical rows of cells upon the common canal. He makes it the type of a new genus, *Triplograptus*. The propriety, however, of associating this remarkable fossil with the true graptolites appears to me very doubtful.

SUPPLEMENTARY.

There still remain for discussion in connection with the general zoology of the Hydroida some subjects which, in strict sequence, ought to be included under the head of Morphology. It has been deemed, however, more convenient to defer their consideration, and they are accordingly here brought together in a separate section supplementary to the first part of the Monograph.

CLASSIFICATION.

An important reform in zoological classification was introduced when Frey and Leuckart separated as a distinct sub-kingdom, under the name of Cœlenterata, certain animal forms which had been previously combined with the *Echinodermata* in the construction of the Cuvierian primary group of the Radiata.[1] In the establishment of the Sub-kingdom Cœlenterata the German zoologists recognised the importance of a fundamental type of organization in which the general somatic cavity communicates freely with the outer world through the mouth.

The Cœlenterata admit of subdivision into two classes, in accordance with the presence or absence of a stomach-sac differentiated from the general body-cavity though freely opening into it. For these two classes the names of Hydrozoa and Actinozoa assigned to them by Huxley may be accepted as sufficiently convenient. Each of these classes is further divisible into orders, and one of the orders of the Hydrozoa is constituted by the Hydroida, the group to which the present Monograph is devoted.

The characters which I regard as essentially distinguishing the Hydroida are expressed in the following table, from which the relations of the Hydroida to the other cœlenterate orders will be at once apparent:

[1] Frey und Leuckart, "Beiträge zur Kenntniss wirbelloser Thiere," 1847.

CŒLENTERATA.	No stomach-sac differentiated from the general body-cavity — HYDROZOA	Locomotion never by bands of vibratile lamellæ	Generative elements discharging themselves externally	Never with a hydriform trophosome united with the gonosome into a natatory colony (woodcuts, figs. 64—67)	HYDROIDA.
				Always with a hydriform trophosome united with the gonosome into a natatory colony (woodcut, fig. 68)	SIPHONOPHORA.
			Generative elements discharging themselves into the body-cavity	Generative elements in symmetrically disposed, longitudinal, band-like projections of the inner surface of the somatic cavity. Body stalked, fitted for attachment (woodcuts, figs. 71, 72)	LUCERNARIÆ.
				Generative elements formed in symmetrically disposed, pouch-like dilatations of the somatic cavity of a body which is not stalked and not fitted for attachment (woodcuts, figs. 69, 70)	DISCOPHORA.
		Locomotion always by bands of vibratile lamellæ (woodcuts, figs. 73, 74)			CTENOPHORA.
	A stomach-sac differentiated from the general body-cavity — ACTINOZOA	Tentacles subuliform; symmetry for the most part hexameral (woodcuts, figs. 62, 63)			ZOANTHARIA.
		Tentacles leaf-shaped, with the margins cirrated; symmetry tetrameral			ALCYONARIA.

When the various living forms included under the order HYDROIDA are compared with one another, it will be found that they present among them four principal modifications, and these afford grounds for the subdivision of the living representatives of the order into four sub-orders; while, if we include the graptolites, a fifth sub-order must be established for the reception of these extinct organisms.

Confining ourselves for the present to the living hydroids, we find that three out of the four sub-orders under which they are included possess a hydriform trophosome, which, in the development of the hydrosoma, intervenes between the ovum and the generative buds, whose assemblage constitutes the gonosome. In the fourth sub-order there is no hydriform gonosome, and the ovum becomes developed by direct metamorphosis into a medusiform hydrosoma, to which is assigned the performance of generative as well as nutritive functions.

Of the three sub-orders which thus possess a hydriform trophosome, there is one in which no perisarc is ever excreted, while the hydrosoma is never permanently attached, and the nutritive buds on attaining a certain degree of maturity disengage themselves from the parent stock and continue their growth independently as free organisms. The designation of ELEUTHEROBLASTEA may accordingly be assigned to the order thus characterised.

In another sub-order a more or less obvious perisarc is always present, while the hydrosoma is always attached, and the zooids of the trophosome never become separated as free, independently developing organisms.[1] In this sub-order there is never developed either hydrotheca or gonangium. So that both nutritive and generative buds are destitute of the characteristic receptacles which afford protection to these parts in the following sub-order. The name of GYMNOBLASTEA suggests itself as a designation sufficiently expressive of this distinction.

In the last of the three sub-orders of living hydroids characterised by the possession of a hydriform trophosome we have the same perisarcal covering of chitine, and the same permanent attachment of the hydrosoma and nutritive buds which we meet with in the GYMNOBLASTEA; but the hydranths are always protected by a hydrotheca, and the generative buds are always included in a gonangium. These characters afford the grounds for distinguishing a third sub-order, and suggest for it the name of CALYPTOBLASTEA.[2]

The last of the four sub-orders of the living HYDROIDA is distinguished by the absence of a hydriform trophosome, the ovum becoming developed through direct metamorphosis into a medusiform body, just as in the other orders it is developed into a hydriform body. To the sub-order characterised by this very exceptional condition I shall assign the name of MONOPSEA.[3]

[1] The detachment of the hydranths in certain *Tubulariæ* (see above, p. 69) indicates the commencement of decadence and death in these bodies, which never undergo further growth or development after their separation from the parent stem. I take it for granted, also, that the free hydranths described by Stimpson and by M'Crady under the names of *Acaulis* and *Nemopsis* have been detached in the same way from some fixed tubularian stem. None of these cases, therefore, can be confounded with the separation of the buds in the ELEUTHEROBLASTEA.

[2] The chitinous covering, which often invests the gonophore in the gymnoblastic hydroids, and which, in some cases, as in *Cordylophora lacustris*, attains considerable thickness, must not be confounded with a gonangium. The true gonangium is always developed round a blastostyle, though the latter may occasionally be forced back, and become atrophied by the pressure of the growing gonophore.

So also the thin expansion of the perisarc, which may be seen extending over the base of the hydranth in certain Gymnoblastea, as in *Cordylophora lacustris*, and more especially in various species of *Bougainvillia*, is entirely different from a hydrotheca. The hydranth is never to any extent retractable within it, as it is within the true hydrotheca, and during the contraction of the hydranth this chitinous sheath merely adapts itself to the contraction, being then thrown into more or less well defined transverse folds.

[3] I am not disposed to regard a non-sexual trophosome as necessarily absent from the MONOPSEA any more than from the other three sub-orders. As yet none but Geryonidan and Æginidan medusæ have been proved to possess the characters on which the sub-order MONOPSEA has been founded; for the case of *Lizzia*, which has been adduced as an instance of direct development of the medusa from the egg, is probably based on some error of observation (see above, p. 100). Now, in both Geryonidan and Æginidan medusæ the generative elements are produced in sac-like offsets of the radiating canals, and reasons have already been given for regarding these generative sacs—at least in the Geryonidan forms—as true zooids; and the medusæ from whose radiating canals they are emitted would then belong

All the living Hydroida are thus either destitute of a chitinous perisarc—ELEUTHEROBLASTEA and MONOPSEA—or else are more or less extensively invested by this protective covering—GYMNOBLASTEA and CALYPTOBLASTEA. In no case, however, does there exist the additional support of a solid chitinous rod. This is found in the extinct group of the graptolites, whose tubular offsets, moreover, we have already compared, not to hydrothecæ, but to nematophores.

Though we are still entirely ignorant of many important points in the structure of graptolites, and know nothing beyond mere surmise of the functions of their parts, or of the phenomena of their lives, we find in them nevertheless a group of characters which—accepting the view advocated above of their hydroid affinities—necessitates the establishment for them of a separate sub-order of HYDROIDA. And even though we may regard the nature here attributed to the tubular offsets or denticles as too hypothetical to form the basis of such a separation, we shall have in the solid rod alone a character sufficient for this purpose.[1] The name of RHABDOPHORA may be assigned to the sub-order thus constituted.

Among the leading groups into which the HYDROIDA are thus divisible the sub-order of the ELEUTHEROBLASTEA is that in which we meet with the greatest morphological uniformity, the entire group being represented only by the single genus *Hydra*.

The MONOPSEA are more diversified, for we find among them the various types of the Geryonidan and Æginidan medusæ. Our knowledge, however, of these medusæ is still imperfect; and though much light has recently been thrown on them, especially by the researches of Haeckel, who has shown close and hitherto unsuspected relations between the Geryonidan and Æginidan forms, we are by no means sure that they are all developed on the same plan, and the group MONOPSEA can scarcely be yet regarded as possessing more than a provisional value.

In the GYMNOBLASTEA there is still more morphological diversity, this sub-order being represented by numerous families and genera.

In the CALYPTOBLASTEA the special morphological modifications are greater than in any of the others, with the exception, possibly, of the RHABDOPHORA. In the CALYPTOBLASTEA, indeed, these modifications necessitate a primary division of this sub-order into two subordinate groups, each of which includes families and genera.[2] The characters here assumed as the basis of hydroid classification may be tabulated in the following scheme:

to the properly non-sexual form or "blastocheme." If this view be correct the Geryonidans must be regarded as composed of a hydrosoma, consisting, as in other hydroids, of a trophosome and a gonosome, but in which the trophosome is medusiform instead of being, as in all the other sub-orders, hydriform.

It is only since the earlier portion of the present Monograph was printed that the development of the medusa from the egg without the intervention of a hydriform trophosome has been established on sufficient evidence. Certain views, founded on the absence of evidence in favour of this phenomenon, have been there expressed, and must accordingly be now received with some modification.

[1] Though the solid rod is present in all the typical graptolites, there are some very aberrant forms (*Retiolites*) in which it has not yet been demonstrated with certainty. It is a matter for consideration whether these do not constitute a group with affinities pointing in quite a different direction from those of the true graptolites.

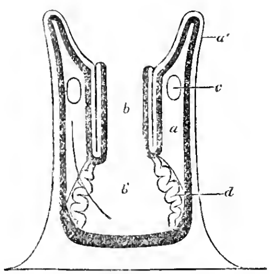
[2] Hincks ('Hist. Brit. Zooph.') divides the HYDROIDA into three suborders, to which he assigns the names of GYMNOCHROA, ATHECATA, and THECOPHORA. These groups are equivalent respectively to the ELEUTHEROBLASTEA, GYMNOBLASTEA, and CALYPTOBLASTEA of the present Monograph. Had not these last names been used by me in the earlier part of the Monograph, before the publication of Mr. Hincks's work, I should have here hesitated to add to the existing heavy nomenclature of zoology.

Order.					Sub-order.		Tribe.	Family.	Genus.
HYDROIDA	Body never provided with a solid rod-like support	Development from the ovum through the intervention of a hydriform trophosome	Perisarc absent; zooids of trophosome never permanently attached		ELEUTHEROBLASTEA				*Hydra.*
			Hydrophyton more or less extensively invested by a perisarc; zooids of trophosome permanently attached	No hydrothecæ or gonangia	GYMNOBLASTEA			Clavidæ	*Clava*, &c.
								Corynidæ	*Coryne*, &c.
								Eudendridæ	*Eudendrium.*
								Tubularidæ	*Tubularia*, &c.
								&c.	
				Hydrothecæ and gonangia present	CALYPTOBLASTEA	Hydrothecæ separated on peduncles from the axis	CAMPANULARINÆ	Campanularidæ	*Campanularia*, &c.
								Lafoeidæ	*Lafoëa*, &c.
								Coppinidæ	*Coppinia.*
								&c.	
						Hydrothecæ more or less adnate to the axis	SERTULARINÆ	Sertularidæ	*Sertularia*, &c.
								Plumularidæ	*Plumularia*, &c.
								Halecidæ	*Halecium*, &c.
								&c.	
		Direct development from the ovum			MONOPSEA			Æginidæ	*Ægina*, &c.
	Body provided with a solid rod-like support in addition to its chitinous perisarc				RHABDOPHORA			Monoprionidæ	*Graptolites*, &c.
								Diprionidæ	*Diplograptus*, &c.

HOMOLOGICAL RELATIONS OF THE CŒLENTERATA.

Independently of the general agreement which necessitates the association of the *Hydra*, *Actinia*, and other Cœlenterate animals into one primary group of the animal kingdom, we must also expect a special morphological correspondence between the various forms of animals thus associated. In other words, a homological agreement ought to be determinable between the parts of animals included in any one subordinate section of the CŒLENTERATA with the parts of animals included in any other.

FIG. 62.

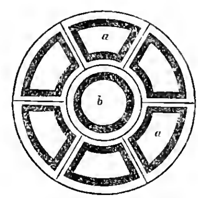


Diagramatic longitudinal section of *Actinia*.

a, Radiating interseptal space; *a′*, tentacle; *b*, differentiated stomach-sac; *b′*, somatic cavity; *c*, aperture in distal end of radiating lamella; *d*, genetalia borne by radiating lamellæ.

In this figure, as well as in figs. 64, 66, 69, 71, and 73, a bristle is represented as having been passed from the main cavity of the body into a gastrovascular canal or its homologue.

FIG. 63.



Diagramatic transverse section of *Actinia*.

a, *a*, Interseptal spaces; *b*, differentiated stomach-sac.

A comparison of the two primary sections of the CŒLENTERATA (*Actinozoa* and *Hyarozoa*), and of the various orders of these with one another, will show that such an agreement really exists, and that it is possible, by easily understood and thoroughly consistent modifications, to convert each special type into any of the others.

With the view of rendering apparent these relations, we shall compare an Actinozoon (*Actinia*, woodcuts, figs. 62 and 63) with a Hydrozoon (*Hydra*, woodcuts, figs. 64 and 65), and shall further compare with one another the various orders of the HYDROZOA.

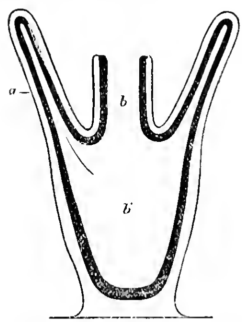
Agassiz was, I believe, the first to compare the radiating chambers which, in an Actinozoon, intervene between the stomach-sac and the outer walls, with the radiating canals of a medusa.[1] He seems to have thus struck upon the true homologies of these parts; but when he maintains further that the differentiated stomach of an Actinozoon is only the proboscis (hypostome) of a

[1] 'Contr. Nat. Hist. U.S.,' vol. iv, p. 377.

Hydrozoon inverted into its body-cavity, he suggests a view which is insufficient to explain the actual structure, for the radiating lamellæ still remain unaccounted for.

We possess very few observations on the early stages in the development of *Actinia*, but it seems to be generally taken for granted that the first appearance of the stomach-sac is to be explained by supposing a bending inwards of the margin of the oral aperture, and if this be admitted the conception of Agassiz will so far be borne out.[1] But then the septa which are found

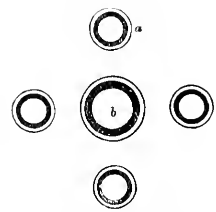
FIG. 64.



Diagramatic longitudinal section of *Hydra*.

a, Tentacles; *b*, hypostome; *b′*, somatic cavity.

FIG. 65.



Diagramatic transverse section of *Hydra* through hypostome and tentacles.

a, Tentacles; *b*, hypostome.

surrounding the stomach-sac must in this case be formed as independent structures between the outer walls and the inverted mouth-margin, and the intervening chambers must have an entirely different origin from that of the radiating canals of a medusa, and can hardly be regarded as their strict homologues.

This introversion of the mouth-margin, however, is not a necessary interpretation of the successive forms presented by the embryo in its early stages, for an exactly similar appearance

[1] See Cobbold ('Ann. Nat. Hist.,' 2nd series, vol. xi), and more especially Kowalevsky ('Nachrichten der K. Gesellschaft der Wissensch. zu Göttingen,' 1868, s. 157). Kowalevsky gives no figure, and his communication is in such a condensed form, stating the results of his observations rather than the steps by which these results are obtained, that it is not always easy to discover his exact meaning, especially with regard to the mode of formation of the septa and the radiating chambers. The formation of the stomach-sac, however, by the turning in of the mouth-margin is clearly maintained.

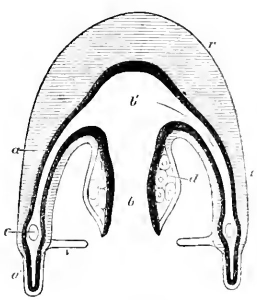
It may be here mentioned that Kowalevsky denies the correctness of parallelising the common cavity of the *Cœlenterata* with the true body-cavity of other groups of the animal kingdom, and maintains that the so-called body-cavity of the *Cœlenterata* is rather the homologue of the intestine of other animals, being, according to him, a secondary formation supervening on that of the proper body-cavity in which it has been formed by a process of introversion of the walls, the proper body-cavity itself becoming more or less obliterated.

A view agreeing in most respects with that of Kowalevsky is also advocated by Semper ('Reise im Archipel der Philippinen,' Zweiter Theil, Erster Band, p. 131), who maintains that the endoderm o would be produced by the prolongation of the oral margin outwardly, accompanied by an extension around it of the general body-cavity.[1]

According to the latter interpretation, the so-called stomach-sac would represent the hypostome of *Hydra* uninverted, and surrounded by a continuation of the body-cavity. But this distal prolongation of the body-cavity is further seen to be divided by radiating septa into chambers which open freely into the simple primitive body-cavity below. The exact meaning of these septa and of their intervening chambers remains for determination, and is at once suggested by a comparison of *Actinia* with *Hydra*.

In order to form a correct notion of the homological relations between an *Actinia* and a *Hydra*, we have to imagine the tentacles of a *Hydra* (woodcuts, figs. 64 and 65, *a*) for a greater or less extent connate with the sides of the hypostome (*b*) and with one another. The hypostome

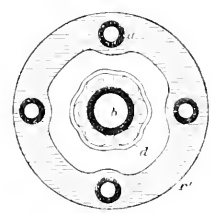
Fig. 66.



Diagramatic longitudinal section of a Hydroid Medusa.

a, Radiating canals; *a'*, marginal tentacles; *b*, manubrium; *b'*, atrium; *c*, lumen of circular canal; *d*, generative elements; *r*, atrial region of umbrella; *r'*, manubrial region of umbrella; *v*, velum.

Fig. 67.



Diagramatic transverse section of a Hydroid Medusa through the manubrial region of the umbrella.

a, Radiating canals; *b*, manubrium; *d*, generative elements; *r'*, manubrial region of umbrella.

of the *Hydra*, while retaining its normal position, will thus become the stomach-sac of the *Actinia* (woodcuts, figs. 62 and 63, *b*), and this will necessarily become connected with the outer walls by a series of radiating lamellæ—the connate tentacle-walls—separated from one another by radiating

the *Cœlenterata* is formed by an introversion of the ectoderm. He asserts that the *Cœlenterata* have no body-cavity, but only an analogue of it in a connective tissue lying between the endoderm and ectoderm, and to which he assigns the name of Cœnenchyma. He maintains that all the canals which in every direction permeate the zooids and the cœnosarc, are only appendages of the digestive cavity, and that, consequently, the generally received view, which represents the alimentary canal of the *Cœlenterata* as opening into the body-cavity, must be given up.

That the views of Kowalevsky and Semper do not hold good for all the *Cœlenterata* there can be no doubt. They certainly are not applicable to the Hydroida.

[1] The account of the development of the Red Coral given by Professor Lacaze Duthiers ('Hist. Nat. du Corail') bears out this interpretation, rather than that which would see in the stomach-sac an inverted hypostome.

chambers (*a*)—the cavities of the tentacles; while such portions of the tentacles of the *Hydra* as still continue free will be represented by a single circle of the tentacles of the *Actinia* (woodcut, fig. 62, *a'*).

Having thus established a fundamental identity between the regions of an *Actinia* and of a *Hydra*, there will be no difficulty in recognising the relations between an *Actinia* and a hydroid medusa (woodcuts, figs. 66 and 67); for as we have attempted to prove in a former part of this Monograph (see p. 40) the tentacles of a *Hydra* are represented by the radiating canals and those extensions of them which form the primary marginal tentacles of the medusa.

The distal ends of the radiating lamellæ in Actinia are perforated each by an opening through which the radiating chambers communicate with one another (woodcut, fig. 62, *c*). Agassiz has compared these openings to the circular canal of a medusa, and I believe that in this view he has correctly expressed the relations in question.

If we further add that the generative apparatus (woodcut, fig. 62, *d*) is borne by the radiating partitions, we shall have all the leading points in the morphology of an Actinozoon.

A comparison of the various orders of the HYDROZOA with one another will result in the detection of close homological correspondencies, and will throw important light on the morphology of each.

Between a siphonophore and a hydroid the homology is so obvious as to be instantly recognisable. The siphonophore (woodcut, fig. 68) as well as the hydroid presents us with a colony of zooids kept in organic union with one another by means of a common connecting basis or cœnosarc; but this cœnosarc, instead of being fixed, as in the HYDROIDA, is in the SIPHONOPHORA invariably free and provided with a special apparatus for natation.

FIG. 68.

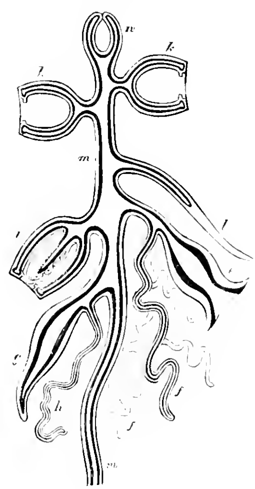


Diagram of a *Siphonophore*.

e, Polypite; *f*, tentacle of polypite; *f'*, branches given off by the tentacle; *g*, hydrocyst; *h*, tentacle of hydrocyst; *i*, generative zooid representing the phanerocodonic gonophore of a hydroid; *k*, *k*, nectocalices; *l*, bract; *m*, *m*, cœnosarc; *n*, pneumatocyst.

In consequence of the great extent to which heteromorphism is carried among the zooids composing a siphonophoral colony, we can scarcely institute a satisfactory comparison between the two orders without determining the homologies of each kind of zooid in the siphonophore. Beginning with the polypites or alimentary zooids (*e*) of the siphonophore, and comparing these with the hydranths of a hydroid, we shall find the two forms to agree in almost every point, except in the number and position of the tentacles, which in the siphonophore are reduced to a single one (*f*), springing, in all the typical siphonophores, from the base or proximal end of the polypite. The branched condition of the tentacle in the siphonophore is in no respect inconsistent with this comparison; and even if it were necessary to find a parallel to it among the HYDROIDA, we should have this in the branching tentacles of *Cladocoryne*.

The hydrocysts (*g*) of the siphonophore are plainly arrested polypites in which the mouth has never become developed.

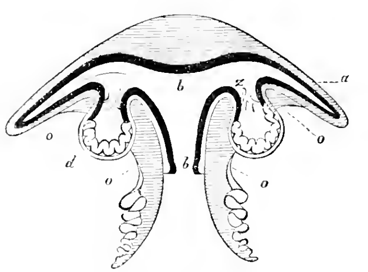
Again, the generative zooids (*i*) are exactly paralleled by those of the HYDROIDA, and are, like them, referable to two types, expressed in the HYDROIDA by the phanerocodonic and the adelocodonic gonophores, the situation of the generative elements being precisely similar in the two orders. So also the nectocalices or locomotor zooids (*k*, *k*) are essentially hydroid medusæ with specially developed umbrella, but with the manubrium suppressed and the somatic cavity reduced to the atrium, from which spring radiating canals which, exactly as in the hydroid medusæ, open round the margin into a circular canal.

The bracts or hydrophyleia (*l*) of the siphonophore are essentially cæcal offsets from the common canal of the cœnosarc, but with the ectoderm greatly developed and modified, as in the umbrella of a medusa, so as to fit them to become organs of protection for the other zooids They have thus essentially the same morphological foundation as the nectocalices, but with a different functional destination diverge widely from these, and constitute an apparatus of protection instead of locomotion.

All these zooids are kept in union with one another by a cœnosarc (*m*, *m*), which in all the typical SIPHONOPHORA is filiform, with an axial canal in free communication with the cavity of each of its appended zooids, thus corresponding essentially with the filiform tubular cœnosarc of a hydroid colony; while in the somewhat aberrant forms with fusiform or discoidal cœnosarc (*Physalidæ*, *Velellidæ*) an obvious comparison is suggested with the appressed, expanded cœnosarc of *Hydractinia*.

From the hydroid cœnosarc, indeed, that of the SIPHONOPHORA mainly differs in the absence

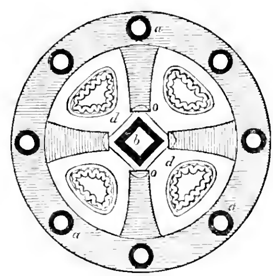
FIG. 69.



Diagramatic longitudinal section of a Discophorous Medusa.

a, Radiating canal; *b*, manubrium; *b'*, somatic cavity; *d*, generative pouches; *o*, *o*, *o*, *o*, pillar-like offsets from the oral side of the umbrella; *z*, tentacula-like appendages of the inner surface of the somatic cavity.

FIG. 70.



Diagramatic transverse section of a Discophorous Medusa.

a, *a*, *a*, Radiating canals; *b*, manubrium; *d*, *d*, generative pouches; *o*, *o*, umbrello-manubrial pillars.

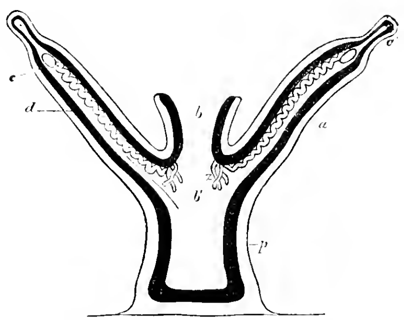
of an external chitinous sheath and in its free mode of existence, the siphonophore dwelling at large in the open sea, through which, in the great majority of the order, it is propelled by the contractions of the nectocalices. In the section *Physophoridæ* the proximal extremity of the cœnosarc, instead of forming, as in the HYDROIDA, a hydrorhiza for fixation, is modified by an inversion of its walls, so as to constitute an air-filled chamber or pneumatocyst (*n*), which acts as a float.[1]

[1] In the above comparison of the SIPHONOPHORA with the HYDROIDA, I have adopted generally the views of Huxley, who was the first to bring out in a complete form the homological relations

Continuing to take the HYDROIDA as a standard of comparison, the other hydrozoal orders may be now contrasted with them. If the atrium (woodcut, fig. 66, *b'*), or that portion of the somatic cavity which lies at the base of the manubrium in a hydroid medusa, be expanded laterally (woodcut, fig. 69, *b'*), and the ectoderm of its floor be projected along four or eight symmetrically disposed radiating lines into as many thick pillars (woodcuts, figs. 69 and 70 *o*, *o*) which converge towards the axis and there meet the manubrial extension of the cavity, while the thin intervening portions of the floor between the pillars become developed into generative pouches (*d*), and the velum or perforated diaphragm which stretches across the codonostome in the hydroid disappears, we shall have the hydroid medusa converted, in the more essential points of its structure, into a discophorous medusa (woodcuts, figs. 69 and 70).

Again, a *Lucernaria* (woodcuts, figs. 71 and 72) may be conceived of by imagining a *Hydra* with four tentacles to have these tentacles expanded laterally until their sides meet and coalesce, while the hypostome (*b*) still remains free, the proximal portion of the body continuing to form a peduncle of attachment (*p*), and generative sacs (*d*) becoming developed on each side of the partitions formed by the coalescent sides of the tentacles.

FIG. 71.



Diagramatic longitudinal section of *Lucernaria*.

a, Circumoral disc; *a'*, marginal tentacle; *b*, hypostome; *b'*, somatic cavity; *c*, aperture by which the chambers of the circumoral disc communicate with one another across the distal end of the partition; *d*, generative bands; *p*, peduncle; *z*, tentacula-like processes of the inner surface of the somatic cavity.

FIG. 72.

Diagramatic transverse section of a *Lucernaria* across the circumoral disc and hypostome.

a, *a*, Chambers of the disc; *b*, hypostome; *d*, generative bands.

Lastly, the CTENOPHORA (woodcuts, figs. 73 and 74) admit of an obvious comparison with a hydroid medusa. In order to understand this we must keep in mind the presence in the hydroid medusa of an *atrial segment* of the somatic cavity. This is formed by that portion of the somatic cavity which is immersed in the substance of the umbrella at the base of the manubrium, and from which the radiating canals proceed (see woodcut, fig. 66, *b'*). The hydroid medusa thus admits of a division by a transverse plane into two regions—an *atrial region* (*r*), which corresponds to the solid summit of the umbrella with the parts therein contained, and a *manubrial*

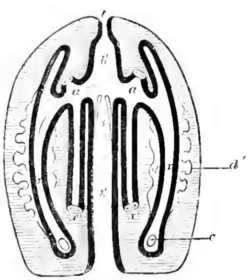
between the two groups. In referring to the parts of the SIPHONOPHORA I have also employed the terminology proposed by Huxley for this order. See his 'Oceanic Hydrozoa,' page 8, &c.

region (*r'*), which corresponds to the manubrium with that portion of the umbrella which, with its associated structures, is projected round the manubrium in the form of a bell.

Now, in a *Beroe* (woodcuts, figs. 73 and 74) the manubrial region is never developed, and the body is represented by the atrial region alone. From the atrium (*b'*, *b'*) contained within this region two radiating canals (*a*, *a*) are given off. These immediately divide and subdivide so as to become ultimately eight, which are, moreover, united at their distal extremities by a circular canal, which corresponds to that of the medusa, though here thrown back by the non-development of the manubrial region of the umbrella. Besides the eight longitudinal canals (*x*, *x*) into which the two radiating canals ultimately subdivide, these two canals give off, each immediately after its origin, an accessory canal (*x'*, *x'*) which runs without division close to the main body-cavity towards the oral orifice, and opens like the others into the circular canal.

The generative sacs (*d*, *d'*) are developed as diverticula along the course of the radiating canals, whence they extend into the gelatinous substance of the body.

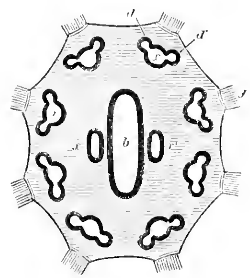
Fig. 73.



Diagramatic longitudinal section of *Beroe* in a plane at right angles to that of the compressed somatic cavity. In order to give a sufficiently comprehensive view of the structure, a few parts are here represented which are in reality somewhat removed from the plane of the section.

a, *a*, Transverse portion of the radiating canal system, two of the primary branches being shown as if cut off close to their origin; *x*, *x*, meridional portion of this system; *x'*, *x'*, deep or accessory canals, their distal terminations in the circular canal cut off; *c*, lumen of circular canal; *b'*, *b'*, somatic cavity; *t*, one of the aboral outlets of the somatic cavity; *s*, valve-like processes of the inner surface of the somatic cavity; *d*, *d'*, generative sacs, male and female.

Fig. 74.



Diagramatic transverse section of *Beroe*.

b' Somatic cavity; *x*, *x*, meridional portion of the radiating canal system; *x' x'*, deep or accessory canals; *d*, *d'*, generative sacs, male and female; *y*, vibratile lamellæ.

Leuckart[1] insisted on the association of the Ctenophora with the Actinozoa rather than with the Hydrozoa, and the same view of their affinities has been advocated by Huxley.[2] According to this conception of ctenophoral homologies, the ctenophore must be provided with a stomach-sac differentiated, as in the actinozoon, from the general body-cavity. Now, though the

[1] Frey und Leuckart, 'Beiträge,' p. 35. [2] Huxley, "Lectures," in 'Med. Times.'

somatic cavity in *Beroe* suddenly diminishes in width towards the aboral end, and is there provided with a pair of valve-like folds (*s*), so that the entire tract admits of being distinguished into two regions, it is nevertheless as continuous as in Hydra.

The advocates of the actinozoal nature of the Ctenophora see in the canal-system of a *Beroe* or a *Cydippe* the radiating chambers of an *Actinia* separated from one another by partitions of relatively enormous thickness. I do not desire to dispute the correctness of this view; we have already compared a hydroid with an actinozoon, and have seen in the radiating canals of a hydroid medusa the homologues of the radiating chambers of an Actinia; so that even though the CTENOPHORA be truly HYDROZOA, we must expect to find in them the same points of agreement with the ACTINOZOA which we have endeavoured to demonstrate for the other hydrozoal orders.

Now, the fact of the radiating canals being widely separated from the axial cavity instead of being adnate to it, is exactly the point which essentially distinguishes a hydrozoon from an actinozoon, and the fact of the intervening space being in the Ctenophore obliterated by the interposition of a voluminous gelatiniform mass does not alter this relation, for it is exactly what we find in the atrial region of an ordinary hydroid medusa, while it is distinctly expressed in the gonophore of *Clavatella* (see below, page 216), where the free or manubrial portion of the umbrella is rudimental, and the whole gonophore, apart from the marginal tentacles, becomes comparable to the atrial region of an ordinary hydroid medusa.

The two accessory canals of *Beroe* run, it is true, close upon the walls of the axial cavity until they leave these to throw themselves into the circular canal; but this fact cannot, in opposition to the greatly preponderating hydrozoal features, be used as an argument for the actinozoal nature of the CTENOPHORA.

These accessory canals are not represented in the hydroid, while the *Beroe* further differs from the hydroid in the presence of the two short aboral canals by which the aboral end of its somatic cavity communicates with the outer world (*l*), as well as in the disposition of its so-called nervous system and sense organs, and in its characteristic bands of vibratile lamellæ (*y*), all which features are among the special characteristics of the order, and in no way justify the absorption of the CTENOPHORA into the ACTINOZOA.

In this attempt to determine the true affinities of the CTENOPHORA, I have taken *Beroe* instead of *Cydippe* or other ctenophorous genus as the subject of comparison, not only because *Beroe* is a typical ctenophorous form and of comparatively simple structure, but because I have myself made its anatomy and development a subject of special study.[1]

[1] "On the Structure and Development of Beroe," 'Proc. Roy. Soc. Edinb.,' 1862.

TERATOLOGY AND PATHOLOGY.

Under this head must be included certain phenomena which, notwithstanding their abnormal character, cannot be omitted in any complete survey of the order, for they are by no means without interest in their bearing on questions connected with specific form, as well as in their relation to the general morphology and physiology of the Hydroida.

Modifications resulting from Parasitism.—One of the most remarkable of the abnormal conditions of the Hydroida is connected with a case of parasitism to which certain species are subject. Specimens of *Coryne pusilla* and of *Syncoryne eximia* may be occasionally met with having some of their branches, which under ordinary circumstances would have carried hydranths, converted into piriform sacs, in whose thickened walls endoderm and ectoderm may be still distinguished, while the whole is invested by a continuation of the external chitinous perisarc of the colony (woodcut, fig. 75).

The sac (*a*, *b*) communicates freely with the somatic cavity of the hydroid, and admits into it the general contents of this cavity. In every case there is also included in it a living animal, which, instead of having any direct relation with the hydroid, belongs to an entirely different and far more elevated group of the animal kingdom.

The transformed branch of the hydroid has, in fact, become the abode of a pychnogonidan, which lives in it at the expense of the fostering animal, and which may be followed through various stages of its development, from the embryo as it leaves the egg to that stage in which it has almost attained its adult form.[1]

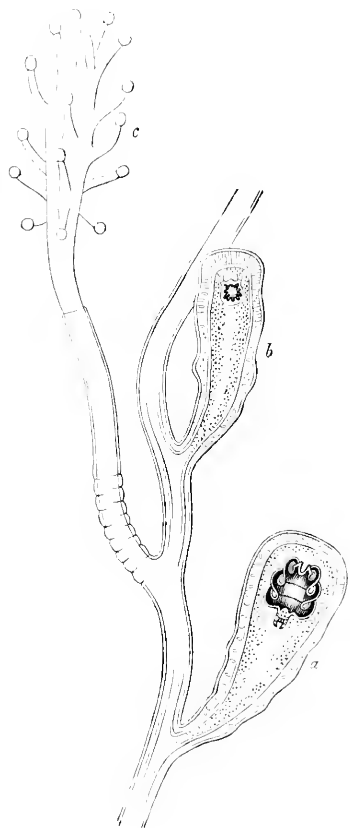
[1] Two stages of the development are represented in the accompanying figure (woodcut, fig. 75). In the earlier (*b*) a pair of pincer-bearing cephalic appendages ("pates-mâchoires," Milne-Edwards) is greatly developed. These appendages stand out free from the body, on which no true legs are at first visible. A closer inspection, however, shows three pairs of legs bent upon themselves and closely appressed to the body, and all included within a common external membrane. Offsets have already begun to bulge out from the stomach; three of these on each side have penetrated the bases of the legs, while two others extend towards the bases of the cephalic appendages. The rostrum is as yet but slightly developed.

In the more advanced stage (*a*) the three pairs of legs have freed themselves from the investing membrane and have become fully developed, while the offsets from the stomach may be followed into the penultimate joints. The anterior offsets have not advanced beyond the bases of the cephalic appendages. The rudiments of the fourth pair of legs may be seen in the form of unjointed hollow processes, one on either side of the rudimentary abdomen. Both the stomach and its offsets are of a deep red colour.

It is in this stage that the pychnogonidan leaves the hydroid, by making its way through the walls of the sac. Its further development takes place during its free life in the surrounding water.

The pychnogonidan which thus infests the *Syncoryne eximia*, and probably also that of other *Corynidæ*, appears to be the *Phoxichilidium coccineum* of Johnston. There can, I think, be little doubt that the eggs of the parent *Phoxichilidium* are swallowed by some of the hydranths of the colony, and thus reach the somatic cavity, from which they gain access to the interior of a young bud, which, under ordinary circumstances, would have become a hydranth-bearing branch, but which now becomes arrested by the developing parasite, and changed into a receptacle for its protection, in a way which strongly reminds us of the production of galls in the vegetable kingdom. In no case were more than a single individual found tenanting the infested branch.[1]

FIG. 75.



A portion of a colony of *Syncoryne eximia* infested by *Phoxichilidium coccineum.*

a, A ramulus of the hydroid transformed into a sac by the presence of the parasite, which has here reached the stage at which it is ready to escape into the surrounding water; *b*, a ramulus, with the contained parasite at a much earlier stage; *c*, a normal hydranth of the *Syncoryne*.

It is not alone, however, species of *Coryne* or of *Syncoryne* which are thus subject to the attacks of a parasitical pychnogonidan. Gegenbaur, as we have just said (see note to preceding paragraph) has noticed it in *Eudendrium ramosum*, while *Hydractinia echinata* may occasionally

[1] The occurrence of this remarkable form of parasitism, which presents the unusual feature of the parasite belonging to a higher group than the animal infested, was first noticed by me, in 1857, at the meeting of the British Association for the Advancement of Science, held in that year.

A similar case has since been described, in considerable detail, by Mr. Hodge, who has found *Syncoryne eximia* infested in this way, and has recognised in the parasite the *Phoxichilidium coccineum* (see 'Ann. Nat. Hist.,' 3rd ser. vol. ix, p. 33, pl. iv and v).

The first, however, to notice the liability of a hydroid to become the abode of a parasitical pychnogonidan was Gegenbaur, who observed the hydranths of *Eudendrium ramosum* frequently changed in form, by becoming greatly enlarged, and by the reduction of their tentacles to short tubercles. Here the transformed hydranth was found to be tenanted by a brood of developing pychnogonidans (see Gegenbaur, 'Generationswechsel,' p. 38, note).

be seen to be similarly affected. In this hydroid the infested hydranths become converted into large oval sacs, each enclosing numerous individuals of a pychnogonidan in various stages of development. The parasite appears to be here of a different species from that of the *Syncoryne*, but I have not followed it to a sufficiently mature stage to enable me to determine it.

The infested and transformed hydranths of *Hydractinia* may be seen associated with other perfectly normal ones in the same colony. Their transformation will be found in various stages of completeness, some still possessing short stunted tentacles, while in others the tentacles will have entirely disappeared. The parasite is here, as in the case already described, most likely introduced in the state of egg by being swallowed either by the infested hydranth or by some other hydranth of the colony.

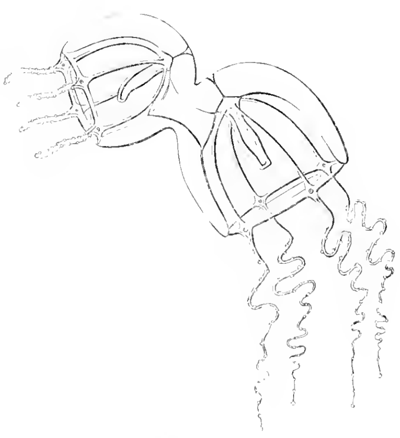
Dr. Strethill Wright was the first to notice the liability of *Hydractinia* to the parasitical attack of a pychnogonidan,[1] and his statements are fully borne out by my own observations.

The misshapen club-like branches which Van Beneden figures in his *Eudendrium* (*Bougainvillia*) *ramosum*[2] originate most probably in a similar case of parasitism.

Other abnormal conditions.—Besides the changes of form dependent on parasitism there are others by no means destitute of morphological and physiological interest.

While examining the medusæ which had been thrown off from a colony of *Syncoryne pulchella* in one of my jars, I was struck by observing two of these medusæ united to one another by a small space on the convex surface of their umbrellas, at a short distance from the summit (woodcut, fig. 76). One of the united medusæ was a little smaller than the other; but otherwise they were both equally developed, and presented the ordinary condition of these zooids at the time of their liberation from the trophosome. The cavities of the two umbrellæ freely communicated with one another through the surface of junction.

Fig. 76.



Conjoined twin medusæ, developed from a specimen of *Syncoryne pulchella*.

That neither of the medusæ thus so intimately united had been produced by a bud from the other was evident; for the original point of union with the trophosome, as well as the remains of the canal, by which the cavity of the manubrium had at one time communicated with the somatic cavity of the trophosome, were still distinct in each, while these facts are also opposed to the view which would regard the twin medusæ as representing a single one in the process of self-division.

[1] 'Proc. Roy. Physical Soc. Edinburgh,' November, 1861.

[2] 'L'Embryogénie des Tubulaires.'

The only explanation which it seems possible to suggest is, that in the twin medusæ we have a case of accidental adhesion contracted between two neighbouring buds while still connected with the trophosome, this adhesion having been followed by a free communication between the two umbrella cavities. I never met with more than a single example, and, whatever explanation we may be disposed to offer as to its origin, it seems evident that it cannot be regarded as otherwise than abnormal.

The other case to which I would here wish to draw attention consists in a change of form observed also in medusæ of *Syncoryne pulchella*, which had been thrown off from trophosomes confined in my jars. In none of these medusæ, though they had remained under observation for nearly a month, had any development of generative elements taken place, but they had all undergone a very remarkable change.

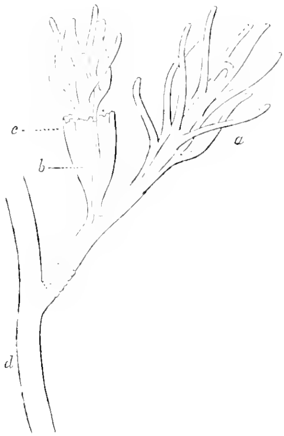
The commencement of this change might have been noticed a few days after their liberation. The umbrella became everted, and then began to diminish in size, contracting from its margin towards its summit, until in a few days it had almost entirely disappeared, being then merely represented by a thick disc of a somewhat quadrangular form, which projected round the base of the manubrium. Each of the four angles of this disc was continued into one of the marginal tentacles, whose proximal end, following the contraction of the umbrella, had been thus brought upon a level with the base of the manubrium. The interior of the disc was occupied by a cavity which communicated freely with that of the manubrium, and with that of each of the four tentacles which extended from its angles. With the contraction of the umbrella the circular canal and velum had disappeared, and the radiating canals were now represented solely by the short channels by which the interior of the hollow disc communicated through the thickness of its walls with the tubes of the tentacles. Neither tentacles nor manubrium had undergone any material change; the former retained their full power of extension and retraction, and the latter all its original irritability—moving from side to side, lengthening and shortening itself, opening and closing its mouth with at least as much vigour as before the disappearance of the umbrella. The medusa in this condition reminded us strongly of the gonophore of *Clavatella*, though the degradation of the umbrella was more complete than in the latter. The medusa had, in fact, become changed by a retrograde metamorphosis into a hydranth.

Changes had been noticed also by Dujardin in the medusa of his *Syncoryne decipiens;* but he had not followed them beyond an eversion of the umbrella, which is probably the commencement of the changes resulting in the disappearance of this part of the structure.

Notwithstanding the very striking character of the changes now described, and their resemblance to a normal metamorphosis, I cannot see in them anything more than a degradation of structure resulting from imperfect nutrition—a mere forerunner of complete disintegration and death. They are, however, most instructive in their bearing upon the homologies between the medusa and the hydranth, and completely support the view that the radiating canals of the medusæ are the homologies of the channels by which the gastric cavity of the hydranth is continued through the thickness of its walls into the interior of the tentacles, which will then represent those marginal tentacles of the medusa which constitute the continuations of its radiating canals.

Colonies of *Hydractinia echinata* may occasionally be met with in which certain hydranths have become bifurcated at some distance from the base, each branch of the bifurcation carrying a mouth and tentacles like those of the ordinary hydranths. Agassiz has described an occasional bifurcation of the spiral zooids of his *Hydractinia polyclina*, and Hincks has figured a bifurcating zooid of *Hydractinia echinata* in which one branch of the bifurcation carries tentacles and possesses all the characters of an ordinary hydroid, while the other is indistinguishable from a blastostyle though no gonophores are developed from it. I have myself seen the spiral zooids of *Hydractinina echinata* depart from their normal condition by developing tentacles on their distal extremities.

Fig. 77.



A portion of a colony of *Cordylophora lacustris*, showing the transformation of a spadix into a hydranth.

a, A normal hydranth; *b*, the spadix of a gonophore transformed into a hydranth after the discharge of the generative elements from the gonophore; *c*, the remains of the external thin chitinous investment of the gonophore; *d*, main branch.

In *Cordylophora lacustris* an abnormal phenomenon, full of interest, may sometimes be seen. This consists in the conversion of the spadix, after the discharge of the generative products from the gonophore, into a true hydranth (woodcut, fig. 77). The spadix in this case, after it has performed its function as a part of the gonosome, elongates itself (*b*), differentiates an ectoderm, and developes upon its extremity a mouth and tentacles.

The conversion of the entire gonophore into a hydranth in *Rhizogeton fusiformis* is described by Agassiz,[1] who regards it as a normal feature in the hydroid. In this view, however, I cannot concur. I am quite of opinion that the phenomenon which Agassiz regards as normal is not so, and that it is one of the same class as that just described in *Cordylophora*.

[1] 'Cont. Nat. Hist. U.S.,' vol. iv, p. 126, pl. xx, fig. 22.

ANATOMY OF SPECIAL FORMS.

THE following are some special studies of hydroid anatomy which I have deemed it right to bring together in this place, in order to render more complete the general exposition of the HYDROIDA attempted in the present work. They have been selected so as to afford examples of the more important morphological variations met with among the gymnoblastic forms—such, at least, as I have had an opportunity of studying. Each includes the anatomy of a species which may be taken as the type of some generic group.

TUBULARIA INDIVISA.

Plates XX and XXIII.

This beautiful and by no means uncommon hydroid, one of the largest and most interesting of the entire order, presents clusters of unbranched stems which spring from a creeping, tubular, branching and anastomosing stolon, attaining a height of many inches and a thickness of about a tenth of an inch, and carrying each a hydranth on its summit.

The Hydrophyton.—The entire hydrophyton is invested by a firm chitinous perisarc, in the older parts of which layers of deposition may be detected. The cœnosarc is closely embraced by the perisarc except in that part of the stem which lies immediately below the hydranth, thus differing from the majority of the HYDROIDA, in which the cœnosarc for the greater part of its course is separated by a considerable interval from the surrounding perisarc, with which its connection is maintained only by irregular transverse processes of the ectoderm, which here and there stretch across the interval from the one to the other. In the present species, however, as well as in the *Tubulariæ* generally, it is only for a short distance below the hydranth that the cœnosarc has withdrawn itself from contact with the surrounding perisarc which here forms a thin membranous sheath with large irregular annulations (Pl. XX, fig. 2).

By means of a carefully made transverse section of the stem the structure of the cœnosarc may be rendered apparent. If the section be made in any part of the course of the stem except immediately below the hydranth, a very remarkable structure will be brought into view (Pl. XXIII, fig. 7). The endoderm will be here seen to consist of two distinct portions, a peripheral and an axial. The axial portion (*d*) consists of large cells with clear colourless contents, and occupies as if with a sort of pith the entire axis of the section, which is quite destitute of an axial somatic cavity. The peripheral portion (*c*) is composed of small spherical cells filled with coloured granules. In this portion numerous empty spaces may be seen; they are somewhat wedge-shaped in section, and are arranged at rather regular intervals in a zone concentric with the circumference of the stem. They are richly ciliated on their sides with very distinct, long, actively vibrating cilia. They are of unequal size, one of them especially being in almost every instance considerably larger than any of the others. They are simple *lacunæ*, and represent the transverse section of a system of longitudinal canals which are excavated in the peripheral portion of the endoderm, and which take the place of the axial somatic cavity of other hydroids. Their presence is indicated even to the naked eye by longitudinal bands, which are visible through the transparent perisarc in the uninjured condition of the stem.

By following these canals through the stem they will be seen to communicate occasionally with one another by short transverse channels, while towards the summit of the stem they coalesce into a common chamber which occupies the axis.

Surrounding the peripheral portion of the endoderm is the zone of ectoderm (*b*). It lies in immediate contact with it, there being here no intervening zone of fibrillated tissue. In the ectoderm no distinctly cellular structure can be demonstrated; only some granules and nucleus-like bodies may be seen scattered through a common plasma in which numerous thread-cells are also imbedded—a structure, however, which indicates a true cellular composition at an earlier period of development.

On the outside of the ectoderm and in close contact with it is the chitinous perisarc (*a*), showing no structure beyond that of concentric laminæ of deposition.

When a living and uninjured specimen of *Tubularia indivisa* is examined under a moderate magnifying power active currents may often be witnessed in the channels of the endoderm. These take a course sometimes from the proximal towards the distal end of the stem, sometimes from the distal towards the proximal, while two currents may often be seen running in opposite directions in two different channels at the same time. They are plainly under the influence of the vibratile cilia which clothe the walls of the canals.

The Hydranth.—The hydranth (Pl. XX, fig. 2) is flask-shaped, with two circlets of tentacles, a proximal and a distal. The tentacles of the distal circlet surround the base of a conical hypostome; they are much smaller than those of the proximal; they slightly alternate with one another and appear to consist of two closely approximated verticils. Their ectoderm (Pl. XXIII, fig. 4) is loaded with thread-cells, but no distinct cellular structure can be detected in it. It is separated from the endoderm by an intervening fibrillated layer. The endoderm consists of large cells, each of which stretches transversely across the tentacle, leaving no pervious canal in the axis, and conferring on the tentacle the characteristic septate condition of this part. These endodermal cells contain a clear colourless fluid and present along the line of the axis accumulations of protoplasm with coloured granules. The tentacle is eminently contractile.

The tentacles of the proximal set are much larger and thicker than those of the distal, and their contractility is much less marked. They are disposed in a single continuous verticil. Their ectoderm is similar to that of the distal tentacles, but their endoderm, instead of consisting of large transversely arranged cells, is formed of smaller cells rendered polygonal by mutual pressure, and presenting the condition of a pith-like tissue by which the tentacle is filled to the complete exclusion of all trace of an axile tube. These cells contain a clear colourless fluid, with protoplasm enveloping some more opaque corpuscles and accumulated in a layer on the cell-wall.

Between the ectoderm and endoderm of the tentacle there exists a fibrillated tissue (Pl. XXIII, fig. 5). I have succeeded in isolating this tissue and its component fibrillæ in the tentacles of a specimen which had been long preserved in spirits. Two sets of striæ, a longitudinal and a transverse were visible in the interval between ectoderm and endoderm. Of these the longitudinal striæ were the more distinct and were manifestly the expression of longitudinal fibrillæ. On tearing the tentacle these fibrillæ might sometimes be isolated, when they were seen to be tubular, with a diameter of about $\frac{1}{5000}$ of an inch. They are perfectly smooth, but in many cases a very distinct oval nucleus, having a shorter diameter of about $\frac{1}{7500}$ of an inch and with a brilliant nucleolus, was visible in them. They might occasionally be seen to taper away to a point, and I have little doubt of their being greatly elongated fusiform cells (fig. 6). The transverse striæ may also represent a fibrillated layer, but I am by no means so certain of this, and yet I can scarcely regard them as rugæ resulting from the contraction of the tentacle.

In longitudinal section (Pl. XXIII, fig. 1) the hydranth is seen to contain a capacious cavity. A little within the mouth the endoderm is thrown into prominent patches of a bright carmine colour, with intervening paler furrows. Passing downwards from the mouth the carmine-coloured patches are replaced by smaller spots; still further down these become resolved into minute puncta, which at the base of the hydranth-cavity are arranged in radiating striæ.

A little above the origin of the posterior tentacles the endoderm sends off a zone of pendulous fusiform lobes (Pl. XXIII, fig. 1, *c*, and figs. 2 and 3). These lobes are composed of large cells containing carmine-coloured granules, among which may be seen several clear spherules, apparently oil-drops (fig. 3).

The Gonophores.—The gonophores form pendulous raceme-like clusters, which spring from the body of the hydranth immediately within the proximal zone of tentacles (Pl. XX, figs. 2 and 3). They are adelocodonic, and are in the form of oval sacs borne on the summits of short peduncles, which are given off alternately from a common tubular stalk whose cavity directly communicates with that of the hydranth. In each raceme the gonophores increase in maturity as they recede from the base of the common peduncle. The racemes thus differ from the inflorescence, which the botanist designates by this term, in being centrifugal instead of centripetal in their evolution (see above, p. 108).

In the walls of the gonophores three layers may be distinguished—an external (ectotheca, Pl. XXIII, figs. 8 and 11, *a*), a middle (mesotheca, *b*), and an internal (endotheca, *e*). The ectotheca is perforated by an aperture in a point which is more or less diametrically opposite to the point of attachment of the peduncle; abundance of thread-cells are imbedded in it. The mesotheca is rendered obvious by the presence in it of four radiating canals (*c*), which extend from the proximal towards the distal end of the gonophore, where they become united by short transverse branches, forming a circular canal, which surrounds an aperture (*d*) in the mesotheca exactly corresponding to that of the ectotheca; where the radiating canals enter the circular canal they become dilated into small bulb-like expansions, containing accumulations of coloured granules. The endotheca in the female gonophore (fig. 11) disappears at an early period, apparently under the pressure of the increasing mass of the generative plasma which is formed within it, though it continues longer as a distinct membrane in the male (fig. 8).

Occupying the axis of the gonophore is the large club-shaped spadix surrounded by the generative mass (*f*). It consists of a hollow process of endoderm, whose lining cells are filled with carmine-coloured granules and have their free surfaces clothed with vibratile cilia (fig. 10). The radiating canals spring from the base of the spadix, where they communicate with its cavity.

The spadix in a very early stage is invested by a layer of ectoderm, but the generative elements soon make their appearance between the endodermal and ectodermal layers, which thus become separated from one another, and the ectoderm becomes an endotheca.

The generative mass in the female (fig. 11, *f*) constitutes a cellular plasma, into which the spadix is plunged and from which portions are successively detached. These detached portions (*g*) lie loose in the cavity of the gonophore after the disappearance of the endotheca. They consist of a mass of clear spherical cells, many having within them a brood of secondary cells (fig. 12). They become developed into embryos, and though I have never succeeded in detecting in them a germinal vesicle or witnessed in them the phenomenon of yolk-cleavage, they must, for reasons stated in a former part of this work (see p. 90, &c.), be regarded as true ova in various stages of development.

As already mentioned, the ovum becomes developed, not into a ciliated planula, but into an actinula. The various stages of this development and the structure of the actinula are represented in figs. 13—16, and have been already fully described (see above, p. 90, &c.).

In the male the spermatogenous tissue also forms a mass (fig. 8, *f*) into the midst of which the spadix is plunged. It is produced, like the generative mass in the female, between the endoderm and ectoderm of the central process, so that the ectoderm becomes separated as an endotheca (*e*), which continues longer apparent than in the female. As the spermatogenous mass approaches maturity it presents the appearance of radiating striæ, and after the rupture of the endotheca the free spermatozoa escape as active caudate corpuscles (fig. 9) through the aperture of the gonophore.

Corymorpha nutans.

Plate XIX.

This beautiful hydroid is eminently conspicuous by the great size of the solitary hydranth with its dense clusters of medusæ, and by the thick fleshy stem destitute of that firm chitinous perisarc which forms a strong protective covering for others, while in its internal structure it is further distinguished by well-marked and peculiar features. Whether our attention be directed to its trophosome or to its gonosome, we cannot fail to recognise in *Corymorpha* a special conformation which marks it out as a very distinct hydroid type among its co-ordinal associates.

The Hydrophyton.—The hydrocaulus (figs. 1, 2), which is always solitary, attains a height of from two to three inches, while it varies in thickness from its distal to its proximal end, usually attaining, in its thickest part, which is situated a little above its attached extremity, a diameter of about two lines, and thence rapidly tapering downwards to a blunt point, which is plunged into the sandy sea-bottom. The hydrocaulus is here a little above its proximal extremity bent nearly at right angles on itself. The place of the perisarc is taken on it by an exceedingly thin colourless and structureless film, which without careful examination would quite escape detection, except towards the proximal extremity, where it is separated by a considerable interval from the ectoderm of the stem, and thus becomes at this part sufficiently obvious.

Towards the proximal extremity fleshy conical processes are developed from the sides of the stem in longitudinal rows (fig. 1, *a*), while still lower down the stem gives off all round great numbers of very much attenuated and elongated filaments (*b*, *b*).

Even by the naked eye the stem will be seen to be traversed from end to end by longitudinal bands. Under a low magnifying power these bands are found to inosculate with one another here and there, while towards the base of the stem they become fewer and broader by coalescence. They represent canals excavated in the endoderm of the stem, and in a transverse section of the stem (fig. 5) these canals may be seen to lie just within the ectoderm. The peripheral portion (*d*) of the endoderm in which they are excavated is composed of small spherical cells filled with reddish granules, which give to the stem its pale reddish tinge, while the whole of the axis (*e*) of the stem is occupied by a sort of pith, composed of large cells with colourless contents. Very distinct currents may occasionally, by means of the microscope, be witnessed in the canals, so that the structure and phenomena presented by these parts closely correspond to what we meet with in the stems of *Tubularia indivisa*.

Under a high power of the microscope delicate parallel longitudinal striæ may be detected lying external to the canals. They may be traced upwards for some distance on the body of the hydranth. They lie between the endoderm and ectoderm, and represent a fibrillated muscular tissue.

The peculiar short conical papillæ (fig. 1, *a*) which are given off from the stem near its proximal end are arranged in regular longitudinal series, which follow the course of the canals, the stem immediately over each canal bearing two alternate rows. They are tubular, with the cavity of the tube apparently communicating with the canal over which they lie, and with their free extremities blunt and imperforate (figs. 10, 11). They appear to be extensile, and one or more of them may occasionally be seen to be much elongated, and then with their extremities slightly clavate (fig. 10).

These tubular processes have never been seen to act as organs of adhesion, nor have we yet any evidence of the office they may serve in the economy of the animal, but it is impossible not to recognise in them structures having a close relation to the filaments of attachment which are given off from the stem a little lower down.

These filaments (fig. 1, *b*, *b*) constitute a remarkable feature in the structure of the *Corymorpha*. When the hydroid is examined shortly after its detachment from the sea-bottom no trace of them may be discoverable; but after resting for a few hours in our aquaria the filaments become developed in great numbers from the whole of that part of the stem which lies below the papilliform processes, passing outwards through the fine structureless pellicle which here loosely invests the extremity of the stem. They now rapidly extend themselves, adhering closely to the sides of the aquarium and by repeatedly crossing one another form an entangled web-like tissue, by which the *Corymorpha* has become attached. It is almost certain that such filaments existed also before the removal of the hydroid from its native bed, but that in the act of detachment they were torn off, to be renewed when an opportunity may be afforded, as in the confinement of the aquarium.

Under the microscope the filaments are found to be tubular, terminating each in an imperforate clavate extremity. They consist of a granular substance, which, as it continues to elongate itself, becomes invested with a perfectly transparent, structureless film of extreme tenuity.

Besides these capillary filaments of adhesion there is nothing which can be regarded as a hydrorhiza, and it would seem that the chief support of the hydroid, when in its natural condition, is afforded by the proximal end of the hydrocaulus, which is then plunged into the sand of the sea-bed, and thus fixes the hydroid to its place.

The Hydranth.—The hydranth (fig. 1) may be described as flask-shaped. It bears, towards its base, a zone of long, imperfectly contractile tentacles, arranged in a single series, while at a considerable interval in front of this zone, and a little below the mouth, is a brush-like group of about eighty very contractile tentacles, much smaller than the proximal ones, and arranged in six or seven closely placed alternate verticils.

When a longitudinal section (fig. 7) is made through the hydranth from the mouth to the stem, it will be seen that the body, as far back as the zone of proximal tentacles, presents a continuous cavity (*a*) lined by small spherical cells containing coloured granules. The floor of this cavity projects into it in the form of a broad conical elevation. This conical projection consists beneath its covering of small pigment-bearing cells, of a large-celled and clear-celled endoderm (*e*), and the same tissue is continued backwards as far as the summit of the stem. A careful examination will show that this cellular mass, which frequently seems to fill up the proximal part of the hydranth, is perforated in its axis by a tubular prolongation of the cavity of the distal part, though, in consequence of temporary obliteration caused by the approximation of its walls, this axial tube is usually difficult to detect. Like the cavity of the distal portion of the hydranth, it is lined with small spherical cells (*f*) filled with coloured granules. It is continued towards the summit of the stem, and then, becoming wider (*b*), receives the longitudinal canals (*c*), which have been already described as traversing the stem in its entire length.

The tentacles forming the proximal zone are destitute of any trace of a cavity (fig. 8), and consist of a simple extension, with little change of form, of the large-celled colourless endoderm of the body, surrounded by a layer of ectoderm. The distal tentacles seem to admit the cavity of the hydranth for a short distance into their interior, but the tube soon becomes obliterated, its axis at the same time assuming the usual septate appearance (fig. 9).

The same difference of structure between the proximal and distal sets of tentacles exists here as in *Tubularia*, and I regard the distal set in both cases as the true equivalents of the tentacles in *Eudendrium*, *Coryne*, &c., while the proximal set must be viewed as superadded structures.

In fully developed specimens the hydranth measures about one inch across the proximal or posterior coronal of tentacles. The colour of the brownish-red contents of the cells which line its cavity is visible through the transparent ectoderm as far back as the proximal zone of tentacles. Similarly coloured granules exist in the stalks of the gonophores, from which they may be traced into the manubrium of the medusa, and, while this is still young, into its radiating canals. The whole of that portion of the hydranth which lies behind the long tentacles is nearly colourless, the pigment-containing cells being here obscured by the thickness of the colourless layer of endoderm which lies external to them.

The Gonophores.—The gonophores (figs. 1, 3, 4, 5, 5[a]) are grouped in crowded clusters on the extremities of branched tubular stalks which form their peduncles. The axis of these peduncles is occupied by a continuous tube, which communicates freely with the cavity of the hydranth. They are usually from fifteen to twenty in number, and are situated immediately within the zone of proximal tentacles in two alternating series (fig. 1 and fig. 7, *i*).

I have not been able to demonstrate in the gonophores any trace of an ectotheca, and must therefore regard them as truly naked. They are planoblasts, and when arrived at that stage in which they are about to detach themselves from the stalk and become free (figs. 3, 4), they present a deep umbrella, having its summit continued into a short conical projection traversed by a narrow canal, which had kept the cavity of the manubrium in connection with that of the stalk. There are four radiating canals, each of which expands into a bulb at the point where it enters the circular canal. Of these bulbs one is much larger than any of the others, and is continued into a tentacle, while none of the others present any trace of such an appendage. They all contain brownish-red pigment-granules, but no true ocellus can be recognised. There is a broad velum.

The solitary tentacle is largely developed, and consists of a very extensile moniliform cord, presenting, when extended, the appearance of ten or twelve little spherules distributed at equal distances upon a cylindrical string. The last of these spherules exactly terminates the string, and is larger than the others, while one or two situated near the proximal end are smaller and less distinct. The spherules are composed of accumulations of thread-cells, and the connecting cord has its axis occupied by an uninterrupted tube directly prolonged from the cavity of the bulb at its root. During contraction the spherules assume the form of circular discs (fig. 4), and in extreme contraction the connecting cord disappears and the surfaces of the discs are brought into contact.

The manubrium is large and sub-cylindrical, and the mouth is without tentacula or lobes.

From the above description it will be at once apparent that the medusa of *Corymorpha nutans* belongs to a form to which Edward Forbes has given the generic name of *Steenstrupia*.[1] Of this relation between *Steenstrupia* and *Corymorpha* Forbes himself had a suspicion; indeed, he expresses a belief that his *Steenstrupia rubra* will turn out to be the free medusa of *Corymorpha nutans*. The development of the medusa from its first appearance to its liberation has been already traced (see above, p. 77).

The medusæ when they become free are about $\frac{1}{5}$ inch in diameter (fig. 2), and as yet show no trace of generative elements, and though I kept them alive for more than a week they scarcely increased in size, and never presented any indication of ova or spermatozoa.

I obtained, however, by means of the towing-net, in the neighbourhood of the locality which produced the *Corymorpha*, a little medusa (figs. 5, 5^a) regarding which there can be no doubt that it is a more advanced stage of the gonophore of *Corymorpha nutans*. It was about four times the size of the newly liberated medusa; the tentacle had proportionately increased in length and now presented upwards of forty spherules, while the radiating canals at their origin from the manubrium curved upwards towards the summit more decidedly than in the younger form. The generative elements—not yet, however, fully developed, and apparently male, though from their immature condition no active spermatozoa could be detected—were very distinctly visible as a pale yellow mass between the endoderm and ectoderm of the manubrium, which was rendered tumid by their presence (fig. 5). In all other respects the little medusa was identical with the younger ones, and continued to present the acuminated summit, which was even still traversed by the canal which originally maintained a communication between the tube of the supporting stalk and the cavity of the manubrium.

It would thus seem that the changes undergone by the medusa between the time of its liberation from the trophosome and its attainment of sexual maturity are of little importance. It is worthy of especial attention that there is never more than a single marginal tentacle developed.

Free Frustules.—But besides the production of medusiform sexual buds, I have also witnessed in *Corymorpha nutans* another process of reproduction, very remarkable, but of whose exact significance I was unable at the time to speak with as much confidence as I can now do. In a glass jar containing living specimens of *Corymorpha*, which had been in my possession for more than a fortnight, I observed attached here and there to the surface of the glass minute oblong bodies

[1] Forbes, 'British Naked-eyed Medusæ,' p. 72.

(fig. 12), about half a line in their longer diameter and one eighth of a line in the shorter. They appeared to be composed of a soft, minutely granular, colourless substance, and their interior was occupied by a very distinct cavity. They were destitute of cilia, and were invested by an extremely delicate membranous or mucous tube, quite structureless, which extended for some distance beyond their ends and adhered for its whole length to the side of the jar.

Besides these little bodies others (fig. 13), which I do not hesitate to regard as the same bodies in a more advanced stage, were also found attached to the sides of the jar. They consisted of a colourless tubular filament, about four lines in length, attached to the glass by one extremity and developed at the opposite into a minute hydranth, having a general resemblance to the hydranth of *Corymorpha*, but with only six or eight tentacles in the proximal circlet, while the distal circlet was also composed of six or eight tentacles, which were shorter than the proximal ones, with blunt, almost capitate extremities, and, like the proximal tentacles, disposed in a single verticil.

Others (fig. 14) representing a still more advanced stage were also found attached to the sides of the jar. They had attained a size about double that of the last, while the posterior tentacles now presented a verticil of sixteen or twenty, and the anterior ones, though still disposed in a single verticil, had become multiplied to about the same extent.

Beyond these three stages I was unable to trace the development through any further steps. The last of them, however, manifestly requires little to convert it into the form of the adult *Corymorpha*.

If it were not that the medusæ thrown off from the adult hydroids in my jars had, so far as I could find, all perished before the formation in them of generative elements, I should have regarded the little organisms just described as presenting three stages in the development of the embryo from the ovum. In the absence, however, of all evidence of the presence of ova, we must seek for some other explanation of these little bodies. The phenomena of spontaneous fission, already described as occurring in a campanularian (see above, p. 152, woodcut, fig 61), will here afford a clue, and the close resemblance of these enigmatical bodies to the fission frustules of the campanularian will suggest the probability that they represent different stages in the development of fragments which had been spontaneously detached from some of the filamentary processes emitted from the proximal end of the adult specimens in the jar.

Clavatella prolifera.

Plate XVIII.

Clavatella prolifera, though of small size, is unrivalled in the elegance of its form, while its wonderful ambulatory medusæ present a combination of characters which, if we except the closely allied *Eleutheria* of De Quatrefages, is quite unparalleled among hydroid planoblasts.

The Hydrophyton.—In this remarkable little hydroid the hydrocaulus is rudimental, having for its sole representative very short simple processes (fig. 1), which are given off at intervals from a creeping filiform hydrorhiza, and which carry each a hydranth on its summit. These processes as well as the hydrorhiza are invested by a delicate perisarc.

The Hydranth.—The hydranth is well developed, and when extended is of an elongated, nearly cylindrical form, abruptly dilated at its base and carrying on its distal extremity a single verticil of from six to eight capitate tentacles round the base of a short conical hypostome. It is very contractile, and in extreme contraction assumes a short, thick, flask-shaped form. During contraction the body is seen to be marked by fine, regular, closely set transverse rugæ.

A longitudinally fibrillated layer can be distinctly demonstrated beneath the ectoderm on the body of the hydranth, through the entire length of which it may be traced (fig. 11). The endoderm presents a peripheral layer of large cells with clear colourless contents, and an axial layer which lines the somatic cavity and is composed of much smaller cells containing coloured granules. In the ectoderm no distinct cellular structure can be demonstrated, but it contains numerous thread-cells imbedded in it.

The tentacles (fig. 3) present the usual septate condition. The spaces included between the septa have their axes occupied by an accumulation of granular protoplasm, often looking like a continuous axile column running through the whole length of the tentacle. The capitulum in which the tentacle terminates is very well marked, and is loaded with large thread-cells.

The Gonophores.—The gonophores (fig. 1 and figs. 4—10) are borne on one or two short-branched tubular peduncles, which spring from the hydranth at the spot where the basal dilatation is seen in the extended hydranth to pass into the narrower, more distal portion of the body. When two of the branched peduncles are present they are situated upon opposite points of the body. There are generally two or three gonophores, in various stages of development, in a cluster, each being borne on the extremity of one of the branches of the peduncle, whose tube communicates freely on one side with the digestive cavity of the gonophore, and on the other with that of the hydranth.

The fully formed gonophore (fig. 4) is medusiform, but yet singularly exceptional among medusæ, for its umbrella is never developed into a swimming-bell, and locomotion is performed by peculiarly constructed marginal tentacles, on which this strange ambulatory planoblast is capable of creeping about from place to place.

The gonophore is dome-shaped, and when viewed from its dorsal aspect under the carefully regulated action of the compressorium, it will be seen to be occupied by a large central cavity, from the circumference of which six short but wide tubes radiate at equal intervals towards the margin of the dome, where they meet a wide circular canal, which runs parallel to this margin and close to it (figs. 4, 5).

At points corresponding to those at which the radiating canals meet the circular the margin is extended into six long tentacles, each of which divides into two branches at some distance beyond its middle. The two branches are situated in a radial plane, so that one is internal or looks towards the axis of the medusa, the other external or directed away from the axis. The external branch terminates in a capitulum of thread-cells, the internal one in a slightly swollen extremity, which carries a minute suctorial disc (fig. 7). The endoderm of the tentacle and of its branches is large-celled, giving to them a somewhat septate appearance; but the axis is pervious, being traversed by a tubular prolongation of the circular marginal canal.

In the centre of the under surface of the dome-shaped disc is the quadrangular aperture of the mouth, sometimes scarcely raised above the general surface, and sometimes elevated on a prominent conical projection. It is entirely destitute of lobes and of tentacular appendages.

On the outer side of the base of every tentacle is a very distinct ocellus, consisting of a heap of red pigment-granules, in which a clear refracting spherule may sometimes be seen to be immersed, and over which a transparent, slightly elevated extension of the ectoderm may be traced (figs. 4, 6). Though I found the refracting lens-like body occasionally very conspicuous, it was frequently impossible to discover it, and it seems to be very soft and easily broken down in the mass of the pigment. This will probably explain the fact that while it was detected by Quatrefages, Krohn, and Claparede in the *Eleutheria-* and *Clavatella*-medusæ described by them, it eluded the attempts of Hincks to discover it. The correctness of Quatrefages' statement of the evidence of a cornea in the ocellus of *Eleutheria* is disputed by Krohn; my own observation, however, of a convex extension of the transparent ectoderm over the surface of the ocellus in *Clavatella* tends, on the other hand, to confirm it.

Just above the base of the tentacles the medusa is encircled by a zone of thread-cells imbedded in the ectoderm.

I have never met with the male, and, with the exception of Krohn, who saw it once, no other observer seems to have been more fortunate. I found *Clavatella prolifera*, in autumn, on the west coast of Scotland, with its medusæ carrying eggs (fig. 8). These were contained between the endoderm and ectoderm of the dorsal or proximal side, as had been already noticed by Quatrefages in *Eleutheria*, and by Hincks and Krohn in *Clavatella*. They were few in number, not more than five or six, were of comparatively large size, and by their pressure from within gave rise to prominent bosses on the dorsal surface of the medusa. In every case in which I noticed them they seemed to have passed the earlier stages of their development, for their germinal vesicle was no longer visible; but I lost my specimens before tracing the ova, as Krohn had done, into the condition of "embryos," which he informs us they attained while still in the dorsal brood-chamber of the medusa. From this chamber it would seem, according to the observations of Krohn, that they ultimately escape by the rupture of the ectoderm which confines them, and then swim away in the form of free ciliated planulæ.

Claparede[1] and Filippi[2] have also described the gonophore of a *Clavatella*, but their accounts differ from that just given in some important points. In Claparede's medusa, which seems distinct from that of the *Clavatella prolifera*, the ova lay beneath the ectoderm of the distal or lower side, whence they projected externally. Filippi, though finding the ova in a dorsal chamber, will not allow that this chamber is formed by the separation of the ectoderm and endoderm, as in all other Hydroida. He regards it, on the contrary, as a special cavity, bounded on all sides by the endoderm—a view which is almost certain to have originated in some error of observation.

The medusa makes its appearance as a minute, closed, pyriform sac (fig. 1), consisting of a layer of ectoderm lined by a layer of endoderm, and having its cavity in communication through its peduncle with that of the hydranth. As development proceeds, its cavity may be seen to extend itself at the distal side in six short, tubular, radially disposed offsets, lined by the endoderm, and prolonging themselves into the substance of the thickened ectoderm of the distal end of the bud. These are the incipient radiating canals, and it is certain that about this time each becomes united to its neighbour by a transverse communication, the commencement of the circular canal, though the actual formation of this communication has escaped me.

Up to this point the ectoderm is continued evenly over the whole bud; but it now begins to show, at the distal side of the bud, six little elevations, which correspond to the distal extremities of the radiating canals (fig. 9). These elevations gradually increase in length, while an exten-

[1] Claparede, 'Beobachtungen über Anat. und Entwicklungesch. wirbellos. Thiere,' p. 4.

[2] Filippi, 'Mem. della Reale Academia d. Scienze di Torino,' Ser. 2, Tom. xxiii.

sion from the canal system prolongs itself into their axes. They are now plainly seen to be the rudimental marginal tentacles, as yet, however, quite simple.

We next observe a small tubercle showing itself close to the extremity and upon the inner side of each of the developing marginal tentacles (fig. 10), so that the tentacles at this stage appear obscurely double-headed, the outer head set with thread-cells, the inner one without any special accumulation of these bodies. The two heads become rapidly more and more distinct from one another, each borne on a stalk, and the tentacle thus becomes bifurcated at its extremity. The thread-cells increase in number on the extremity of the outer branch, which now terminates in a distinct capitulum, while a suctorial disc of attachment is developed on the extremity of the inner branch. The ocellus is by this time quite distinct, and we soon find that the little medusa, fitted for an independent existence, has detached itself from its stalk and creeps about on the corallines and sea-weeds of its rock-pool, the inner branch of its tentacles serving for attachment and locomotion, the other aiding it apparently in the prehension of its prey (fig. 4).

It will be noticed that in the development just traced an ectotheca is never present, the medusa being exposed during the whole time to the direct contact of the surrounding water.

The important observation was made by Krohn that the *Clavatella*-medusa may repeat itself by buds from the medusa itself, and he has further shown that this gemmation may take place simultaneously with sexual reproduction, the buds being borne by medusæ which are at the same time laden with ova.

I can fully confirm these observations of Krohn. The buds are developed from the margin of the disc, and from the middle of the interval between two tentacles (fig. 5, *a*, *b*). They are almost always two in number, and are then produced in two opposite interradial spaces, from which they project outwards between the roots of the tentacles. They originate in the form of a small hernia-like process from the circular canal, consisting of a layer of ectoderm lined by one of endoderm and having its cavity freely communicating with that of the circular canal. Their development is entirely similar to that of the medusæ budded from the hydranth.

I found the buds produced both by medusæ in which eggs were at the same time present and by those in which eggs had not yet shown themselves.

A very remarkable difference from the position just described as that of the buds in *Clavatella prolifera* had, however, been noticed by Claparede in the species which came under his observation. In this the buds, while still produced from the circular canal in the interradial spaces, are described as developing themselves under the ectoderm, so as to lie between the disc of the medusa and its digestive cavity. It is difficult to say where the space exists for them in this direction unless that in their growth they insinuate themselves between the ectoderm of the disc and the endoderm of the enlarged atrium. Indeed, Claparede expresses some doubt as to their being really buds, and thinks it possible that they may be eggs which had passed on to an advanced stage of development in the proper egg-cavity, which in this species is described as lying beneath the ectoderm of the lower side.

A comparison of the medusa of *Clavatella* with an ordinary hydroid medusa gives results of much interest.

It will be borne in mind that in many medusæ, such, for example, as those of *Syncoryne* and *Bougainvillia*, the proximal end of the manubrium or that from which the radiating canals are given off presents a special dilatation, and has those endodermal cells which are characterised by the secretion in them of the coloured granules more abundantly developed there than elsewhere.

This dilatation, at least in the young stage of the medusa, is more or less deeply plunged into the substance of the umbrella. It is the "common cavity" of Huxley, the "chyme-receptacle" of Gegenbaur, and the "atrium" of the present Monograph.

If we suppose this atrium to become greatly developed and to extend itself laterally until it occupies nearly the entire width of the umbrella summit or atrial region, while the concave portion or manubrial region of the umbrella, as well as the free portion of the manubrium itself, attains but slight development, we shall have as the result a medusa with the characteristic features of that of *Clavatella*.[1] The umbrella will no longer present the free dilatable and contractile bell of an ordinary medusa, while the radiating canals, which in the latter extend throughout nearly the whole height of the umbrella, will in *Clavatella*, by the approximation of the atrium to the circular canal, be reduced to the condition of the short tubular passages necessary to keep up the communication between these two parts of our singularly modified medusa. The marginal tentacles agree with those of the natatory medusa in their position and relation to the gastro-vascular system, but to compensate for the loss of locomotive function in the umbrella they take this function upon themselves, and are fitted for the conveyance of the medusa from place to place by acting as organs of reptation.

The modification undergone by the manubrium will explain the situation of the ova, apparently so very different from that of those bodies in the natatory medusa. In consequence of the very imperfect development of a free pendulous manubrium, the generative elements which in a natatory medusa would be developed within the cavity of the umbrella in the walls of the manubrium are here, as it were, forced upwards and compelled to occupy a space immediately beneath the ectoderm of the back, through which they at last escape by rupture; though in the species described by Claparede they approach more to the usual position, lying beneath the ectoderm of the lower surface, and ultimately escaping at this part of the medusa. In all cases, however, whether the medusa be natatory or ambulatory, the generative elements have their origin between the ectoderm and endoderm.

Cladonema radiatum.

Plate XVII.

This singular and beautiful little hydroid was first described by Dujardin. It possesses special interest not only as a well-marked type with striking peculiarities of structure, but as having been the first in which the entire life-series was followed through the complete succession of hydranth, medusa, and planula, back to the hydranth again.

The Hydrophyton.—The hydrophyton consists of very slender branched stems, which spring from a creeping filiform stolon (figs. 1, 2). The whole is invested with a smooth perisarc. The ramification, however, varies much, and specimens may frequently be seen consisting of a delicate tubular filament adherent to the walls of the aquarium, over which it may extend for several inches, while it sends off from distance to distance short simple hydranth-bearing ramuli. In some of the specimens examined long slender branches, which showed no hydranths on their

[1] The comparison of the digestive cavity of the *Clavatella*-medusa with the "chyme-receptacle" of Gegenbaur has already been made by Krohn.

summits, and had the perisarc, a little beyond the origin of the branch, thrown for a short distance into spiral folds, were given off here and there from the hydrocaulus. I can scarcely, however, regard these branches as normal; and as all the cases in which the trophosome of *Cladonema radiatum* has been observed were those of specimens which had shown themselves in the confinement of the aquarium, it is not improbable that the growth of these adventitious branches is the result of the unnatural conditions to which the hydroid had been there exposed.

The Hydranths.—The hydranth, which is somewhat fusiform in shape, has its tentacles disposed in two verticils, with four tentacles arranged crucially in each. The two verticils differ from one another in the form of the tentacles. In the distal verticil, which surrounds the base of a well-developed hypostome, the tentacles terminate in spherical capitula, crowded with thread-cells; while in the proximal verticil, which is situated close to the base of the hydranth, the tentacles are much smaller than those of the distal verticil, are less contractile, and are destitute of capitula. The endoderm of both sets is septiform, with some opaque granules imbedded in protoplasm which occupies the axis.

The Gonophores.—The gonophores (figs. 3—10) are phanerocodonic, and present us with an interesting and remarkable type of hydroid medusæ. They bud from the hydranth immediately above the proximal verticil of tentacles.

After detachment from the trophosome these curious planoblasts easily attain to maturity in the aquarium, differing in this respect from most other planoblasts, which in the confinement of the aquarium soon perish, without ever attaining their mature condition.

The mature planoblast of *Cladonema* (figs. 3, 4, 10) is about a line and a half in height. When in repose the vertical and transverse diameters of the umbrella are nearly equal to one another, but during systole the vertical considerably exceeds the transverse. The walls are thin, and the outer and inner surfaces nearly parallel. A small boss-like hemispherical elevation projects from the outer surface of the summit.

The sub-umbrella is of a pale raw-sienna colour, and under the microscope may be seen to be marked with distinct striæ, which take a transverse, somewhat wavy course between every two radiating canals. They appear to indicate the action on the sub-umbrella of the contractile tissue of its walls.

The velum is very wide, the diameter of its central aperture when most diminished being scarcely more than one eighth of the entire diameter of the codonostome (fig. 8). It is marked by very distinct concentric striæ, intersected by radiating striæ, which extend from the margin of its central aperture to its outer edge. Both these sets of striæ represent the contractile fibrillated tissue of the velum.

The manubrium manifests great contractility. It is sometimes drawn together, so as to present the appearance of an irregular globular mass in the top of the bell, and at other times extended so as to touch with its distal end the surface of the velum, or even become protruded beyond it. When extended it is seen to consist of two regions, a proximal and a distal (figs. 3, 4). The proximal region occupies about two thirds of the entire length of the manubrium. It is somewhat fusiform when viewed from the side, but in transverse section it is seen to be pentahedral. It is in this portion alone that the generative elements are developed, and their presence gives rise to five hemispherical projections, by which the manubrium becomes encircled near its middle. The distal portion constituting the remaining third is very much thinner, and is nearly cylindrical, though tapering slightly towards the mouth. The oral margin is continued into five short cylindrical processes, each of which carries on its extremity two or three small globular clusters of thread-cells.

At the proximal extremity of the manubrium its cavity is prolonged into five small narrow pouches, which are seen at the angles of a pentangular area, which forms its fundus and which is visible when we look down upon the medusa from its vertex (fig. 7). When the manubrium is viewed laterally the pouches give to it the appearance of being suspended by five short roots from the summit of the bell. It is in these pouches that the radiating canals originate. Sometimes one or more of the pouches give off directly two canals; sometimes a single canal arises directly from a pouch. After a longer or shorter course the single canals will bifurcate, and as the ultimate result ten radiating canals are formed. These pass down at exactly equal distances from one another to the circular canal, into which they open after presenting just before their junction with this canal a marked enlargement of their calibre.

All the other authors who have described the *Cladonema*-medusa give eight as the number of the radiating canals and marginal tentacles. It is evident that there is in this respect a variation which must not be regarded as pointing to a specific distinction.

The marginal tentacles correspond in number with the radiating canals, of which they are, in fact, the direct continuation; in my specimens there were therefore ten of them. They are at first very thick, continuing so for some distance from their origin, but as soon as they begin to give off their branches they rapidly taper away to their extremities. A bulbous dilatation with a very distinct ocellus exists at their junction with the circular canal. After continuing simple for about a third of their length they begin to emit peculiar appendages. These are given off alternately, and all direct themselves inwardly or towards the axis of the medusa. The first three of these appendages are very different from the others. They are nearly cylindrical, though tapering slightly towards their distal extremity, where each terminates in a spherical capitulum thickly set with thread-cells (fig. 5). Their endoderm is composed of large cells, which give them an irregularly septate appearance, while a line of coloured granules occupies their axis. The proximal one is shorter than the other two, which are equal to one another in length.

The rest of the appendages consist of very extensile offsets from the tentacle, the last forming a bifurcation with the terminal portion of the tentacle. When extended (figs. 3, 4, 6) they are in the form of cylindrical filaments, all thickly set with spherical clusters of thread-cells, which give them a nodulated appearance, a single cluster, larger than the others, terminating each appendage. When contracted (fig. 5) they are in the form of short, thick, club-shaped offsets. Each tentacle carries four such appendages.

The tentacle from the point at which the nodulated appendages begin to be given off to its extremity is covered in a similar way with knot-like clusters of thread-cells, and, like the appendages themselves, is terminated by a large spherical cluster.

The axis of the tentacle presents throughout a continuous tube, which extends laterally into the nodulated appendages as far as their ends, and contains abundance of dark crimson-brown granules, thus contrasting with the smooth capitate appendages, which merely present a few scattered coloured granules in the axis of their large-celled endoderm. At the spot where the last-mentioned appendages are given off the main tube of the tentacle slightly widens, and then again becomes diminished in diameter, to taper away with the tapering tentacle to its distal extremity.

The three smooth appendages which are given off near the base of the tentacle possess very little contractility (fig. 5). They serve the medusa as organs of attachment, the terminal capitulum having the power of closely adhering sucker-like to any surface to which it may be applied, and the little medusa may be often seen attaching itself by means of these appendages to the sides of the glass jar in which it is confined.

The ocellus is very conspicuous. It is situated in the walls of the bulbous expansion, in which the tentacle originates, and on that side of it which is turned away from the axis of the medusa. It consists of an accumulation of pigment-granules, appearing of a deep crimson by reflected light, and having a spherical refracting body imbedded in them (fig. 5).

In a very early stage the marginal tentacles of the medusa are quite simple (fig. 1), but when it is about to free itself from the trophosome they present each a single appendage (fig. 9). This consists of one of the smooth capitate organs of adhesion, while that portion of the tentacle which lies beyond it is covered with knot-like groups of thread-cells. As development proceeds the organs of adhesion increase in number to three, the nodulated branches being at the same time given off in succession, from the more distal portion of the tentacle, until they acquire the complete number which characterises the adult medusa. During no period of the development of the medusa could I detect the presence of an ectotheca.

While the medusa is in the act of swimming the tentacles are contracted and curved upwards round the margin of the umbrella. The cirri, or nodulated appendages of the tentacles, are at the same time more strongly contracted, but the appendages destined for attachment always remain extended (fig. 5). While floating passively in the water (fig. 3) the tentacles with their appendages are extended to their entire length, and then hang down in a graceful tassel-like cluster from the margin.

The most remarkable attitude, however, is assumed when the medusa has fixed itself to the side of the aquarium (fig. 4). It then adheres to the glass by means of the sucker-like capitula which terminate the organs of attachment. On these appendages the medusa is elevated as on so many feet, while all the rest of tentacle is extended to the utmost, and thrown back over the umbrella. The cirri are at the same time fully extended, and as they are now turned outwards, float freely in the surrounding water, spreading themselves out with their thread-cell-loaded spherules, as if in search of prey. A more fascinating object it is scarcely possible to conceive of than this wonderful little planoblast, whether moving in rapid darts through the water with alternate systole and diastole of its crystal bell, or carried along passively by some gentle current with its long pendulous tentacles drooping from the margin, or fixed by its suckers with these same tentacles now thrown around it in a whole grove of long flexile stems and undulating branches.

Hydractinia echinata.

Plate XV and Plate XVI, figs. 10 and 11.

In many respects this hydroid departs widely from the usual condition of the order. It is full of interest, whether we regard the very exceptional structure of the hydrophyton or the great extent to which heteromorphism has been carried in the zooids.[1]

The species is found spreading over the surface of dead univalve shells, almost always such as are inhabited by a hermit crab.

The Hydrophyton.—There is nothing in the morphology of *Hydractinia* more deserving of attention than the cœnosarc with its chitinous excretion. Investing the shell of which the hydroid had taken possession, and usually extending for some distance beyond the shell-mouth, is a continuous layer (Pl. XV, figs. 1, 2), soft and fleshy in the living animal, but replaced after the death of the hydroid and the disappearance of its soft parts by a firm chitinous crust, thickly covered by blunt spines. This crust was the only part of the animal with which the earlier observers were acquainted, and, being very different from all other hydroid forms then known, its real nature was entirely misunderstood, and it was sometimes regarded as a polyzoon, sometimes as a sponge. It is the chitinous secretion of the fleshy cœnosarc which forms a common basis for the various zooids of the polymorphous colony.

When a section of this common horizontal basis of the colony is made in the living animal from the more superficial towards the deeper parts, the knife lays open a multitude of polyhedral spaces (Pl. XVI, fig. 10). These are the cross sections of freely anastomosing tubes, which, being placed in different planes, form a canaliculated or sponge-like structure. These tubes consist of the soft fleshy cœnosarc, bounded by a wall of chitine, and having their cavity surrounded by a layer of minute cells filled with coloured granules. The fleshy mass itself I believe to consist mainly of an endoderm, the cells with coloured granules which surround the cavity of the tubes corresponding to a similar layer which surrounds the somatic cavity in hydroids generally. The peripheral portion of this endodermal mass appears to be surrounded by a true but very thin ectoderm, on which devolves the function of secreting the chitinous investment of the canals. This ectodermal layer is sufficiently obvious in the very young cœnosarc, and in the superficial canals of the older, but in other portions of the adult cœnosarc it is very difficult to demonstrate it.

At the free surface of the cœnosarcal expansion (Pl. XVI, fig. 10, *a a*) its intercommunicating canals (*b*) are only partially invested by chitine, this excretion being in the superficial layer of canals confined to their deeper parts, thus forming open channels, in which the canals are lodged, so that when the soft parts are removed the chitinous perisarc forms on the surface a multitude of intersecting ridges having between them the channels which had contained the superficial cœnosarcal canals. Upon the whole of the free surface, however, the ectoderm of these canals forms a continuous and very conspicuous layer (*a a*), having acquired increased thickness and developed in its

[1] Dr. Strethill Wright has given an excellent account of this hydroid. He was the first to call attention to the occurrence in it of the spiral zooids. See 'Proc. Roy. Phys. Soc. Edin.'

substance abundance of thread-cells. The whole free surface of the common basal expansion of the colony thus presents an absolutely naked layer of ectoderm.

Over the entire surface short blunt conical spines spring at short intervals (Pl. XV, fig. 1). These spines consist of a chitinous framework, continued from the general chitinous system of the common basis, and overlaid and penetrated by an extension of the cœnosarc.

The framework of each completely formed spine consists of a conical process of chitine (fig. 7), whose surface is traversed, from the base to the apex, by longitudinal jagged ridges, which at the base of the spine are continuous with the ridges of chitine, between which, as already said, the superficial cœnosarcal canals are lodged. A transverse section close to the base of a well-developed spine shows it to contain numerous cavities, which are here arranged in more or less regularly concentric series (fig. 4). These cavities diminish in number and regularity towards the middle of the spine, while close to the summit they have entirely disappeared, and the longitudinal ridges here meet in the axis (fig. 5).

The cavities of the spine intercommunicate with one another, like those of the common horizontal layer, and, like them, each is filled with a mass of cœnosarc, having a central cavity surrounded by cells filled with coloured granules. The furrows occupying the intervals of the longitudinal ridges are also filled with cœnosarc (figs. 4, *b*, 5, and 7, *b*), which is here excavated into similar cavities, while they are closed in by a layer of distinct thread-cell-bearing naked ectoderm, which thus invests the whole spine, precisely as in the common horizontal basis.

It is plain from this that the structure of the spine is in all essential points the same as that of the horizontal basis, chiefly differing from it in the greater development of its chitinous element, which acquires much greater thickness and shows very evident layers of successive deposition. Towards the mouth of the shell the spines are but slightly developed, and are here little more than short, blunt, conical tubercles (fig. 1).

There can be no doubt that the whole hydrophyton of *Hydractinia* must be regarded as consisting of a set of cœnosarcal, freely intercommunicating tubes, which have excreted from their surface a chitinous perisarc, and have intimately coalesced with one another.

The reproduction of the hydrophyton may be watched in a mutilated specimen, kept alive in a jar of sea-water; and it will be then seen to be at first a simple network of cœnosarcal tubes (Pl. XVI, fig. 11) invested by a chitinous perisarc, and, as Dr. Strethill Wright first pointed out, presenting very distinct currents in the contained somatic fluid. It is obvious that there is in this stage no essential difference between the hydrophyton of *Hydractinia* and that of other hydroids with undeveloped hydrocaulus. The meshes of this network, however, are ultimately obliterated by the thickening and coalescence of their chitinous walls.

The Hydranths and Spiral Zooids.—From the whole of the naked surface of the cœnosarc, whether covering the horizontal layer or extending over the spines, the hydranths arise; while the spiral zooids, to be presently described, are confined to a narrow space along the extreme edge of the colony. The somatic cavity of both hydranths and spiral zooids is in direct communication with the system of canals which traverse the cœnosarc in every direction, while their ectoderm is directly continuous with the naked superficial ectoderm of the cœnosarc, and their endoderm with the endodermal portion of this same common basis of the colony.

The hydranths (Pl. XV, fig. 1, *a*, *a*, *a*) are eminently contractile, and distinct longitudinal muscular fibres may be traced in them through their entire length. When fully extended they have the form of long, attenuated, nearly cylindrical columns, dilated towards the summit;

but when in various states of contraction they may assume the shape of thick clubs, or be more or less fusiform, or present a trumpet-shaped figure. The mouth may be so completely closed that it will be difficult to find any indication of it, or it may be kept widely open with the cavity of the hypostome actually everted, and the contracted tentacles thrown back and in great part concealed beneath the reflected lip. So very mutable, indeed, are the hydranths that the observer can scarcely avoid attributing to the colony a greater amount of heteromorphism than it really possesses. In its most contracted state the body of the hydranth is marked by very distinct transverse rugæ.

The tentacles vary much in number. They are usually from fifteen to twenty, but I have counted as many as thirty-one in a full-grown hydranth. They consist of two or more alternating series, so closely approximated as to constitute a single circlet surrounding the base of a well-developed hypostome. They are irregular in length, those belonging to the distal series of which the circlet is composed being longer than those of the proximal series. The axis of the tentacle is formed by the usual large-celled endodermal tissue, but the cells are of more unequal size, and give a less regularly septate appearance to the axis than is the case in many other hydroids.

I have occasionally met with a hydranth which has become double-headed by a bifurcation near its middle. Quatrefages has also noticed this condition, and Agassiz has noticed it in the spiral zooids to be next described.

Near that portion of the margin of the colony which lies over the mouth of the univalve shell invested by it there occurs a set of very remarkable zooids (fig. 1, *c*, *c*, *c*). These are long cylindrical bodies, usually attaining, when fully extended, about two thirds of the height of the ordinary hydranths when similarly extended. Their distal extremity is slightly enlarged, and provided with a coronal of spherical clusters of thread-cells. Their axis is hollowed out into a tubular cavity like that of the ordinary hydranths, but they seem to be entirely destitute of mouth. They are provided with a strongly developed layer of muscular fibres between ectoderm and endoderm. Their most remarkable feature consists in their power of rolling themselves into a spiral, whose coils are in vertical planes, somewhat recalling the circinate vernation of a fern. On any irritation of the neighbouring parts they throw themselves into energetic and violent action, uncoiling and coiling themselves, and lashing backwards and forwards on their basis. They are quite constant in their occurrence. Among all the specimens of *Hydractinia* I have examined I have never met with one in which they were not present; and it is difficult to understand how Quatrefages and Van Beneden could have overlooked them. The first published description of them is by Dr. Strethill Wright.

The Gonosome.—The gonophores are always borne upon blastostyles (Pl. XV, fig. 1, *b*, *b*, *b*, and fig. 3). These are scattered among the hydranths without any apparent order. They are cylindrical, slightly dilated at the distal extremity, and for the most part about half the height and thickness of the hydranth. The summit is provided with globular projections, which take the place of the tentacles in the hydranths. These projections are arranged in two or three alternating, closely approximated verticils. Each of them is formed by a cluster of thread-cells, thickly set in a projection of the ectoderm. I have not satisfied myself as to the complete absence of a mouth in the blastostyle. If, however, it be present, it is only in the state of a minute, scarcely perceptible puncture, which may occasionally be witnessed on the summit of the blastostyle, and through which Wright has seen the contents of the somatic cavity voided under pressure; but it can hardly serve the purpose of ingestion of nutriment, though Agassiz has mentioned the existence of a well-developed mouth in the American species described by him. A fibrillated layer is developed, as in the hydranths and the spiral zooids, between the ectoderm and endoderm, throughout the whole length of the blastostyle.

The gonophores are simple sporosacs and are borne near the distal extremity of the blastostyle, usually in a closely aggregated cluster. They are of an oval form, with a well-developed spadix. Their walls (fig. 6) consist of two membranes, an internal thin membrane (endotheca), in which no evident structure can be detected, and an external (ectotheca), with a distinctly cellular structure and containing abundance of thread-cells. No mesotheca is developed.

The ova are invested by a delicate but distinct vitellary membrane. They contain a very large and evident germinal vesicle, within which a nucleated germinal spot may be easily detected (fig. 6). Each colony is absolutely unisexual.

Quatrefages mentions the occurrence of bodies which he regards as eggs, and which he has seen escaping from the cœnosarc when this had been torn under the microscope. I have never noticed those bodies, and am unable to form any opinion as to their nature. We may compare the observation of Quatrefages with Cavolini's account of egg-like bodies which he also found escaping from the cœnosarcal cavity of his *Sertularia parasitica*.

The hydranths, blastostyles, and spiral zooids are constant, but besides these Dr. Wright has described certain long filiform bodies which, like the spiral zooids, occur near the margin of the colony. He calls them "tentacular polypes," and regards them as constant, and employed by the colony in the prehension of food. They are, however, by no means constant, nor are they even usually present, and I cannot consider them as otherwise than abnormal. They are probably malformations which some of the spiral zooids or some of the hydranths situated close to the margin have undergone, from having been there exposed to conditions unfavorable to their development.

Dr. Wright also describes as an essential part of the colony certain sporosacs similar to those which are borne on the blastostyles, but which, instead of being so borne, spring directly from the cœnosarc. I think that there is here some error. I have never met with these cœnosarcal sporosacs, while in a specimen given to me as affording an example of their occurrence I could find nothing of the kind, the sporosacs which on a superficial view had the appearance of arising directly from the cœnosarc proving on close examination to arise from the sides of very short blastostyles.

Gemmaria implexa.

Plate VII.

This beautiful little hydroid may be found on the under side of stones at extreme low-water mark, or it may be dredged up from the Coralline Zone, where it grows over the surface of old shells. It is well deserving of a special study, for its medusa is in many respects one of the most remarkable in the whole range of planoblasts.

The Hydrophyton.—The hydrophyton is but little developed in proportion to the hydranth, and consists of short stems, very rarely sending off a branch, and with a creeping filiform hydrorhiza (figs. 1, 2).[1]

[1] A variety with the hydrocaulus more developed and more decidedly branched would seem occasionally to occur.

The condition of the perisarc is peculiar in that part of the hydrocaulus which lies immediately below the hydranth (fig. 1). It here becomes suddenly thin and transparent, and is separated by a wide interval from the contained cœnosarc. The cœnosarc, however, is kept in connexion with it by regularly disposed, radiating offsets of its ectoderm. It would seem to be this condition which both Alder and Wright have described as an inner annulated perisarcal tube, surrounded at an interval by an external smooth and thinner one. In my specimens no internal tube of perisarc was apparent.

The Hydranths.—The hydranths are proportionately large, and when extended are nearly cylindrical. They are very contractile, and when in extreme contraction assume the form of a thick club. The tentacles are very numerous and scattered over the body; they present the usual septate condition of their endoderm, and terminate each in a spherical capitulum loaded with thread-cells. Those hydranths which carry gonophores appear to be in every instance somewhat less developed than the others, though never reduced to the condition of blastostyles.

The endoderm of the hydranth body (fig. 5) presents a peripheral zone of large prismatic cells (*c*), and containing a clear colourless protoplasm, having their longer diameter transverse to the axis of the hydranth, and an axial zone (*d*) of spherical and much smaller cells containing pale reddish granules. Between the endoderm and ectoderm lies a very distinctly fibrillated tissue (*b*). In the ectoderm (*a*) no distinct cellular structure can be demonstrated, though obscure indications of cells may become apparent under a high power and carefully adjusted compression. Numerous thread-cells may be seen imbedded in it. Besides thread-cells of the ordinary form, there occurs here a large oval form of thread-cell in which the coils of the contained filament are very regular and distinct (figs. 9, 10). After evolution the exserted portion is seen to present some curious and suggestive modifications of the form more common in the HYDROIDA. These have been fully described in a former part of the present work (see p. 119).

The Planoblasts.—It is in the planoblasts (fig. 3) that the most striking characters are to be found. They spring from the body of the hydranth in a group near the proximal limit of the tentacles. They are phanerocodonic, and among the whole of the hydroid medusæ I know of none more remarkable than those of *Gemmaria.*

The umbrella is deep bell-shaped, with four radiating canals and two opposite marginal tentacles, with large bulbous bases, destitute of ocellus, while the place of two other tentacles is taken by a small bulbous dilation of the distal extremity of each of the intervening radiating canals. The axis of the tentacle is traversed by an uninterrupted tube from its base to its summit (fig. 4). Lying immediately over each of the four radiating canals, and running in the walls of the umbrella close to the outer surface, is an elongated fusiform sac. It seems to originate by its narrow end in the circular canal, and then running exactly parallel to the radiating canal extends over about one fourth part of a meridian of the umbrella. It is filled with thread-cells immersed in a clear fluid (fig. 6). These singular sacs admit of a comparison with the superficial ridges loaded with thread-cells which Gegenbaur describes as running from the summit of the umbrella to the codonostome in his *Zanclea costata;* while similar but much smaller sacs, also filled with thread-cells, are developed in the umbrella-walls of the little medusæ which constitute the genus *Willia* of Forbes.

Imbedded in the substance of the umbrella just within its margin are some oval thread-cells with the contained filament in distinct spiral coils. They are disposed in a line parallel to the circular canal (fig 3). During contraction four meridional furrows may be seen on the outer surface of the umbrella, alternating with the radiating canals, and extending from the summit to the codononostome.

The manubrium extends through about one half the vertical diameter of the umbrella. It is nearly cylindrical, destitute of oral tentacles or lobes, and having the mouth surrounded by a circle of minute thread-cells.

A still more remarkable feature than that derived from the presence of the thread-cell-bearing sacs in the umbrella is afforded by the two marginal tentacles (fig. 3, 4). Along its entire length from the bulbous expansion at its base to its tip each tentacle carries oval capsules filled with thread-cells. They are thickly set along the whole length of the tentacle, each arising by a peduncle from its outer side. The capsule itself carries a pencil of long vibratile cilia on its summit. Along the sides of its peduncle small spherical masses containing granules are irregularly scattered. These appendages of the marginal tentacles would seem to have their representatives in what appear to be very similar bodies figured by Gegenbaur in *Zanclea.*

Whether, however, the pedunculated capsules which are carried on the marginal tentacles of *Gemmaria* resemble in all respects the tentacular appendages of *Zanclea* is a question which remains open for future observation, but it is certain that these bodies in *Gemmaria* present a phenomenon to which nothing similar has yet been recorded in any other hydroid.

Some years ago I dredged off the Forfarshire coast a colony of *Gemmaria implexa,* which, after remaining for about a fortnight in a jar of sea-water, threw off its medusæ. On examining these with a hand-lens as they floated through the water I was struck by the appearance of a mould-like growth with which many of them seemed covered, and for a moment I thought that they had become infested by some low parasitic vegetation. That this, however, was something very different from what it appeared to be soon became evident, for when the little medusa was touched ever so slightly with the point of a needle the whole of the flocculent mass instantly vanished.

It needed, however, a higher power of the microscope to reveal the true nature of this phenomenon and show that the apparently parasitical growth consisted of the enormously elongated peduncles of the thread-cell-bearing capsules, each of which, as it now proved, had the power while still carrying the capsule on its extremity of extending itself to a length which considerably surpassed that of the longer or vertical diameter of the umbrella (see fig. 3).

While the medusa continued to float undisturbed through the water the peduncle would remain projected in a straight line from the tentacle, becoming at the same time amazingly attenuated, but on the least disturbance it would suddenly shorten itself to less than one twentieth part of its length when extended, drawing the capsule back with it in its contraction. The extended condition of the peduncles was seen only while the medusa was passively floating in the water, while engaged in active locomotion the peduncles were always contracted.

The small spherical masses which are attached to the sides of the peduncle become widely separated from one another on extension, and the whole peduncle with its terminal capsule was seen during the extended condition to be in a state of constant vibration. This was due to the pencil of long fine vibratile cilia which the capsule carried on its summit.

I believe that the remarkable phenomenon now described presents us with a case of true sarcode extension and contraction, and that the peduncles of the thread-cell-bearing capsules consist of a simple granular protoplasm, which in its power of extension and retraction at once recalls the pseudopodia of a rhizopod.

Dicoryne conferta.

Plate VIII.

This hydroid may be found investing the surface of various univalve shells in the form of a dense moss-like growth. It affords the only example we yet know of a free locomotive sporosac.

The Hydrophyton and the Hydranths.—The hydrophyton (fig. 1) consists of branched stems with occasionally some simple ones, all arising from a creeping retiform hydrorhiza, the whole invested by a rather coarse perisarc.

The hydranths (fig. 1) are fusiform, with a single circlet of filiform tentacles surrounding the base of a conical hypostome.

The Gonophores.—It is the gonophores, however, which confer upon *Dicoryne* a special interest, and eminently distinguish it from all other known hydroids. They are borne on true blastostyles (fig. 1), which spring either from the hydrocaulus or from the hydrorhiza, and which represent hydranths modified by the complete suppression of both tentacles and mouth. The gonophores are in the form of an oval sac, and are densely crowded on the sides of the blastostyle. The male and female clusters entirely resemble one another in external form; they are always borne on separate stems, but I have occasionally met with both male and female stems in the same colony. While still attached to the blastostyle the gonophores (fig. 5) may be seen to consist of an external sac (ectotheca), within which is a second sac (endotheca). Within this second sac are the ova or spermatozoa, while a long simple spadix occupies its axis. By carefully adjusted compression it will also be seen that just behind the proximal end of the spadix two tentacula-like processes are given off. These run forward between the ectothecal and endothecal sacs until they reach a point nearly half way between the proximal and distal ends of the gonophore.

On attaining maturity the endothecal sac and its contents are ready to liberate themselves, and the sac accordingly becomes detached from the summit of its peduncle along a defined line which lies just behind the roots of the tentacular appendages, and, carrying these appendages along with it, breaks through the endotheca and becomes a free zooid in the open sea (figs. 3, 4, 6), leaving the torn ectotheca behind it attached to the summit of the peduncle.

The planoblast thus set at liberty is a sexual zooid of an exceedingly singular kind, and, so far as we yet know, without any exact parallel. Immediately on acquiring its freedom it throws back its two tentacles which had been previously turned forward as they lay impacted between the ectotheca and endotheca of the gonophore, and which, now becoming extended to at least twice their former length, diverge from the proximal extremity of the liberated zooid.

This zooid is thus a free sporosac. It is an oval sac with a pair of tentacles diverging from its proximal extremity. It is completely covered with vibratile cilia, which extend even to the extremities of the two tentacles, and by their aid it swims actively in the surrounding water. A long spadix runs through the entire axis of the sac impinging on its summit and there remaining adherent to its wall. In the male (fig. 6) the spadix is surrounded by a continuous mass of spermatozoa. In the female (figs. 3, 4) the place of the spermatozoa is taken by ova, which are invariably two in number, and are situated one on each side of the spadix, and in such a position that only one is visible when the zooid is viewed at right angles to the plane of the two tentacles (fig. 3).

The endoderm of these tentacles is composed of large transverse cells, giving the usual septate appearance to the axis of the tentacle, and by the careful employment of the compressorium this structure may be seen to be continued for some distance into the walls of the spadix (fig. 7), where, however, the cells become less regular, while the cavity of the spadix is immediately surrounded by a layer of endodermal cells filled with reddish-brown granules. The walls of the sac contain imbedded thread-cells (fig. 7).

The ovum presents a well-defined germinal vesicle, in which a germinal spot is visible, or may be easily rendered so by slight compression. Each ovum is invested by a proper membrane, which presents the remarkable and unique character of possessing considerable thickness and being richly set with thread-cell-like bodies (fig. 7).

It is plain, then, that the planoblast of *Dicoryne* is a free sporosac, consisting of a simple endotheca traversed by a spadix. To the base of the spadix the endotheca still adheres for some distance, the generative elements not intervening here between spadix and endotheca so as to separate them from one another. It is from the extreme end of this part that the two tentacles are given off.

The planoblast of *Dicoryne* admits of a very instructive comparison with an ordinary medusiform gonophore. It is, in fact, a medusa in which the place of the umbrella and its canals is taken by two tentacles, the manubrium of the medusa being represented by the rest of the planoblast. It will be recollected that the two tentacles are turned forward, while the sporosac is still invested by its ectotheca, and that they then hold exactly the place of an umbrella (mesotheca) between endotheca and ectotheca. They are, in fact, the radiating canals of the medusa reduced to two and developed as free tubes, instead of being immersed in the walls of an umbrella. It will also be borne in mind that in the medusæ of *Obelia*, the umbrella with its canals is frequently inverted and thrown back, so as to assume the position of the tentacles in the planoblast of *Dicoryne*, after this body has broken through the ectotheca and become free. The free sporosac of *Dicoryne* is thus a medusa reduced to the condition of a manubrium and two opposite radiating canals. In order, indeed, to convert it into an ordinary medusa, little more is necessary than to suppose the number of the tentacles increased to four by the symmetrical development of two others, their extremities connected by a circular canal, and their sides by a continuous muscular membrane (umbrella) inflected at its free margin so as to form a velum.

It will be noted that the planoblast of *Dicoryne* is one of the three forms of locomotive zooids which occur among the Hydroida, these three forms being the natatory medusa (*Syncoryne*, *Cladonema*, *Corymorpha*, &c.), the ambulatory medusa (*Eleutheria*, *Clavatella*), and the natatory sporosac (*Dicoryne*).

The planoblast of *Dicoryne conferta* always swims with its body in a vertical position, carrying the posterior or tentacular extremity uppermost, and maintaining all the time a constant rotation on its longer or vertical axis.

SUPPLEMENTARY NOTE.

STRUCTURE OF CORDYLOPHORA.

Since the earlier part of the present Monograph was printed there has appeared a valuable Memoir by Dr. Schulze, of Rostock, on *Cordylophora lacustris* ('Ueber den Bau und die Entwicklung von *Cordylophora lacustris* nebst Bemerkungen über Vorkommen und Lebensweise dieses Thieres,' von Dr. Franz Eilhard Schulze, Leipzig, 1871).

Dr. Schulze obtained the *Cordylophora* in brackish water near Rostock, and has made its minute structure the subject of a laborious and exhaustive examination. By the aid of osmic acid, and steeping in Müller's solution and in iodized serum, he has succeeded in making sections eminently fitted for examination under high powers of the microscope.

Perhaps the most important point contained in the Memoir is his demonstration of a structureless hyaline membrane which lies between the ectoderm and the endoderm, and which, in those parts where a muscular layer exists, is found on the inner or endodermal side of this layer. It is the supporting lamina, "Stützlamelle" of Reichert, who recognised its presence in the same position in other hydroids, though he confounded with it the muscular layer whose existence in the Hydroida he denies.

Though I have had no opportunity of verifying by new examinations the results at which Dr. Schulze has arrived, I am quite ready to accept his confirmation of the presence of the "Stützlamelle" of Reichert. I have been long aware of the appearance of a very narrow clear space between the endoderm and ectoderm, as visible in various sectional views of hydroids (see especially Pl. IV, fig. 3; Pl. VII, fig. 6; Pl. XXIII, fig. 9; and woodcut, fig. 48, p. 12, of the present work); but I could never convince myself that this appearance ought to be regarded as the expression of an independent membrane. Schulze's very careful investigation, however, appears to me now to set this question pretty nearly at rest, and to justify us in regarding the "Stützlamelle" as a second element lying between ectoderm and endoderm, the muscular layer being the other.

Schulze informs us of an internal annular process of the "Stützlamelle," which runs transversely across the base of the tentacle in Cordylophora, forming a septum with a central aperture. I have not seen anything of this kind.

He can in no case find either in *Cordylophora* or in *Hydra* the secondary cells which I have described as existing in the interior of the large endodermal cells of the somatic cavity, and to which I believe myself justified in attributing a secreting function. Notwithstanding, however, the trustworthy means of observation adopted by Schulze, I am not prepared to relinquish my belief in the reality of these cells. It is not impossible that their existence may depend on certain states of nutrition, and that they may be present at one time and absent at another.

The author is inclined to regard the free surface of the endodermal cells as destitute of membrane, and believes that the protoplasm which is accumulated at this spot has its surface freely exposed to the somatic cavity—an important and interesting fact if confirmed by subsequent observations. He has also succeeded in clearly making out the presence of vibratile cilia over the whole of the endoderm of the somatic cavity, not only in *Cordylophora*, but in *Hydra*, each of the cells carrying a single long fine cilium on its free surface. *Hydra*, therefore, affords no exception to the ciliated condition of the endoderm.

The occurrence of longitudinal rugæ which I have described in the endoderm of the stomach in *Cordylophora* and *Hydra* is attributed by Schulze to the mere contraction of the walls. There is no doubt that the distinctness of these rugæ depends to a certain extent on the state of contraction of the hydranth, but their existence is not on that account the less real. In many marine hydroids the endoderm of the gastric walls presents well-marked lobes and rugæ.

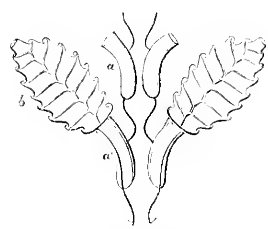
The author maintains the ectodermal origin of the generative elements. In this I cannot agree with him. I believe, on the other hand, that I have satisfactory evidence that they are products of the endoderm (see above, p. 148). Schulze, it is true, affirms the existence of a continuation of the hyaline "Stützlamelle" over the spadix, so that the generative elements would be thus separated from the endoderm of the gonophore. If this be the case it would go far to prove the view taken by him, but with the strong evidence on the other side I must suspend my belief in the correctness of his interpretation of the appearances here presented by his dissections.

Accepting, indeed, the statement of Schulze, that the "Stützlamelle" can be traced over the spadix, it will still, I believe, be found that the generative elements originate at the endodermal side of this membrane. In some instances, as in *Laomedea caliculata*, a hydroid with a branching spadix, an extremely delicate, structureless membrane may, with careful illumination, be traced over the free surface of the ova while these are still in contact with the spadix, and I now believe that it is the same membrane which may, in some cases, be seen to be carried out, hernia-like, before the ova when these are expelled under pressure from the gonophore, and which I formerly regarded as probably representing a condition of the vitellary membrane (see p. 64). Is not this the membrane which Schulze has traced over the spadix, and which he regards as a continuation of the "Stützlamelle"? If so, the ova must have been produced *between* the "Stützlamelle" *and the spadix*, and not upon the outer side of this membrane, as maintained by Schulze.

THE GONANGIUM.

Among the hydroids in Mr. Busk's collection, which he placed in my hands for examination, is a calyptoblastic species from New Zealand. Its trophosome, so far as its state of preservation in the dried specimen allows of comparison, differs in no respect from that of a typical *Sertularian*, but its gonosome presents the hitherto entirely unprecedented character of having its gonangia borne upon peduncles, which *spring from within the hydrothecæ*.

The gonangia are oval, opening at their distal extremity by a tubular orifice, and ornamented by curved ridges which terminate at each side in a zigzag line, which runs down the middle of the gonangium walls from the summit to the base. Each gonangium is borne on a long cylindrical peduncle, which springs from the bottom of a hydrotheca, in which it occupies the position of a hydranth. The peduncle extends through the whole length of the hydrotheca, and as it nearly equals it in diameter it almost fills its cavity. It is covered by a delicate chitinous perisarc, and immediately, on emerging from the cavity of the hydrotheca, carries the gonangium on its summit.



Synthecium elegans.
a. Ordinary hydrotheca destined for the reception of a hydranth. *a'*. Hydrotheca in which the hydranth is replaced by the peduncle of the gonangium. *b*. Gonangium.

Whether those hydrothecæ from which the peduncles of the gonangia emerge ever carried hydranths, which subsequently became replaced by the gonosome, or whether they have been all along exclusively devoted to the gonosome, it is impossible to determine from dead and desiccated specimens. At all events, it is certain that there is not a single point, either in position or in form, by which these gonangia-bearing hydrothecæ differ from the others.

The hydroid thus so very exceptionally constructed must constitute the type of a new genus and species, to which the name of *Synthecium elegans* may be given.

FUNCTION OF THREAD-CELLS.

In the account given above (p. 108) of the alleged stinging property of the thread-cells, reference ought to have been made to the researches of Mr. G. H. Lewes ('Sea-side Studies'), who has investigated, both by observation and experiment, the thread-cells of various species of *Actinia*, with the view of determining how far we are justified in attributing an urticating property to those bodies.

Mr. Lewes decides against their alleged powers of urtication. He supports his view on the admitted fact that thread-cells are often situated in places where it is impossible for them to exert such powers, as well as on the further observation that in their number and development they present no ratio to the stinging powers of the animal. He believes, moreover, that experiment leads to the same results, for he has allowed small living annelids and crustaceans to come in contact with the filaments connected with the radiating septa of *Actiniæ*, and which are loaded with thread-cells, without finding that the little animals so treated had thereby suffered any harm. So also animalcules touched by the filament ejected from the thread-cells in the tentacles of an *Actinia* were not killed nor disabled by it.

Against the conclusions of Mr. Lewes there may be adduced the statements of other observers, who describe the sudden arrest of all motion in the prey when touched by the thread-cell-bearing surface; and while it is true that the soft bodies of the annelids fit them for the experiment, it may be objected to the employment of crustaceans that the resisting nature of their surface would enable them to bear the exposure with impunity. Mr. Lewes, it is true, explains the arrest of motion in the captured prey by referring it to the habit of feigning death so well known in many insects and spiders, but this can apply to only a very small number of the animals affected. That an actual penetration of the thread-cell to a slight extent takes place I believe there is sufficient evidence, and the probability that this is accompanied by the injection of a poison has been already maintained (see p. 129). Still, however, with the investigations of so careful an observer as Mr. Lewes tending towards an opposite conclusion, and supported as they are by those of Möbius and others, we cannot yet regard the alleged stinging powers of the thread-cell as beyond doubt.

EVOLUTION OF THE HYDROIDA—ANCESTRAL TYPE.

Haeckel ('Generelle Morphologie,' vol. ii, p. li) regards the whole of the *Cœlenterata* as derived from a hypothetical aboriginal form, to which he assigns the name of Archydra, and which has continued itself with but little change down to our own times in *Hydra* and *Cordylophora*, the only freshwater representatives of the *Cœlenterata*. He supposes that these animals, in consequence of the simple nature of the influences to which their fresh water habitat has exposed them in the struggle for existence, have, like many other dwellers in fresh water, retained nearly their original simple structure. With these persistent archydral forms he further unites those marine hydroids which come nearest to *Hydra* in never giving origin to planoblasts, and in developing fixed sporosacs in place of free locomotive buds. He regards *Hydra* as having for the *Cœlenterata* a significance similar to that which *Amphioxys* has for the *Vertebrata*.

Under the name of *Protohydra* Dr. Greef, of Bonn ('Zeitschr. f. wis. Zool.,' vol. xx, p. 37, pl. iv), describes a remarkable little organism which he obtained among diatom-mud and algæ from an oyster bed at Ostend. It is almost of microscopic size, but has a very close relation with *Hydra*, from which it chiefly differs in never developing a trace of tentacles, and in multiplying itself solely by spontaneous fission. It is very contractile, varying in form from that of a sphere to that of an elongated club. It attaches itself to algæ and other bodies by one extremity, in the manner of the *Hydra*, and is perforated at the opposite end by a mouth which leads into the cavity of the body.

Its minute structure appears to be in all essential points similar to that of *Hydra*, and its body is composed of a distinct endoderm and ectoderm with interposed muscular layer; both endoderm and ectoderm consisting of undoubted cells with nucleolated nuclei. The ectoderm contains abundance of thread-cells, and the endoderm scattered reddish-brown pigment-granules.

The endoderm may be broken down under the microscope, and the protoplasmic contents of the cells liberated by the rupture of the cell-walls. The liberated protoplasm will then often show amœbiform movements, and emit pseudopodial prolongations.

The spontaneous fission of the body takes place transversely, dividing the animal into quite similar halves, each of which may again present successive fissions.

Dr. Greef calls attention to a very interesting phenomenon which presents itself during the division. While the constriction which is to result in the complete separation of the two segments is as yet slight, the movements of the dividing animal are, as may be expected, quite simple, and such as might be imagined to follow from the volition of a single individual; but as soon as the constriction has attained a certain depth the form of the segments has become changed, and each now carries out in itself its own movements, but yet without the mutual dependence of the still united segments being destroyed, for the movements of each segment are perfectly conformable to those of the other, and quite synchronous with them. If the one stretches itself out or contracts itself, so does the other, in precisely the same way and during the same time, the shape of the one being always exactly that of the other, until, finally, the complete separation of the two puts an end to their dependence.

Dr. Greef regards his *Protohydra* as representing the lowest type of a cœlenterate animal, and, in accordance with the descent hypothesis, he assumes it as the true ancestral form of the whole of the *Cœlenterata*.

The unsuitableness of the HYDROIDA for preservation in a fossil state leaves us almost entirely without direct evidence as to the forms which may have been presented by their remote ancestry. Reasons, however, have been already given which would seem to justify our going as low as the *Protozoa* for the ancestral form of the HYDROIDA, whose relations to the *Rhizopoda* would seem to be traceable through the graptolites. See above, p. 179.

PART II.

THE GENERA AND SPECIES OF THE GYMNOBLASTEA.

THE GENERA AND SPECIES OF THE

GYMNOBLASTEA.

General Principles of Hydroid Zoography.

While the first part of this Monograph is devoted to those general questions of hydroid organization and life which concern the Hydroida as a whole, I purpose in this second part to deal with the zoography or descriptive and systematic zoology of the various genera and species which are embraced under the Gymnoblastea, that great section of the Hydroida to which the special part of the Monograph must be confined.[1]

It is but quite lately that those principles of classification which are acknowledged as the only sound ones, and which have been our guide in the study of every other group of the animal kingdom, had begun to be recognised in the systematic treatment of the Hydroida.

The cause of this long exclusion of the Hydroida from the domain of a philosophic classification is sufficiently obvious. The individual hydroid, as we now know, frequently presents itself in disconnected parts which are very different from one another, and it is only recently that zoologists have shown the mutual relations of these parts, and have demonstrated that organisms totally different from one another in form, and now enjoying an independent life, may have been at one time united into a single individual of which they formed essential constituents, and are at all times necessary for an adequate conception of it.

So long, however, had these component elements of the zoological individual been regarded as entirely independent of one another, that even after their true relations became known zoologists continued to find it more convenient to treat them as independent organisms, to assign to them separate places in their systems, and to record them under distinct generic and specific names.

A practice, however, so totally at variance with the first principles of a philosophic classification and of a scientific nomenclature could not last. With the possible exception of the Monopsea, in which no hydriform trophosome exists,[2] the individual hydroid can only be

[1] See Part I, pages 188—191, for the systematic position of the Hydroida, and the leading diagnoses of the larger groups.

[2] I say, "with the *possible* exception," for even in the Monopsea we ought probably, as already pointed out (see p. 106), to recognise the existence of the two zooidal elements, trophosome and gonosome; here, however, the medusiform condition of the trophosome and its permanent union with the gonosome will be sure to secure to both a full consideration in any diagnosis.

Victor Carus, in his excellent treatise on the Hydroida (Carus und Gerstaecker, 'Handbuch der Zoologie,' vol. ii), has proposed the name of *Haplomorpha* for the group to which I have in the former part of this Monograph applied that of *Monopsea*. There is no possible objection to the name of *Haplomorpha*; and were it not that I had accidentally overlooked its existence, I should not have ventured to substitute another for it.

understood by regarding it as the product of two factors—one of them finding its expression in the trophosome and the other in the gonosome; and whether the gonosome remains permanently attached to the trophosome, or becomes in whole or in part free, attaining thereby an independent existence, it is equally necessary that it should take its place in our diagnoses of families, genera, and species.

We accordingly now find that our leading descriptive treatises recognise the necessity of combining in their diagnoses, not only those parts which are destined for the nutrition of the colony, but those also which are destined for the sexual perpetuation of the species, whether these last-mentioned parts be in the form of fixed sacs or in that of free locomotive planoblasts.[1]

If all trophosomes which presented no difference sufficiently great to justify generic separation had their gonosomes just as closely resembling one another, while, on the other hand, all closely resembling gonosomes had closely resembling trophosomes, the classification of the HYDROIDA would be freed from one of its great difficulties.

This, however, is far from being the case, and the study of the HYDROIDA renders us acquainted with two sets of phenomena, which signally break down the uniformity assumed in the above suppositions. These are—1. *The association of similar trophosomes with dissimilar gonosomes;* and 2, *the association of dissimilar trophosomes with similar gonosomes.* The difficulty which these phenomena throw in the way of a natural classification of the HYDROIDA may be compared to that which the mineralogist meets with when he finds isomorphism and dimorphism interfering with the uniformity of his mineralogical system.

But the great difficulty, after all, in the application of the method here advocated is found in the fact that the planoblast at the time of its liberation is still in an immature state, and may be destined to undergo important changes before arriving at its adult condition. In such cases, unless we have succeeded in following it to its ultimate form, our determination of its type must be regarded as only approximate. Analogy, however, will greatly aid us in this determination, by pointing out what are the parts most liable to change, and what the direction in which this change is likely to take place.

From these considerations we learn that the number and form of marginal and oral tentacles in the recently liberated medusa must be accepted with great caution, as affording valid systematic characters, these organs being especially liable to an increase in number, and often to an alteration in form as the medusa advances towards maturity, while the form of the umbrella is also subject to a certain amount of change.

In some cases, however, especially as regards the number of the marginal tentacles, we may fairly assume the condition presented by the young medusa as representing its permanent characters, as, for example, in the case of the single long tentacle in the planoblast of *Corymorpha*, where we find, by going back to the early stages of the development of this planoblast, that the peculiar asymmetrical form which in a later stage finds its expression so decidedly in the great development of a single tentacle is quite apparent before any trace of a tentacle can be detected.

[1] This principle has been recognised in the following publications:

Agassiz, 'Contr. Nat. Hist.' U. S.; M'Crady, 'Gymnophthalmata of Charleston Harbour;' Victor Carus in 'Carus u. Gerstaecker Handbuch der Zoologie,' vol. ii; Allman, "On the Construction and Limitation of Genera among the *Hydroida*," in 'An. Nat. Hist.' for May, 1864; Alex. Agassiz, 'Illustr. Catal. of North American Acalephæ;' Hincks, 'Brit. Hydr. Zoophytes.'

In assigning their proper limits to the classificatory groups under which the gymnoblastic hydroids are here distributed, I have accordingly availed myself of both trophosome and gonosome in the selection of the characters. As to the gonosome, I have regarded the condition of the gonophores—whether phanerocodonic or adelocodonic, as well as certain important differences in the form of the planoblast, as of primary importance, and have employed these characters in the limitation of FAMILIES. It is true that there are certain cases which may be viewed as transitional from the adelocodonic to the phanerocodonic gonophore, yet the difference between the medusa and the sporosac is, on the whole, so strongly marked as to afford valuable characters for the limitation of the higher groups in any philosophical classification of the HYDROIDA.

It may be objected that to regard the differences between phanerocodonic and adelocodonic gonophores as of so high an order as to justify our employing them in the definitions of families would involve the necessity of widely separating species in all other respects closely resembling one another; that among the calyptoblastic hydroids, for example, the *Campanularias*, with their phanerocodonic gonophores, and the *Laomedeas*, with their adelocodonic gonophores, would have to take their places in separate families.[1] I am, nevertheless, prepared to defend such a separation as would be here involved, for I do not, admit the principle that any agreement of the trophosome can justify the depreciation of so very important a difference as is involved in these two conditions of the gonosome. It has been already fully recognised in the comparison of genera, and I believe we are quite justified in employing this well-defined and excellent character as a limiting element in the diagnoses of families.

While the gonosome will thus afford characters for the diagnoses of the higher groups, characters of corresponding value will also be yielded by the trophosome. These will be derived chiefly from the condition of the tentacles as showing itself in their disposition, whether verticillate or scattered; and in their form, whether filiform or terminating in capitula.

Characters of subordinate importance available for the diagnosis of GENERA are also derivable from both gonosome and trophosome. The gonosome will yield them in certain subordinate differences of form in the planoblast, and in the presence or absence of a blastostyle; while in the trophosome we shall find them in such features as are afforded by the presence or absence of a developed hydrocaulus and by certain minor differences in the disposition of the tentacles of the hydranth.

Characters which are merely SPECIFIC will be found in still more subordinate differences, which are also presented both by gonosome and trophosome, and will easily suggest themselves to the observer.

With regard to nomenclature, I am convinced that except in cases where a manifestly incorrect determination has been made, and in a few other special cases, we must retain for our hydroid the name under which it was first described, whether this original description refers to the gonosome or to the trophosome. The fact of our assigning to the complete hydroid the generic name by which the planoblast alone had been previously known, needs not prevent our continuing to employ the same name for all those planoblasts, which do not differ from this in characters of generic importance, but whose trophosomes have not yet been discovered; we

[1] I refer to the genera *Campanularia* and *Laomedea* in the sense in which I have already defined them, and which I see no reason to alter. 'On the Construction and Limitation of Genera among the HYDROIDA,' 'Ann. Nat. Hist.' for May, 1864.

must keep in mind, however, that the name, when used in this sense, is purely provisional and liable to be changed when the discovery of the trophosome shall determine the true genus of our, then no longer incomplete hydroid. So also no name which has been given to a trophosome whose gonosome is unknown can be regarded as otherwise than provisional.

It is upon these principles that I have based the diagnoses, nomenclature and arrangement, of the families, genera and species, of hydroids, to whose description the second part of the Monograph is devoted.

Keeping in mind that it ought to be the aim of the systematist, in framing his diagnosis, to render it absolutely exclusive of every object or group of objects to which it is not intended to apply, I have endeavoured in every case to carry out this principle. With the view also of securing against diffuseness, it has been my aim in the definitions of the more special groups to avoid a repetition of those characters on which the more general groups are based. In other words, I have endeavoured to confine each diagnosis to its proper "differentia." It is true that the conception of any group involves, not only the "differentia" of the group, but also the characters of those more general groups under which it is included. These characters, however, instead of being repeated at length, may in our technical diagnosis be expressed by the use of a single word—that which has been adopted as the name of such higher group as immediately includes the group under definition. This word would, then, like an algebraical expression, become a short symbolic representation of a multitude of distinct facts, the facts which constitute the essential characters of the group of which it is the accepted name, and which is supposed to have been previously defined; and though it may not be deemed necessary actually to express this word in the definition, it or rather the facts it represents must in every case be understood.

In order to facilitate comparison I have adopted as far as possible a uniformity in the selection of characters, and in the order in which these characters are noted, while in every diagnosis I have given one paragraph to the trophosome and another to the gonosome.

When the colour of the hydroids composing a species is known I have always given it. Colour affords a character which cannot be neglected in our specific descriptions, but as it is in many cases too variable to be relied on with certainty I have not ventured to introduce it into the proper diagnosis.

The technical terms employed in the descriptions are not numerous, and, if these be not immediately understood, there will be no difficulty in rendering them so by a reference to the section on Hydroid Glossology (see part I, pages xiii, &c.), where every term is defined. By the use of such terms I have hoped to avoid tedious circumlocution, and to condense the descriptions without sacrificing their precision; and if in some cases the definitions may appear more diffuse than could be desired, they do so because I believed that condensation in such cases could not have been carried further consistently with exactness. The beautiful simplicity and terseness of the Linnæan definitions is scarcely possible any longer; for the vast increase of known species since the days of the great systematist renders necessary the employment of a very much larger number of characters for exact diagnosis than sufficed at a time when comparatively few species had to be distinguished from one another.

The following table will show the mode in which I have distributed the genera of gymnoblastic hydroids under their respective families:—

SYNOPSIS OF THE FAMILIES AND GENERA OF THE GYMNOBLASTEA.

HYDROIDA GYMNOBLASTEA.

Fam. I.—CLAVIDÆ.

Clava, Rhizogeton, Cordylophora, Tubiclava, Merona.

Fam. II.—TURRIDÆ.

Turris, Campaniclava, Corydendrium.

Fam. III.—CORYNIDÆ.

Coryne, Actinogonium.

Fam. IV.—SYNCORYNIDÆ.

Syncoryne, Corynitis, Gymnocoryne, Gemmaria.

Fam. V.—DICORYNIDÆ.

Dicoryne.

Fam. VI.—BIMERIDÆ.

Garveia, Bimeria, Wrightia, Hydranthea, Stylactis, Heterocordyle, Cionistes.

Fam. VII.—BOUGAINVILLIDÆ.

Bougainvillia, Diplura, Perigonimus.

Fam. VIII.—EUDENDRIDÆ.

Eudendrium.

Fam. IX.—HYDRACTINIDÆ.

HYDRACTINIA.

Fam. X.—PODOCORYNIDÆ.

PODOCORYNE, CORYNOPSIS.

Fam. XI.—CLADONEMIDÆ.

CLADONEMA.

Fam. XII.—NEMOPSIDÆ.

NEMOPSIS.

Fam. XIII.—PENNARIDÆ.

PENNARIA, HALOCORDYLE, STAURIDIUM, VORTICLAVA, HETEROSTEPHANUS, ACHARADRIA.

Fam. XIV.—CLADOCORYNIDÆ.

CLADOCORYNE.

Fam. XV.—MYRIOTHELIDÆ.

MYRIOTHELA.

Fam. XVI.—CLAVATELLIDÆ.

CLAVATELLA.

Fam. XVII.—CORYMORPHIDÆ.

CORYMORPHA, HALATRACTUS, AMALTHÆA, ACAULIS.

Fam. XVIII.—MONOCAULIDÆ.

MONOCAULUS.

Fam. XIX.—TUBULARIDÆ.

TUBULARIA.

Fam. XX.—HYBOCODONIDÆ.

HYBOCODON, ECTOPLEURA.

Provisional.—LARIDÆ.

LAR.

In the following descriptive zoology of the GYMNOBLASTEA the species which have not yet been found round the shores of the British Isles are indicated by a tripple asterisk.

CLAVIDÆ.

TROPHOSOME.—HYDROCAULUS rudimental or developed. HYDRANTHS, with scattered filiform tentacles.

GONOSOME.—GONOPHORES fixed SPOROSACS.

CLAVA, *Gmelin.*

Name.—From *Clava*, a club, in allusion to the form of the hydranths.

CORYNE, *Lamarck.*

TROPHOSOME.—HYDROCAULUS rudimental, and consisting of very short simple tubular processes from the free surface of a HYDRORHIZA which is composed of creeping tubes, either distinct or adnate to one another by their sides, and invested, as well as the rudimental hydrocaulus, by an obvious PERISARC. HYDRANTHS claviform.

GONOSOME.—SPOROSACS springing from the body of the hydranth at the proximal side of the tentacles.

In the thirteenth edition of the 'Systema Naturæ,' published in 1788, the genus *Clava* is constituted by Gmelin, the editor of that edition, for a hydroid which had been described by O. F. Müller, in a paper published in 1775, in the 'Beschäftigungen der Berlinischen Gesellschaft naturforschender Freunde.' Müller gave no name to the hydroid there described, but under that of *Hydra squamata* he described and figured in the 'Zoologia Danica,' 1777, a nearly allied species.

Lamarck, in his 'Animaux sans Vertèbres,' omits the genus *Clava* altogether, and refers Müller's hydroid to a genus to which it has no claim—the *Coryne* of Gärtner.

The genus *Coryne*, with the extended limits thus assigned to it by Lamarck, was subsequently subjected to a revision by Sars, who, however, instead of restoring the genus *Clava* to its rightful place, retains the name of *Coryne* for the forms properly included under *Clava*, and institutes a new genus of his own, under the name of *Stipula*, for the true *Corynes* of Gärtner; while Ehrenberg follows Sars, objecting only to Sars' name of *Stipula* on the grounds that it belongs to the botanist, and substituting for it one of his own, namely, *Syncoryne*.

The first to restore the name of *Clava* to its legitimate place, after its long banishment from the nomenclature of the HYDROIDA, was Johnston, who has thus not only performed an act of justice to the memory of Gmelin, but has removed no slight element of confusion from the classification of the HYDROIDA.

1. CLAVA SQUAMATA, *O. F. Müller.*

Plate I.

ZOOPHYTON MINUTUM CORYNÆ SIMILLIMUM,—*Pallas*, Spicil., fasc. x, p. 36, pl. lv, fig. 9.

HYDRA SQUAMATA,—*Otho Fred. Muller*, Zool. Dan. Prod., 2786. Zool. Dan. Icon., tab. iv. *Otho Fabricius*, Fauna Groenlandica, p. 347.

CORYNE SQUAMATA,—*Lamarck*, An. s. vert., 1816, II, 62. *Steenstrup*, Hermaphr. i Nat., pl. i, figs. 17—21.

CORYNA MULTICORNIS,—*Ehrenberg*, Corallenthiere, Abhandl. Berl. Akad., 1832, p. 293.

CLAVA MULTICORNIS [in part],—*Johnston*, Brit. Zooph., 1847, p. 30.

CLAVA MEMBRANACEA,—*Strethill Wright*, Proc. Roy. Phys. Soc. Edinb., vol. i, p. 228, pl. x, figs. 2 and 3.

CLAVA CORNEA,—*Strethill Wright*, Proc. Roy. Phys. Soc. Edinb., vol. i, p. 228, pl. xi, fig. 4.

CLAVA SQUAMATA,—*Hincks*, Brit. Hydr. Zooph., p. 4, pl. i, fig. 2.

TROPHOSOME.—HYDROCAULUS, about one twentieth of an inch in height, consisting of minute, simple, closely aggregated, tubular offsets from the surface of the hydrorhiza. HYDRORHIZA formed of closely approximated inosculating tubes, united to one another along their sides by an extension of their perisarc, so as to form a continuous basal expansion. HYDRANTHS very much elongated, somewhat fusiform between the rudimental hydrocaulus and the club-shaped head, when fully extended attaining a height of about one inch, closely approximated at their base, so as to form a tassel-like cluster; tentacles about twenty.

GONOSOME.—GONOPHORES in clusters springing from the body of the hydranth immediately behind the proximal tentacles, each cluster carried upon a very short peduncle.

Colour.—A clear yellowish-red, with pale hyaline tentacles.

Development of Gonosome.—April to September.

Habitat.—On Fuci, especially *Fucus serratus*, *Fucus vesiculosus*, and *Fucus nodosus*, on timber-piles, &c., in estuaries and sheltered bays.

Bathymetrical distribution.—Litoral zone.

Localities.—Shores of Denmark and Norway, O. F. Müller; coast of Greenland, Otho Fabricius; sea-coast near Norwich, Pallas. Generally distributed round the shores—especially the more northern ones—of the British Isles.

The figures given by O. F. Müller, on the fourth plate of his 'Zoologia Danica,' are so characteristic as to leave no doubt regarding the animal to which the celebrated Danish zoologist has assigned the name of *Hydra squamata*, and must remove all hesitation as to the identity of Müller's species with that described above, though a nearly allied species described a few years previously by Forskal, under the name of *Hydra multicornis*, has been confounded with the present form, not only by Müller himself, but by most subsequent writers.

The first, however, who gave a description of the present species, as has been pointed out by Johnston, was the celebrated Pallas. He discovered it in England, on the shore near Harwich, and under the designation of "zoophyton minutum corynæ simillimum," has recorded it in the tenth fasciculus of his 'Spicilegia Zoologica,' published in 1774, accompanying his description with an indifferent figure.

That the species which Pallas had in view is identical with the *Clava squamata* of the present Monograph is evident from his description of it:—"Pedunculus hujus zoophyti mollis est intestiniformis, subannulatus eoque *gregatim denæ pluresve simul*, passim fucis adherens."

Few hydroids equal in beauty and interest this fine species, and most students of the lower forms of marine life will readily accept the estimate of it by the famous author of the 'Zoologia Danica:'—"Animalium quæ zoophyta dicuntur, nullum elegantius, observatorique majus gratum esse potuit." Attached to the fronds of the olive-coloured seaweeds, it may be seen at half-tides with its clear Venetian-red hydranths, forming soft, flexuous, and pensile clusters, which float passively in the surrounding water as they yield to every motion of the ebbing or flowing current.

Its proper station being from half-tide to near low-water mark, it may remain for several hours exposed upon the shore to the air and sun along with *Coryne pusilla*, *Laomedea flexuosa*, and *Sertularia pumila*, which, like it, love the higher regions of the tide range. The hydranths are then much contracted, and lie close to one another, so that the whole cluster, looking like a round, fleshy mass clinging to the seaweed, is enabled to retain sufficient moisture until the returning tide brings the sea again within its reach; and then the hydranths once more stretch themselves out to their full length, and the entire colony again expands itself in all its beauty beneath the flowing water.

In every specimen which I have examined in its fully extended state the hydranth, at the point where it springs from the little tubes which form the rudimental hydrocaulus, is much attenuated; soon afterwards it increases in diameter, and then again slightly thins away before it ultimately enlarges into its club-shaped head. Throughout the whole there extends a continuous gastric cavity, whose width varies from distance to distance with the varying diameter of the hydranth, and which, during the contraction of the hydranth, is thrown into close zigzag folds still visible through the surrounding tissues.

Clava squamata is in perfection during the whole of the summer months, and then the heavy clusters of gonophores, grouped round the base of the club-shaped head of the hydranth, add greatly to its singularity and beauty. It is strictly monœcious, each tuft-like colony giving rise to gonophores, which are all exclusively male or all exclusively female.

The adult hydranth in its extended state sometimes shows a slight enlargement of the extreme points of its tentacles, as if these manifested a tendency to terminate in the capitula so characteristic of *Coryne* and certain other hydroid genera. The terminal enlargement of the tentacles, however, in Clava is entirely transitory and dependent on a particular state of contraction. It must not, therefore, be confounded with the capitula of *Coryne*, which are not only independent of the state of contraction, but possess a structure different from that of the rest of the tentacle. *Heterocordyle Conybearei* and some other hydroids with filiform tentacles show, like *Clava squamata*, a tendency to the terminal enlargement of the tentacles in certain states of contraction.

One of the most distinctive features of *Clava squamata* is to be found in the peculiar cœnosarcal expansion which forms a hydrorhiza, by means of which the whole cluster becomes united into a compound colony, and rooted to the surface which supports it (fig. 1).

Instead of being formed, as in the majority of HYDROIDA, by a system of separate filiform tubes, the component tubes of the hydrorhiza are here adnate along their sides, adhering to one another by their very thin chitinous perisarc, so as to constitute a continuous expansion, which is formed by sinuous anastomosing tubes, from whose free surface the rudimental stems, with the little cup-like investment of perisarc, are given off at such short intervals that the hydranths which they carry are closely crowded upon one another at their base.

The chitinous tubes of the hydrorhiza and hydrocaulus have been described and figured by Dr. Strethill Wright, in what he regards as two distinct species, and names *Clava membranacea* and *Clava cornea*,[1] but which are both identical with the *Hydra squamata* of Müller, the *Clava squamata* of the present Monograph. The first, however, to draw attention to the fact that *Clava* is not properly a naked hydroid, as had been previously asserted in descriptions of this genus, was Leidy, who has shown[2] that an American species, which he names *Clava multicornis*, but which Agassiz refers to his *Clava leptostyla*, is invested at its base by a distinct perisarcal tube. A similar character is presented by all the other species of *Clava*.

The development of the ovum in *Clava squamata* may be followed without much difficulty. The female gonophores usually carry each a single ovum (figs. 3, 6). I have occasionally met with two ova in the gonophore, but never with more. The ciliated planula (figs. 7, 8) is of an elongated club-shape and of a deep red colour. It is very contractile, and may sometimes be seen stretched out in a straight line, sometimes more or less coiled on itself, occasionally to such an extent that the two ends are brought into contact. After it has lost its cilia and become fixed the first tentacles are produced in a verticil of four near the distal extremity (fig. 10). Immediately below these, and alternating with them, another verticil of four tentacles is then developed, and then successive tentacles are thrown out behind those previously formed; but all trace of any distinct verticillate arrangement soon becomes lost.

In the mean time, short fleshy processes (fig. 11)—which afterwards multiply, ramify, and coalesce, so as to form the hydrorhiza—extend themselves from the base of the young hydroid, and from these new hydranths are budded forth, and thus give rise to the clustered colonies of the adult. At a very early period—shortly after the appearance of the first tentacles—a very delicate structureless pellicle may be traced over the body of the hydranth, from its base almost to the roots of the tentacles (fig. 11). During the life of the hydroid this continues upon its body as a scarcely perceptible film, but at the base it becomes thickened by new layers, so as to constitute the tubular perisarc of the hydrorhiza and of the rudimental hydrocaulus.

[1] Wright, in 'Proc. Roy. Phys. Soc. Edinb.,' 1857, p. 228, pl. xi, figs. 3, 4.

[2] "Marine Invertebrate Fauna of Rhode Island and New Jersey," in 'Journal of Acad. Nat. Sc. of Philadelphia,' vol. iii, second series, 1855, pl. ii, figs. 33, 34.

Clava squamata loves the more sheltered bays and estuaries of our coast; and I have never found it in situations exposed to the surf of the open sea. It is not uncommon in the more sheltered parts of Dublin Bay, and is abundant in most of the fiord-like inlets of the sea which characterise the western shores of Scotland. It occurs also in abundance on the shores and rocky islands of the upper parts of the Firth of Forth, where I have met with it in great perfection about forty miles from the open sea, at Craigflower, the seat of Sir J. Colvile, a point where the fresh waters of the river have not yet ceased to exert their influence on the life of the estuary.

It is a hardy species, and may be kept alive for many weeks in our aquaria.

2. Clava multicornis, *Forskal.*

Plate II, figs. 1, 2.

Hydra multicornis,—*Forskål*, Descript. Animal., 1775, p. 131, and Icones, tab. xxvi, fig. B b.
Coryne multicornis,—*Lamarck*, An. s. Vert., 1816, vol. ii, p. 62.
Coryne squamata,—*Van Beneden*, Mem. sur les Tubulaires, p. 60, pl. v.
Clava multicornis,—*Johnston* [in part], Brit. Zooph., 1847 (pl. i, figs. 1, 2)? *Leidy*, Marine Invert. Fauna of Rhode Island and New Jersey, p. 3, pl. xi, figs. 33, 34.[1] *Hincks*, Brit. Hydr. Zooph., p. 2, pl. i, fig. 1.
Clava repens,—*Wright*, Proc. Roy. Phys. Soc. Edinb., 1857.
Clava discreta,—*Allman*, Ann. Nat. Hist., 1859.

TROPHOSOME.—Hydrocaulus consisting of minute tubes, about 1-20th of an inch in height, distributed at distinct intervals over the hydrorhiza. Hydrorhiza consisting of a ramified, tubular, creeping filament, whose branches are not adherent to one another. Hydranths about a quarter of an inch in height, not clustered; tentacles in well-grown specimens, twenty or more.

GONOSOME.—Gonophores forming very shortly pedunculated, almost sessile clusters, which are aggregated on the body of the hydranth, immediately behind the proximal tentacles.

Colour of hydranth and gonophores varying from very pale brown to light red.

Development of Gonosome.—April to September.

Habitat.—Creeping over stones, sea-weeds, &c., near low-water mark.

Bathymetrical distribution.—Laminarian zone and lower limit of Litoral zone.

Localities.—Coast of Denmark, Forskal; New Jersey, Leidy; Firth of Forth, Dr. Wright; Firth of Forth, Firth of Clyde, Orkney and Shetland Islands, and various other parts of the British Isles, G. J. A.

[1] Leidy's *Clava multicornis* is regarded by Agassiz as identical with his own *Clava leptostyla*. I can see nothing, however, in Leidy's figure or description to distinguish it from the *Clava multicornis* of Forskål.

The species here described appears to be that which Forskål had in view when describing his *Hydra multicornis*, which is plainly a different species from the *Hydra squamata* of Müller and must be regarded as a scattered rather than a clustered form of the genus *Clava*.

The two forms, however, continued to be confounded by most subsequent writers. Johnston describes them both under the name of *Coryne squamata* in the first edition of his 'British Zoophytes,' 1838, and under that of *Clava multicornis* in the second edition, 1847, while his figures, when they refer to a *Clava* at all, represent a scattered rather than a clustered form.

The first, however, who described with sufficient fulness a scattered as distinguished from a clustered species of *Clava* was Wright, who, under the name of *Clava repens*, described a scattered species from the Firth of Forth. Not being aware of Wright's paper, the same species was shortly afterwards described by myself under the name of *Clava discreta*. I now believe that this species is identical with the *Hydra multicornis* of Forskål, and that it must therefore be recorded under the specific name assigned to his hydroid by the Danish naturalist.

Forskal's description is undoubtedly obscure, but I entirely agree with Mr. Hincks's criticism which leads him to refer the present species to the *Hydra multicornis* of Forskål.

Clava multicornis is a much smaller and less conspicuous species than *Clava squamata*, from which it is at once distinguished by its scattered habit, being never clustered like *Clava squamata*, and by its filiform hydrorhiza, which never forms as in the last-named species a continuous expansion by the lateral adhesion of its branches to one another.

It attaches itself to stones much more frequently than is the case with *Clava squamata*, which is almost always found on fuci or on timber piles between tide marks, and its bathymetrical area is lower than that of this species. Its favorite resort is the under surface of detached stones near low-water mark in situations but little exposed to the surf of the open sea. It would thus seem to be a light-shunning animal—a habit in which it contrasts strongly with *Clava squamata*.

3. Clava diffusa, *Allman*.

Plate II, figs. 3, 4.

Clava diffusa,—*Allman*, Ann. Nat. Hist. for January, 1863.

TROPHOSOME.—Hydrocaulus rising to a height of about half a line from a creeping filiform hydrorhiza. Hydranths slender, from one quarter to half an inch in height; tentacles about twenty.

GONOSOME.—Gonophores scattered singly and in small clusters upon the body of the hydranth, along which they extend for some distance behind the proximal tentacles.

Colour of hydranth and gonophores, light rose-colour.
Development of Gonosome observed in July.

Habitat.—Growing over the bottoms of exposed rock-pools.
Bathymetrical distribution.—Laminarian zone.
Locality.—Shetland Islands, G. J. A.

This pretty little *Clava* comes very near to *Clava multicornis*—so near, indeed, that doubts might at first be entertained as to the justice of regarding it as a distinct species. The scattered condition of its gonophores, however, offers a character which cannot be set aside. It is true that in at least one other species of *Clava,* in which the gonophores are habitually clustered immediately behind the proximal tentacles, there may occasionally be met with individuals in which the clusters of gonophores are more or less separated from one another, and carried back for some distance from the tentacles. This is the case in the *Clava leptostyla,* Agas., of which a woodcut representing this condition is given by Agassiz,[1] but I know of no case in which the segregation of the gonophores is carried to such an extent as in the present form, in which the clusters are not only widely separated from one another, but in which many may be seen completely broken up into their component gonophores, which are then scattered singly upon the body of the hydranth. It must also be noticed that this peculiarity was not confined to one or two individuals, but was presented by every gonophore-bearing hydranth of the colony. If to this character we add a greater slenderness of the hydranths and their delicate rose-colour, and further take into consideration the difference in habitat, the hydroid just described being met with at the lowest spring tides, when it is found upon the bottom of shallow rock-pools exposed to the roll of the open sea, we shall find reason to justify us in regarding it as specifically distinct from all other described Clavas.

It was upon the most exposed shores of the Out Skerries, a small rocky cluster at the extreme east of the Shetland group, that our little clava was obtained. It occurred in shallow rock-pools, overgrown with *Laminaria.* Occasionally some of the hydranths were found with atrophied tentacles, as if showing a tendency to become converted into blastostyles.

4. Clava leptostyla, *Agassiz.*

Clava leptostyla,—*Agassiz,* Contr. Nat. Hist. U.S., vol. iv, p. 218, pl xx, figs. 11—16, and pl. xxi. Also fig. 32, on p. 222. *Alex. Agassiz,* Illustr. Catal., p. 170, fig. 274. *Hincks,* Brit. Hydr. Zooph., p. 6.

TROPHOSOME.—Hydrorhiza consisting of a basal expansion formed by closely approximated and coherent tubes, which become distinct only at the extreme margin of the colony. Hydranths much attenuated for some distance from their proximal end, where they spring from the rudimental hydrocaulus, and then, suddenly increasing in thickness, continue cylindrical or slightly tapering to the base of the clavate head; tentacles from twenty to thirty-five in number.

[1] 'Contr. Nat. Hist. U. S.,' vol. iv, p. 222.

GONOSOME.—Gonophores in shortly pedunculated clusters aggregated immediately behind the posterior tentacles, or occasionally with the clusters detached from one another and extending for some distance backwards.

General Colour—Red.
Development of Gonosome observed in June and July.
Habitat.—On *Fucus vesiculosus.*
Bathymetrical distribution—Litoral zone.
Locality.—Massachusetts Bay, Professor Agassiz ; Morecambe Bay, Lancashire, Mr. West (teste T. Hincks).

The *Clava leptostyla* of Agassiz is so closely allied to the European *Clava squamata* that its recognition as a separate species is by no means obvious. Its distinguishing characters would seem to lie in its greater number of tentacles, and especially in the more cylindrical form of its hydranths, which thus contrast with the more fusiform hydranths of *Clava squamata.* Mr. Hincks believes that he has identified with it specimens of a *Clava* obtained from Morecambe Bay, and on the strength of this identification I have retained it among British species. I have never seen it, and the diagnosis given above is compiled from characters selected from the description published by Agassiz.

5. Clava nodosa, *Strethill Wright.*

Clava nodosa,—*Wright.* In Proc. Roy. Phys. Soc. Edinb., for 1862.

TROPHOSOME.—Hydrorhiza in the form of delicate threads, which "at intervals twine themselves into a convoluted knot of membranous tubes, from which a single polyp arises."—*Wright.*

GONOSOME.—?

Colour.—" Aurora red."
Habitat.—On the fronds of *Delesseria sanguinea.*
Locality.—Firth of Forth, Dr. Wright.
Bathymetrical distribution.—Laminarian zone.

I have never met with this hydroid, and all I know of it is from Dr. Wright's short description. The knotted condition of the hydrorhizal tubes is certainly very peculiar. A fuller description of the entire hydroid, however, is much to be desired, more especially as no figure accompanies the published account of it.

RHIZOGETON, *Agassiz.*

Name.—From ῥίζα, a root, and γείτων, a neighbour; so called from the situation of the sporosacs on the hydrorhiza.

TROPHOSOME.—HYDROCAULUS evanescent. HYDRORHIZA a creeping tubular stolon, invested by a delicate perisarc. HYDRANTHS sessile on the hydrorhiza, elongated, subcylindrical, carrying towards their distal extremity scattered filiform tentacula.

GONOSOME.—SPOROSACS springing from the hydrorhiza.

Rhizogeton is one of the new genera described by Agassiz in his 'Contributions.' It has certain affinities with *Clava*, from which it differs chiefly in its gonosome, for the gonophores arise separately from the hydrorhiza, while in *Clava* they spring from the body of the hydranth.

Only one species has been as yet described.

⁂ RHIZOGETON FUSIFORMIS, *Agassiz.*

RHIZOGETON FUSIFORMIS,—*Agassiz*, Contr. Nat. Hist., U.S. vol. iv, p. 224, pl. xxii, figs. 17—23. *Clark,* Mind in Nature, p. 73, note, figs. 38, 39.

TROPHOSOME.—HYDRANTHS attaining a height of from one eighth to one quarter of an inch, invested by a delicate filmy pellicle, tapering distally to a blunt point; tentacles about twelve in number, borne by nearly the whole of the distal half of the hydranth.

GONOSOME.—GONOPHORES oval, elevated on peduncles, which arise singly from the hydrorhiza; both peduncles and gonophores invested by a filmy perisarc.

General Colour.—Orange.
Development of Gonosome observed in May.
Habitat.—In rock-pools between tide marks.
Bathymetrical distribution.—Litoral zone.
Locality.—Massachusetts Bay, Professor Agassiz and Professor H. J. Clarke.

The description and figure of *Rhizogeton fusiformis* given by Agassiz are those of male specimens only, but Prof. H. J. Clarke, who had an opportunity of observing both sexes, has described and figured female colonies. He has noticed that the ova, after the earlier stages of their development have been passed in the interior of the gonophore, break through its walls, and then remain for some time confined between the outer ectodermal layer of the gonophore and its perisarcal investment.

Agassiz, from whose descriptions I have selected the characters out of which the diagnosis just given has been constructed, informs us that the male gonophore becomes converted into a hydranth after the discharge of its contents. This converting of a gonophore into a hydranth has been already referred to in the former part of the present monograph,[1] where it is regarded as an abnormal phenomenon.

CORDYLOPHORA, *Allman.*

Name.—From κορδύλη, a club, and φορέω, I bear; in allusion to the form of the trophosome.

SYNCORYNE,—*Agassis.*
(?) TUBULARIA,—*Agardh.*

TROPHOSOME.—HYDROPHYTON consisting of a well-developed ramified HYDROCAULUS, which springs from a creeping filiform HYDRORHIZA; the whole invested by a PERISARC. HYDRANTHS fusiform.

GONOSOME.—SPOROSACS borne on the hydrocaulus.

The genus *Cordylophora* was instituted by me many years ago[2] for a tubularian hydroid singularly exceptional in its mode of life, for it was found in fresh water, and thus along with one other genus, namely, *Hydra*, affords an exception to the otherwise universally marine habitat of the HYDROIDA.

Agassiz,[3] believing that the hydroid on which I founded the genus *Cordylophora* is congeneric with a hydroid discovered long ago by Cavolini in the Bay of Naples, and described by him under the name of *Sertularia parasitica*, would refer them both to the genus *Syncoryne* of Ehrenberg.

From this determination, however, I must altogether dissent. The name of *Syncoryne* was introduced by Ehrenberg in 1833[4] in order that it might replace that of *Stipula*, Sars' name for a genus of hydroids exactly equivalent with the *Coryne* of Gärtner. To this genus *Syncoryne*

[1] See above, p. 204.

[2] 'Reports of the Meeting of the British Association,' held in Cork, 1843, and 'Ann. Nat. Hist.,' xiii, p. 330.

[3] 'Contr. Nat. Hist. U.S.,' p. 239.

[4] 'Corallenthiere des Rothes Meeres.'

Ehrenberg erroneously referred Cavolini's hydroid, and he has in this respect been followed by Agassiz, who, moreover, refers to it the species of the genus *Cordylophora*, which, no less than the *Sertularia parasitica* of Cavolini, are absolutely excluded from it.

But in order that the genus *Syncoryne* may admit these forms, Agassiz finds it necessary to modify it by removing from it all the species included in it by Ehrenberg except the *Sertularia parasitica* of Cavolini, which, as has just been said, was erroneously placed there by Ehrenberg.

Now this reconstruction of *Syncoryne* in a sense in which the genus was not understood by its founder is inadmissible, but even supposing it allowed, I must still differ from the distinguished North American zoologist in his generic association of *Cordylophora* with the *Sertularia parasitica*.

The *Sertularia parasitica* already taken by Van Beneden as the type of a new genus, *Corydendrium*, Van Ben.,[1] is certainly a very remarkable hydroid, and though much is still needed for a satisfactory knowledge of it, we can gather from the figures and description left by Cavolini that it has a curious complex hydrophyton, that it has a singularly extensile and dilatable proboscis, and that its gonophores are phanerocodonic. In all these points Cavolini's hydroid stands widely separated from the species of *Cordylophora*, so widely that it cannot be associated with them in a common generic group.

1. Cordylophora lacustris, *Allman*.

Plate III.

Tubularia cornea ?—*Agardh*, Kongl. Vetensk. Ak. Förhandl. Stockholm, 1816.

Cordylophora lacustris,—*Allman*, Brit. Assoc. Reports, for 1843; Phil. Trans., 1853, p. 367, pl. xxv and xxvi. *Hincks*, in Ann. Nat. Hist., for March, 1853; and Brit. Hydr. Zooph., p. 16, pl. iii, fig. 2. *Van Beneden*, in Bul. Ac. Roy. de Belg., 2me sér., vol. xxiii, No. 5, 1867. *F. E. Schulze*, Ueber den Bau und die Enwicklung von Cordylophora lacustris, mit sechs Kupfertafeln, Leipzig, 1871.

Syncoryna lacustris,—*Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 339.

TROPHOSOME.—Hydrocaulus alternately branched, attaining a height of from two to three inches; perisarc gradually losing itself on the neck of the hydranth, and with shallow annulations at the origins of the ultimate ramuli. Hydranths with about sixteen tentacles.

GONOSOME.—Gonophores obovate, invested by an extension of the perisarc; on short stalks, springing from the sides of the ultimate ramuli on which they are alternately disposed.

Colour.—Hydranth nearly colourless, but with a pale reddish-brown tint; gonophores with a reddish-brown spadix; perisarc brown in the older parts, pale straw colour in the younger.

[1] 'Bull. Acad. Brux.,' 1844.

Development of Gonosome.—June to August.

Habitat.—Attached to the under surface of floating timber, and to various submerged bodies in fresh and slightly brackish water.

Localities.—Grand Canal Docks, Dublin, G. J. A.; Commercial and West Indian Docks, London, Dr. Bowerbank and G. J. A.; a freshwater cistern near London, Busk; agricultural drains near Lynn Regis, Dr. Lowe; canal near Ostend, Van Beneden; Schleswig, Semper; neighbourhood of Stockholm, Retzius; near Rostock, F. E. Schulze.

I first met with *Cordylophora lacustris* on the bottom of an old canal boat which had been lying for a long time in the docks of the Grand Canal, near Dublin. These docks form the termination of a canal which receives its supply of water from lakes in the interior of the country. The docks are many feet above the river Liffey, from which, however, vessels can be admitted into them by means of a lock; and though the part of the river with which they can be thus made to communicate is under the influence of the tide, the quantity of salt water which may get access to the docks at the time when vessels enter them from the river is altogether inappreciable.

Cordylophora lacustris occurs also very abundantly and in great perfection on floating timber in the Commercial and West Indian Docks on the river Thames, where it is accompanied by *Spongilla fluviatilis*, and by Hydras, freshwater *Polyzoa*, and other freshwater mollusca, as well as by Potomogetons, Lemnas and various other freshwater plants. Here also any sea water which during the entrance of vessels may get admittance to the docks is quite inappreciable to the taste.

But the *Cordylophora* has been also found in water supplied to the inhabitants of London for drinking and other domestic purposes, for Busk has identified with it a hydroid met with in a dark cistern filled with water obtained for these purposes from the river Thames. Quite recently it has been found by Professor Van Beneden on shells of *Dreissena polymorpha*, and on timber from a canal near Ostend. Specimens of *Cordylophora lacustris* have been kept alive and in health by myself for many weeks in the ordinary drinking water of the City of Dublin. This water is brought from freshwater lakes which lie far away in the interior of the country, so that there can be no question as to the present species living and thriving in absolutely freshwater.

I must here mention, however, that specimens obtained in the West Indian Docks were, after having been brought to Edinburgh, placed in some of the water supplied to the inhabitants for domestic purposes, where they continued to live for some weeks, but with an evident loss of vigour; many of the hydranths had fallen off the branches, and fresh buds were but feebly produced. In this state of things I added a very small quantity of sea water to the fresh water in my jars—less than one hundredth part of the whole—when my specimens, after a few days, had quite recovered their original vigour, and had begun to throw out abundance of healthy hydranth buds.

From this it would seem that the specimens from the West Indian Docks were unable to dispense, at least suddenly, with the very minute quantity of sea water which may occasionally gain access to the Docks, a quantity so small as to be entirely inappreciable to the sense of taste, and which in no way interferes with the healthy growth of truly freshwater animals and plants which, along with the *Corydylophora*, are found abundantly in the Docks.

It is highly probable that *Cordylophora lacustris* is an introduced species, possibly imported into this country, as *Dreissena polymorpha* has been supposed to be, on foreign timber, and like this mollusc is now making its way into our canals and rivers. It is a light-shunning animal delighting in such obscure places as the under side of a large log of floating timber, and always avoiding exposure to the direct rays of the sun. The specimens already mentioned as flourishing in water supplied for domestic purposes to the inhabitants of London were found in a dark cistern constructed in the interior of a house, and totally excluded from all access of daylight.

The hydranths of *Cordylophora lacustris* are very mutable in shape, and they may be seen, according to their state of contraction, varying from a short fusiform or clavate figure to a nearly cylindrical one. The tentacles when contracted are short and thick, but may be extended to long thin thread-like appendages, which float listlessly in the water, as they yield to every impulse of the passing current.

The gonophores afford a good example of that form in which the spadix becomes branched, enveloping in its ramifications the ova or the spermatozoa. This branched condition of the spadix I mistook at first for a system of radiating canals,[1] an error which subsequent observations, aided by experience in the investigation of other hydroids, have enabled me to correct.

Dr. F. E. Schulze has recently made this species the subject of an excellent memoir, in which he discusses many important points bearing in the minute structure of the HYDROIDA. (See above, Part I, p. 228.)

*** 2. CORDYLOPHORA ALBICOLA, *Kirchenpauer*.

CORDYLOPHORA ALBICOLA,—*Kirchenpauer*. In a letter to Mr. Busk in Journ. Mic. Sci., 1861, p. 283, pl. ix, figs. 12—14.

TROPHOSOME.—HYDROCAULUS attaining about one inch in height; branches alternate, annulated; perisarc terminating abruptly below the hydranth.

GONOSOME not known.

Habitat.—On buoys in tidal rivers near the highest limit of the tide.

Locality.—The River Elbe, Senator Kirchenpauer.

I have selected the characters given in the above diagnosis from Senator Kirchenpauer's description and figures communicated by Mr. Busk to the 'Journal of Microscopic Science.' Kirchenpauer believes that in the form of the body and tentacles of the hydranth characters may also be found by which *Cordylophora albicola* shows itself to be a distinct species from *Cordylophora lacustris*; in these, however, I can see nothing beyond indications of a particular state of contraction. It is in the well-marked annulation of the branches, not merely at their origin but throughout, and in the abrupt termination of the chitinous perisarcal tube as shown in Kirchenpauer's figure, that the only valid grounds of specific distinction are to be found.

The species was discovered by Senator Kirchenpauer on those buoys in the estuary of the Elbe, which lie furthest from the upper limit of the tide, and consequently most removed from

[1] 'Phil. Trans.,' loc. cit.

the influence of the sea water. On those buoys which lay further down the river no *Cordylophora* was found, but in its stead abundance of truly marine hydroids.[1]

The observations made by Kirchenpauer on the change of life as seen in the forms which successively show themselves on the buoys in proceeding from the sea at the mouth of the river upwards into the fresh water, are full of interest and significance.

TUBICLAVA, *Allman.*

Name.—From *Tubus*, a tube, and *Clava*, a genus of hydroids; in allusion to the form of the trophosome, which resembles a *Clava* invested by a tubular perisarc.

TROPHOSOME.—HYDROPHYTON consisting of a conspicuous HYDROCAULUS in the form of simple or branched stems, and of a creeping filiform HYDRORHIZA; the whole invested by a chitinous PERISARC. HYDRANTHS claviform, with scattered filiform tentacles.

GONOSOME.—[GONOPHORES adelocodonic, borne by the hydranth at the proximal side of the tentacles.]?[2]

It was in one of the shallow rock pools left by the retiring tide at Torquay that I obtained the trophosome of a hydroid which resembled that of a minute *Clava* in all respects, except in the fact that the hydranths were supported on conspicuous though simple stems, which were invested by a distinct perisarc.

The specimens were unfortunately destitute of gonophores, but the trophosome brought to my mind a very similar hydroid which I had obtained several years previously on the shores of Dublin Bay, and in which the gonosome was present.

The Dublin Bay specimens, like those of Torquay, had a developed hydrocaulus, which was invested by a perisarc. The gonosome was exactly that of *Clava multicornis*, consisting of similar clusters of gonophores grouped round the base of the hydranth-head. I regarded it, indeed, at the time as a mere variety of *Clava multicornis*, in which the hydrocaulus had taken on an unusual development, and I thought little more about it until the occurrence of the Torquay hydroid brought it to my memory.

While I consider the Torquay hydroid with its well-developed hydrocaulus as generically distinct from *Clava*, I am now disposed to regard it as identical with the hydroid of Dublin Bay. If so, the gonosome is known, and we have all the data necessary for a complete generic diagnosis.

[1] Kirchenpauer, "Die Seetonnen der Elbmündung." 'Abhandl. naturwiss. Vereine in Hamburg,' iv Band, 1862.

[2] See the general remarks on the genus given below.

Some time afterwards I obtained at Tenby another hydroid resembling the Torquay one in all its more important characters, but with a still more conspicuous hydrocaulus, for this was occasionally branched, while it attained at least twice the height of that of the hydroid from Torquay. Like this, however, the Tenby hydroid was unfortunately without a trace of gonosome.

From a comparison of the three hydroids now mentioned, I consider myself justified for the present in regarding the Tenby and Torquay hydroids as generically identical, though specifically distinct, while that from Dublin Bay is probably of the same species as the Torquay one.

It is to the new genus thus represented by two species that I have given the name of *Tubiclava*; but since I do not at this distance of time feel absolutely certain as to the identity of the Dublin Bay and Torquay hydroids, the gonosome of *Tubiclava* must still be regarded as in some respects hypothetical, and the genus itself as defined above must be accepted with just so much of a provisional element.

If the gonosome of *Tubiclava* be formed as here considered probable on the type of that of *Clava*, then *Tubiclava* is a *Clava* with a developed hydrocaulus, and is especially interesting as a transition form between *Clava* and *Cordylophora*, its gonosome being that of the former, and its trophosome that of the latter.

1. Tubiclava lucerna, *Allman*.

Plate II, figs. 7, 8.

Tubiclava lucerna,—*Allman*. In Ann. Nat. Hist., for June, 1863, and for May, 1864.

TROPHOSOME.—Hydrocaulus about two lines in height, simple, cylindrical, with a slight dilatation at the base of the hydranth; perisarc with shallow corrugations. Hydranth when extended about equal in height to the stem, and with about twenty tentacles, which are confined to its distal third.

GONOSOME.—[Gonophores in dense clusters, immediately below the proximal tentacles.]?[1]

Colour.—Hydranths milk white, with pale ochreous tint on the stomach cavity.
Development of Gonosome.—(?) observed in June.
Habitat.—Creeping over stones in rock pools.
Bathymetrical distribution.—Litoral zone.
Localities.—Dublin Bay and Torquay, G. J. A.

Tubiclava lucerna is a minute hydroid, and might easily be overlooked or without close examination be mistaken for a creeping form of *Clava*. The hydranth is very contractile: when

[1] See for the evidence as to the nature of the gonosome the general remarks on the genus given above.

fully extended it is nearly cylindrical, but may assume when contracted a short thick pyriform shape. In its extended state it brings to mind somewhat the form of a lighted torch, a resemblance which has suggested the specific name which I have assigned to it.

2. Tubiclava fruticosa, *Allman.*

Plate 11, figs. 5, 6.

TROPHOSOME.—Hydrocaulus attaining a height of four or five lines, more or less branched; perisarc smooth. Hydranths nearly cylindrical in extension; tentacles, from fourteen to eighteen, occupying about two thirds of the hydranth.

GONOSOME unknown.

Colour.—Hydranth deep vermilion passing into pale red in the cœnosarc, where it is invested by the translucent pale straw-coloured perisarc.

Habitat.—Attached to rocks at extreme low water spring tides.

Bathymetrical distribution.—Lower limits of Laminarian zone.

Locality.—Tenby, G. J. A.

Tubiclava fruticosa forms small vermilion tufts on rocks which are exposed only at very low spring tides. The hydranths when extended are nearly cylindical, but become clavate in contraction. They may occasionally be seen bent on one side so as to assume a nutant attitude. The periderm is light straw colour, and so translucent as to allow the pale red cœnosarc to be seen through it.

The budding hydranth is entirely enveloped in a delicate extension of the perisarc of the stem which carries it, and within the sort of capsule thus formed the tentacles of the bud are developed. When it has attained sufficient maturity the hydranth breaks through its chitinous envelope, and thus comes into immediate contact with the surrounding water.

MERONA, *Norman.*

Name.—An arbitrary name without any special significance.

Tubiclava,—*Norman,* in Ann. Nat. Hist., 1864.
Merona,—*Norman,* in Ann. Nat. Hist., 1865.

TROPHOSOME.—Hydrophyton consisting of a developed hydrocaulus and a creeping filiform hydrorhiza; the whole invested by a chitinous perisarc. Hydranths claviform.

GONOSOME.—SPOROSACS borne on BLASTOSTYLES, which spring directly from the creeping hydrorhiza.

This genus has been instituted by the Rev. A. Merle Norman, for the reception of a hydroid which he at first referred to the genus *Tubiclava*. The gonosome, however, belongs to a type generically different from that which we have reason to believe is the gonosome of *Tubiclava*, for while in the latter genus the gonophores would seem to be borne directly by the hydranth, they are in *Merona* carried upon blastostyles which spring from the hydrorhiza.

MERONA CORNUCOPIÆ, *Norman*.

TUBICLAVA CORNUCOPIÆ,—*Norman*, in Ann. Nat. Hist., for Jan., 1864, pl. ix, fig. 5. *Hincks*, Brit. Hydr. Zooph., p. ii, pl. ii, fig. 2.
MERONA CORNUCOPIÆ,—*Norman*, Ann. Nat. Hist., for April, 1865.

TROPHOSOME.—HYDROCAULUS consisting of slightly curved trumpet-shaped tubes, which are given off at short intervals from the creeping HYDRORHIZA, and gradually increasing in diameter from the base to the summit, attain a height of one fifth of an inch, or a little more, the tubes marked by a few slightly elevated transverse lines of periodic growth. HYDRANTHS with greatly elongated club-shaped heads.

GONOSOME.—GONOPHORES forming mulberry-like masses on the summit of very short BLASTOSTYLES, which are invested at their base by a tubular extension of the hydrorhizal perisarc.

Habitat.—Growing on the shells of living mollusca from deep water.

Bathymetrical distribution.—Deep sea zone.

Locality.—About twenty miles north of Unst in Shetland, Rev. A. M. Norman. Other parts of the Shetland seas, Mr. Peach.

Merona cornucopiæ was observed by Mr. Norman upon the shells of *Astarte sulcata* and *Dentalium entalis* which had been dredged from a depth of from 80 to 100 fathoms. The very considerable depth thus frequented by this hydroid constitutes an interesting fact in its economy. Mr. Norman also informs us "that in every instance it was observed upon shells still occupied by the living mollusca, and that it had invariably assumed a position at the posterior extremity of the shell where it would receive the benefits of the aqueous currents caused by the mollusc."

TURRIDÆ.

TROPHOSOME.—Hydrocaulus rudimental or developed. Hydranths with scattered filiform tentacles.

GONOSOME.—Gonophores medusiform; planoblasts with simple radiating canals, and simple marginal tentacles.

TURRIS, *Lesson.*

Name.—From *Turris*, a tower, in allusion to the form of the umbrella.

TROPHOSOME.—Hydrophyton consisting of a creeping filiform hydrorhiza and a rudimental hydrocaulus, the whole invested by a perisarc. Hydranths claviform.

GONOSOME.—Gonophores phanerocodonic. Umbrella of mature medusa subcylindrical; manubrium massive, with a four-lipped mouth; radiating canals four; marginal tentacles numerous, each with a bulbous base having a distinct ocellus.

The gonosome of this genus has long been known, but it is only within a few years that its trophosome has been detected. For the discovery of the trophosome of *Turris*, we are indebted to Gosse, who found that the eggs discharged from the medusa to which Lesson assigned the name of *Turris neglecta*, developed themselves into a *Clava*-like trophosome, an observation which was afterwards confirmed and extended by Strethill Wright.

Turris neglecta, *Lesson.*

Turris neglecta (planoblast),—*Lesson*, Prodromus (1837), No. 38; Hist. Nat. des Acad. (1843), p. 281. *Forbes*, British Medusæ, p. 23, pl. iii, fig. 2.
(Planoblast and trophosome), *Gosse*, Devonshire Coast, p. 318, pl. xiii, figs. 6—10.
Clavula Gossii (trophosome), *Strethill Wright*. In Edinb. New Phil. Journ., for July, 1859, pl. viii, fig. 1.

TROPHOSOME.—HYDRANTHS about a line in height, scattered on the HYDRORHIZA, and with twelve or more tentacles.

GONOSOME.—Umbrella of mature MEDUSA mitrate; marginal tentacles sixty or more.

Colour.—Hydranths and ovarian masses in the walls of the manubrium bright crimson.
Habitat of gonosome pelagic, of trophosome unknown.
Locality (of gonosome), European seas.

Observations are still needed for an adequate knowledge of the completely developed trophosome of this beautiful little hydroid. The ciliated planula is of a fine crimson, and Gosse traced its development as far as the production of a creeping stolon, and the formation of a hydranth which he followed to the emission of its first four tentacles, while Wright, carrying his observations further, saw the tentacles become multiplied to twelve, and noticed the production of a chitinous perisarc on the stolon and rudimental stem. Beyond this, however, no observations have been carried, and we as yet know nothing of the part of the trophosome from which the gonophores are developed, nor of the condition of the medusæ at the time of their liberation.

Wright gave to the trophosome of *Turris neglecta* the name of *Clavula Gossii*, a name, however, which, in accordance with the principles which must regulate the nomenclature of the HYDROIDA, has to yield to that long previously given to the medusa.

CAMPANICLAVA, *Allman.*

Name.—From *Campana*, a bell, and *Clava*, a genus of hydroids; in allusion to the medusiform gonophores and the clava-like trophosome.

SYNCORYNE,—*Gegenbaur.*

TROPHOSOME.—HYDROPHYTON a creeping filiform HYDRORHIZA, invested by a PERISARC; HYDROCAULUS undeveloped. HYDRANTHS claviform.

GONOSOME.—GONOPHORES phanerocadonic, borne by the hydrorhiza; umbrella at the time of liberation deep bell-shaped; manubrium destitute of oral tentacles; radiating canals four; marginal tentacles two, continuous with two opposite radiating canals, and having bulbous bases without ocelli, two intervening smaller bulbs corresponding with the terminations of the other two radiating canals in the circular canal.

The genus *Campaniclava* has been constituted for a remarkable hydroid described by Gegenbaur under the name of *Syncoryne Cleodoræ*, but which cannot be received into the genus *Syn-*

coryne as understood in the restricted sense required by our present views of the limitation of hydroid genera. It includes a single species.

*** Campaniclava cleodoræ, *Gegenbaur*, sp.

Syncoryne cleodoræ,—*Gegenbaur*, Generationsweehsel, p. 11, pl. i, figs. 3, 4.
Campaniclava cleodoræ,—*Allman*, in 'Ann. Nat. Hist.,' for May, 1864.

TROPHOSOME.—Hydrorhiza branched, carrying the hydranths at distinct intervals along its course. Hydranths one half a line in height, with from five to eight tentacles.

GONOSOME.—Gonophores sessile, scattered on the hydrorhiza. Umbrella of planoblast, with a superficial band of thread-cells lying over each radiating canal, and extending from the summit of the umbrella to its margin; manubrium extending to about half the depth of the umbrella-cavity, its mouth provided with four short lobes set with thread-cells.

Development of Gonosome.—November to March.
Habitat.—Growing on the shell of living *Cleodora tricuspidata*.
Bathymetrical distribution.—Surface zone.
Locality.—Coast of Sicily, Gegenbaur.

The two-tentacled medusa of *Campaniclava cleodoræ* is without doubt destined to undergo changes before attaining maturity. It is almost certain that at least two additional tentacles become developed, one from each of the intermediate marginal bulbs, as indeed the observations of Gegenbaur, who obtained in the open sea free medusæ which he refers to this species, but which were provided with four tentacles, go far to prove.

In its habitat *Campaniclava cleodoræ* presents, as Gegenbaur notices, a feature of no little interest, for it grows on the shell of a pelagic mollusc, so that not only do the medusæ which constitute its gonosome enjoy a free locomotive life, but the trophosome also spends its life upon the open sea, always wandering over its surface like the active pteropod with which it has associated itself.

Among forty specimens of *Cleodora tricuspidata* observed by Gegenbaur no less than four fifths of the whole carried a colony of *Campaniclava* on their shells.

CORYDENDRIUM, *Van Beneden.*

Name.—From κορύνη, a club, and δένδρον, a tree; in allusion to the form of the trophosome.

SERTULARIA,—*Cavolini,* Mem. Polyp.

TROPHOSOME.—HYDROPHYTON consisting of a well-developed HYDROCAULUS, and a creeping filiform HYDRORHIZA; the whole invested by a distinct PERISARC. HYDRANTHS fusiform, with scattered filiform tentacles.

GONOSOME.—PLANOBLASTS borne on the hydrocaulus. Form of MEDUSA unknown.

The present genus was instituted by Van Beneden for the *Sertularia parasitica* of Cavolini, a hydroid which Ehrenberg had incorrectly referred to his genus *Syncoryne;* Agassiz, believing that the species of *Cordylophora* are congeneric with Cavolini's hydroid, refers them both to the genus *Syncoryne,* which, however, he finds it necessary to reconstruct for their admission. I have already shown that this view is untenable.

⁎ CORYDENDRIUM PARASITICUM, *Cavolini.*

SERTULARIA PARASITICA,—*Cavolini,* Mem. Polyp., Sprengel's translation, p. 83, tab. vi, figs. 8—13.

SYNCORYNE PARASITICA,—*Ehrenberg,* Corallenthiere, Abhandl. der Akad. Wissens., Berlin, for 1832, p. 295. Agassiz, Contr. Nat. Hist. U.S., vol. iv, p. 339.

CORYDENDRIUM PARASITICUM,—*Van Beneden,* Bul. Ac. Roy. de Bruxelles, 1844, p. 313.

TROPHOSOME.—HYDROCAULUS attaining a height of about two inches; much branched; fascicled[1] in the main stems, single in the smaller ramuli. HYDRANTHS with a very extensile and dilatable hypostome.

GONOSOME.—GONOPHORES on short peduncles, springing singly from a point close to the junction of the ultimate ramuli with the branches from which they arise.

General colour.—Dark red.

[1] I use the term "fascicled" here and elsewhere to indicate a composition out of many longitudinally coherent tubes, each invested by its own perisarc.

Development of Gonosome.—Summer.

Habitat.—Growing on the hydrorhizal stolons of *Eudendrium racemosum* (Cavolini).

Bathymetrical distribution.—Litoral zone?

Locality.—Bay of Naples, Cavolini.

Since the time when Cavolini, towards the end of the last century, described his *Sertularia parasitica*, no one has met with this remarkable hydroid; and though Cavolini's description of it is, like all his others, full and lucid, we must wait for further observations made with the advantages afforded by our present knowledge of the HYDROIDA, in order that some points of which we are as yet ignorant in its structure and habits may be cleared up.

That it produces phanerocodonic gonophores there can be no doubt from Cavolini's description and figures, though the Neapolitan zoologist takes them for budding hydranths. It follows too from his description that the main stems consist of a fascicle of tubes which breaks up into single tubes before entering the branches; and though it would seem that he believed the bundle of tubes composing the stem to be enveloped in a common perisarc, it is more probable that each tube has its own perisarcal investment as in other fascicled hydroids.

A remarkable feature is found in the great extent to which the hypostome can be elongated and dilated; indeed, Cavolini's figure of the hypostome when thus distended reminds one of the exserted proboscis of certain annelides.

A curious fact on which Cavolini dwells at considerable length is the occurrence at certain periods of egg-like bodies in the interior of the hydrocaulus where they replace the cœnosarc, and from which they are subsequently discharged through the extremities of the branches now destitute of hydranths.

Cavolini takes these bodies for the proper eggs of the hydroid, and even describes their development into young trophosomes; but as it is rather by inference than by direct observation that he traces his young hydroids from the supposed eggs, we must here withhold assent from his conclusions. Indeed, it is far more probable that the egg-like bodies are parasitical organisms than that they have any direct relation with the hydroid.[1]

Cavolini always found the present species growing from the root-like basis of the *Eudendrium racemosum* after the hydranths of the *Eudendrium* had perished and disappeared. He accordingly regards it as a parasite of the *Eudendrium* at whose expense he imagined it to live, and it was this supposed habit which suggested to him the specific name by which he has designated it. It is almost certain, however, that there is here no case of true parasitism, and it is very likely that the *Corydendrum parasiticum* enjoys other habitats as well as that which was alone known to the celebrated Neapolitan observer.

[1] We may here, however, compare Cavolini's account of these egg-like bodies with an observation made by F. E. Schulze on *Cordylophora lacustris*. Schulze informs us that he had occasionally met with bodies indistinguishable from young ova imbedded in the ectoderm of the branches of *Cordylophora*. (Schulze, 'Ueber Cordylophora Lacustris,' p. 37). A very similar observation had been made on *Hydractinia echinata* by M. de Quatrefages. See above, p. 223.

CORYNIDÆ.

TROPHOSOME.—HYDROCAULUS developed. HYDRANTHS with scattered or more or less spirally disposed capitate tentacles.

GONOSOME.—GONOPHORES fixed SPOROSACS.

CORYNE, *Gärtner.*

Name—From κορύνη, a club; in allusion to the form of the hydranths.

TUBULARIA,—*Gmelin.*
SYNCORYNE,—*Ehrenberg.*
HERMIA,—*Johnston.*

TROPHOSOME.—HYDROPHYTON consisting of a simple or branching HYDROCAULUS, rooted by a creeping filiform HYDRORHIZA: the whole invested by a chitinous PERISARC. HYDRANTHS claviform, with scattered capitate tentacles.

GONOSOME. — SPOROSACS developed from the body of the hydranth.

The genus *Coryne* was founded by Joseph Gärtner, the author of the famous botanical work 'De Fructibus et Seminibus Plantarum.' It is described in a letter written by Gärtner to Pallas, an extract from which, with a figure of the species on which Gärtner founded his genus, was published by Pallas in 1774, in the tenth fasciculus of his 'Spicilegia Zoologica.'

The limits of *Coryne*, however, as a well-defined generic group, were afterwards disturbed by the introduction into it of certain forms not contemplated by its founder. In this way the *Hydra squamata* of O. F. Müller—though a separate genus under the name of *Clava* had been constituted for it by Gmelin—came to be included in the genus *Coryne*, and we find Bosc,[1] Lamarck,[2] and Cuvier[3] adopting this association.

[1] 'Hist. Nat. des Vers.,' tom. ii, p. 239.
[2] 'An. s. Vert.'
[3] 'Règne Animal,' 1817.

In 1829, however, Sars[1] drew attention to the heterogeneous nature of the group *Coryne* as then accepted by systematists, and proposed to break it up into two genera, retaining the name of *Coryne* for the *Hydra squamata* of Müller, and referring the true Corynes of Gärtner to a separate genus, which he named *Stipula*, apparently unaware that the forms which he desired to include under his new genus were those for which Gärtner had long previously founded his genus *Coryne*.

Though Sars has thus done good service in discriminating forms falsely associated, there was no need for his new name, *Stipula*; for it is plain that he ought to have retained in the genus *Coryne* the forms for which this genus had been founded by Gärtner, while he should have assigned the *Hydra squamata* to the genus *Clava*, already constituted for it by Gmelin.

We next find Ehrenberg[2] accepting the dismemberment of *Coryne*, as proposed by Sars, but instead of objecting to the name of *Stipula* on the ground that it was needless, he objects to it on the ground that it was already in use among the botanists; and then, instead of referring the *Hydra squamata* to its legitimate genus, *Clava*, and restoring to its proper place Gärtner's name of Coryne, he introduces the generic name of *Syncoryne*, to supplant the *Stipula* of Sars. The *Coryne* of Gärtner, *Stipula* of Sars, and *Syncoryne* of Ehrenberg, are thus merely synonymes of the same group.

But though the group under these different names was accurately determined, it began once more to lose its unity by the introduction into it of forms generically distinct from the original *Coryne*, and a new dismemberment was accordingly called for.

This dismemberment I adopted some years ago.[3] The grounds on which it must be based will be found, not in the trophosome, but in the gonosome, the gonophores of which, in some of the species included by modern systematists under the genus *Coryne* or *Syncoryne*, are adelocodonic, while in others they are phanerocodonic; and again, among these phanerocodonic gonophores forms will be found which differ from one another by characters of generic value.

If we can satisfy ourselves as to the form Gärtner had in view when he constituted his genus *Coryne*, there can be no doubt as to those to which this name must now be restricted. The whole question, therefore, necessarily turns on the identification of the *Coryne pusilla* of Gärtner.

It must be admitted that we cannot always determine with certainty the exact species which the earlier systematists had before them in their descriptions, for it was not until a more accurate knowledge of the structure and life-history of the HYDROIDA pointed to the significance of certain characters previously overlooked that the true value of these characters could be recognised in systematic zoology. There can be thus no doubt that many very distinct species, and even genera, of hydroids have been described under the same name; and though our attempts at the identification of many of the hydroids referred to in the writings of the last century and the earlier parts of the present can have little more than approximate results, still I believe that we shall be justified in regarding as Gärtner's "pusilla" a well determined and abundant species of our shores.

It is by no means easy to find among the true *Corynes* characters available for specific distinction, and most of the forms which have been described as distinct are far from being so strongly

[1] 'Bidrag til Söedyrenes Naturhistorie,' p. 4.
[2] 'Corallenthiere,' 1833.
[3] 'Ann. Nat. Hist.,' for May, 1861.

marked as to enable them to be unhesitatingly received as so many well-defined species. Indeed, though I have enumerated under the genus *Coryne* several species with the diagnoses proposed for them by their describers, I am well disposed to believe in the absolute validity of only three of these, the *Coryne pusilla*, the *Coryne vaginata*, and the *Coryne cæspes*.

1. Coryne pusilla, *Gärtner*.

Plate IV, figs. 1—7.

Coryne pusilla,—*Gartner*, in Pallas. Spicil. Zool., fasc. x, p. 40, tab. iv, fig. 8. Johnston, Brit. Zooph., 1847, p. 39, pl. ii.
Tubularia coryna,—*Gmelin, Linn.*, 3834.
Coryne glandulosa,—*Lamarck*, An. s. Vert., tome ii, p. 62.
Syncoryne pusilla,—*Ehrenberg*, Corallenthiere, 294.
Hermia glandulosa,—*Johnston*, Brit. Zooph., 1838, p. 111, woodcut 12.

TROPHOSOME.—Hydrocaulus attaining a height of about an inch, much and irregularly branched; perisarc distinctly annulated, not sending off a sheath upon the base of the hydranth. Hydranth with about thirty tentacles.

GONOSOME.—Sporosacs globular; developed among the tentacles from the body of the hydranth.

Colour.—Hydranths and sporosacs flesh colour, perisarc reddish-brown.
Development of Gonosome.—May to September.
Habitat.—Growing on fuci and on rocks between tide marks.
Bathymetrical distribution.—Litoral zone.
Localities.—Coast of Cornwall, ? Gärtner; east and west shores of Scotland, and Orkney Islands, G. J. A.; Shetland Islands, Rev. A. M. Norman and G. J. A.; Dublin Bay, G. J. A.

The determination of the true *Coryne pusilla* of Gärtner is by no means an easy task. The figure in the "Spicilegia Zoologica" is rude, and far from being sufficiently exact for undoubted specific identification, and I know of no species which exactly answers to the description.

It is thus, perhaps, impossible to determine with certainty the species which Gärtner had before him, and which, it would appear, he obtained on the coast of Cornwall, when he furnished Pallas with the first description and figure on record of a *Coryne*. A species, however, which is widely distributed round our coasts, and is in some localities very abundant, would seem to agree as nearly as any other with Gärtner's hydroid. It is this species which Johnston, in the first edition of his "British Zoophytes," figures and describes under the name of *Hermia glandulosa*, adopting the specific name from Lamarck, who used it for the *Coryne pusilla* of Gärtner. In his second edition Johnston describes and figures the same hydroid, but now restores to it Gärtner's name of *Coryne pusilla*.

This determination I shall follow. It is the nearest which the data at our command entitles us to adopt, and I agree to it all the more willingly, as by doing so we retain in the nomenclature of Zoology a name which has no slight historical claims on our acceptance.

Coryne pusilla is a litoral species occurring between tide marks, where it may be found attached to various sea-weeds, more especially *Fucus nodosus* and *Fucus serratus*. When well developed it forms dense tufts, about three quarters of an inch or even an inch in height, and with the stems attaining a thickness of about one quarter of a line, the whole conspicuous by the fine deep flesh colour of the hydranths. Shorter and more slender varieties however, which scarcely attain more than half these dimensions, are not uncommon. It is not unfrequently associated with *Clava squamata*, though its zone of greatest perfection is a little below that of the *Clava*. It may often be seen after the retreat of the tide, exposed for a considerable time to the air and sun while waiting for the return of the sea, and protected from desiccation only by the moisture of the surrounding sea-weeds and the water it still contains entangled among its crowded branches.

It is a fine typical *Coryne*, and while living forms under a low power of the microscope a most beautiful object for the zoophyte trough.

2. Coryne vermicularis, *Hincks*.

Coryne vermicularis,—*Hincks*, in Ann. Nat. Hist. for Oct., 1866. Brit. Hydr. Zooph., p. 1, 2, pl. viii, fig. 2.

TROPHOSOME.—Hydrocaulus branched dichotomously, and forming dense shrubby tufts, which attain a height of about three quarters of an inch; perisarc annulated, especially towards the base; often smooth or slightly wrinkled on the branches and upper portions of the stem. Hydranths "of great length (about one sixth of an inch when mature), stout, almost cylindrical for half their length when extended, and then tapering off very gradually towards the oral extremity; tentacles in irregular and very distant whorls, rather stout, with large capitula, about twenty-five in number."

GONOSOME.—Sporosacs "borne at the base of the tentacles over the lower part of the body; spherical; shortly stalked."

Bathymetrical distribution.—Deep-sea zone.
Locality.—Shetland Isles; Rev. T. Hincks.

I have never met with any species which exactly agrees with that just described. Mr. Hincks, from whose account of it I have given the above diagnosis, informs us that it is "distinguished by the great size and worm-like appearance of the polypites, and the sparing distribution of the tentacles over the body." It is, however, by no means easy to distinguish it from *Coryne pusilla*.

3. Coryne vaginata, *Hincks.*

Plate IV, figs. 8, 9.

Coryne pusilla, *var.* muscoides,—*Johnston,* Brit. Zooph., 1847, p. 12, pl. vi, figs. 4, 5.
Coryne vaginata,—*Hincks,* in Ann. Nat. Hist. for 1866. Brit. Hydr. Zooph., p. 41, pl. viii, fig. 1.

TROPHOSOME.—Hydrocaulus rising to a height of from two to three inches, alternately branched, each of the main branches sending off numerous short alternate simple ramuli; perisarc distinctly and regularly annulated. Hydranths borne upon a narrow neck, which is surrounded by a loose membranous sheath, derived from the perisarc, and losing itself on the body of the hydranth; tentacles about twenty.

GONOSOME.—Sporosacs globular, developed from the body of the hydranth, each springing by a short peduncle from the axil of a tentacle.

Colour.—Hydranths and sporosacs pale pink, perisarc light brown.

Development of Gonosome.—Summer and autumn.

Habitat.—Attached to sea-weeds and to the sides of rock pools, near low-water mark.

Bathymetrical Distribution.—Lower part of Litoral zone.

Localities.—Coasts of Devonshire, Rev. T. Hincks and G. J. A.; Coast of Cornwall and Southern and Eastern Coasts of Ireland, G. J. A.; North-east Coast of Ireland, Mr. William Thomson.

Coryne vaginata forms branching hydrosomes, longer, looser, and more flexile than those of *Coryne pusilla*, while its large size and the symmetrical distribution of its branches renders it a conspicuous and beautiful object in the clear rock pools where it is rooted.

One of its most striking characters is the sheath-like extension of its perisarc, by which the neck of every hydranth is invested in a loose transparent pellicle, a feature to which attention was first called by Mr. Hincks. This is plainly a continuation of the most external or oldest layers of the perisarc, which in the young state of the hydranth constitute an external capsule, in which the entire hydranth-bud is included, and within which this bud passes through the earlier stages of its development.

It is a very abundant and characteristic species on the southern shores of Devonshire and Cornwall, and on the southern shores of Ireland. It occurs also on the eastern shores of Ireland, where I have found it in considerable abundance in Dublin Bay, while it has been obtained by Mr. William Thomson on the same shores, as far north as Strangford Lough. I have never met with it on any part of the Scottish coast or on the coasts of the adjacent islands, the genus being there chiefly represented by *Coryne pusilla.*

4. Coryne fruticosa, *Hincks*.

Coryne fruticosa,—*Hincks,* in Ann. Nat. Hist., ser. 3, vol. viii, p. 158, [pl. vi. Brit. Hydr. Zooph., p. 14, pl. vii, fig. 2.

TROPHOSOME.—Hydrocaulus bushy, slender, slightly and irregularly annulated throughout, much and irregularly branched, with the perisarc delicate, branches erect, long, closely set. Hydranths swollen below, tapering above; tentacles about twenty, rather long, with small capitula, a verticil of about five immediately below the mouth, the rest scattered.

GONOSOME.—Gonophores densely clustered, chiefly about the lower part of the body; sessile; very large when mature.

Habitat.—On Fuci.
Bathymetrical Distribution.—Litoral zone.
Locality.—Exmouth, Rev. T. Hincks.

I have never seen this species, and have contented myself with simply giving Mr. Hincks' description of it. He further tells us that it "forms dense clustered bushy masses on Fucus." It is plainly very nearly allied to the *Coryne pusilla*—so nearly that, though I have here accepted Mr. Hincks' determination of it, I feel much tempted to regard it as a mere variation of that species, more slender and less distinctly annulated than the typical form.

*** 5. Coryne ramosa, *Sars*.

Stipula ramosa,—*Sars,* Bidrag til Söedyrenes Naturhistorie, p. 4, tab. i, fig. 1.
Syncoryne ramosa,—*Ehrenberg,* Corallenthiere, Abhandl. Akad. Wissens., Berlin, 1832, p. 295.

TROPHOSOME.—Hydrocaulus attaining a height of from one to two inches, slender, much ramified, with the branches subalternate, and very divergent from the stem at their origin; perisarc annulated. Hydranths elongate, subcylindrical, with from twenty to twenty-five tentacles.

GONOSOME.—Gonophores oval, shortly pedunculate, springing from among the tentacles towards the proximal end of the hydranth.

Colour.—Hydrocaulus light brownish yellow; hydranth brownish red; gonophores pale red.

Development of Gonosome.—July.

Habitat.—On sea-weeds.

Bathymetrical Distribution.—Litoral zone.

Locality.—Coast of Norway (Sars).

It was upon the present species that Sars, in the year 1829, founded his genus *Stipula*, with the intention of removing to it the true Corynes which had, at the time when Sars proposed his reform of the genus *Coryne*, been mixed up with *Clava*. We have already given the reasons which render necessary the rejection of the nomenclature thus introduced by the celebrated Norwegian zoologist.[1]

I have never met with the *Coryne ramosa*. It is described by Sars as occurring in great abundance in the neighbourhood of Bexen, where it grows close to the surface of the water, on a sea-weed which he names *Fucus natans*. Its taller growth and more elongated hydranths would seem to distinguish it from *Coryne pusilla*, though I cannot regard its distinctness from this species so fully established as to remove all doubts as to its validity as a separate species, while it is distinguished from *Coryne vaginata*, not only by the absence of a sheath-like extension of its perisarc, but by its more irregular ramification.

*** 6. Coryne cæspes, *Allman*.

TROPHOSOME.—Hydrocaulus scarcely exceeding a quarter of an inch in height, unbranched, or occasionally with one or two simple branches; irregularly annulated, the stems all closely crowded upon a hydrorhiza, which is formed by a creeping entangled mass of tortuous tubes. Hydranth elongated with about twenty-five tentacles.

GONOSOME.—Sporosacs globular, scattered on the lower portion of the hydranth, where they spring by short peduncles from the axils of the tentacles.

Colour.—Hydranths and spadix pale flesh-colour, perisarc reddish-brown.

Development of Gonosome.—March.

Habitat.—Spreading over the surface of submerged rocks.

Bathymetrical distribution.—Region of the *Cystoseira*. About two feet below the surface of the sea at low water.

Locality.—Gulf of Spezia.

Coryne cæspes forms a dense moss-like growth, which spreads like a close turf over the surface of submerged rocks, for many square miles in extent. It is a well-marked species; its short and, for the most part, simple stems, and its dense, crowded, moss-like growth, easily distinguish it from all the described species.

[1] See above, p. 265.

It occurs in considerable abundance on the west side of the Gulf of Spezia, on rocks which are never uncovered by the sea.

PROVISIONAL AND INDETERMINABLE SPECIES.

Certain hydroids have been from time to time described whose probable, or at least possible, place is in the genus *Coryne*; but which from the fact of our as yet knowing only their trophosomes, cannot be assigned to this genus otherwise than provisionally; while others, though referred by their describers to *Coryne*, have been so very imperfectly described as to render their determination impossible.

Among those which are in all probability correctly referred to this genus is the following :—

Coryne nutans, *Allman* (provisionally).

TROPHOSOME.—Hydrocaulus attaining a height of about four lines, much branched; branches subalternately disposed, deeply and distinctly annulated, the annulation of the hydrocaulus becoming less distinctly marked towards the base. Hydranths depressed on one side of the stalk, so as to assume a nutant posture; ovate, with about fifteen tentacles.

GONOSOME unknown.

The little coryniform hydroid here described was obtained in Burraforth Caves, Shetland, by the Rev. A. M. Norman, who placed in my hands for examination some specimens which had been preserved in spirits.

These specimens were entirely destitute of gonosome, and its determination cannot, therefore, be regarded as otherwise than provisional. The trophosome, however, was well preserved, and one of its most characteristic features consisted in the drooping attitude assumed by the hydranths, a feature which has suggested the name by which I have designated the species.

Among provisional species must also be included the *Coryne sessilis* of Gosse.[1] This is a minute coryniform hydroid with undeveloped hydrocaulus, and with nearly colourless, very elongated hydranths, having the tentacles more than forty in number, and arranged in about six verticels. As the trophosome is the only part of the hydroid known, the determination of the genus must be held over until the discovery of the gonosome shall afford the necessary data. It will then be most probably seen that the gonophores are phanecodonic, and that the hydroid must consequently be removed from *Coryne*. Mr. Gosse himself, indeed, assigns to his determination of it only a provisional value. He obtained it attached to a rock on the coast of Ilfracombe.

[1] Gosse, 'Devonshire Coast,' p. 208, pl. xiv, figs. 2, 3.

The *Coryne ramosa* of Chamisso and Eysenhardt,[1] recorded by Ehrenberg,[2] under the name of *Syncoryne Chamissonis*, is also indeterminable from want of a detailed description of the gonosome. It is a branching species, attaining a height of about half an inch, and having its gonophores clustered on the body of the hydranth just below the tentacles; but of the nature of those gonophores we have, as may be expected, no account. It was obtained on the coast of La Manche.

Among indeterminable species must also be mentioned three which were discovered by Bosc on floating fucus in the open sea, and figured and described by him under the names of *Coryne prolifica*, *Coryne amphora*, and *Coryne filifera*.[3] Of these his *Coryne filifera* is probably a *Clava*, but so very imperfect are the figures and descriptions of these hydroids that no zoologist of the present day would venture to assign to them a definite place in his system.

ACTINOGONIUM, *Allman*.

Name.—From ἀκτις, a ray, and γόνος, offspring.

SYNCORYNE, *Van Beneden*.
CORYNE, *Hincks*.

TROPHOSOME.—HYDROPHYTON consisting of a developed HYDROCAULUS springing from a creeping filiform HYDRORHIZA, the whole invested by a conspicuous PERISARC. HYDRANTHS claviform, with scattered capitate tentacles.

GONOSOME.—SPOROSACS developed from the body of the hydranth, and giving origin to ACTINULÆ.

The genus *Actinogonium* is founded on a hydroid, described by Van Beneden under the name of *Syncoryne pusilla*, but which, judging from the account given by the Belgian naturalist, differs altogether from the genus *Syncoryne* by the earlier stages of its development. Its mature trophosome is that of a *Syncoryne* or of a *Coryne*, but its development is from an actinula instead of a planula, a character which I regard as of sufficient importance to entitle it to a distinct generic rank.

[1] 'Nov. Act.,' x, p. 370, tab. xxiii, fig. 3 *a*, *b*.

[2] 'Corallenthiere,' p. 295.

[3] Bosc, 'Hist. Nat. des Vers.,' tome ii, pp. 239-40, pl. xxii, figs. 6—8.

*** ACTINOGONIUM PUSILLUM, *Van Beneden.*

SYNCORYNE PUSILLA,—*Van Beneden,* Mém. sur l'Embryog. des Tubulaires, p. 53, pl. iii, figs. 1—12.
CORYNE VAN BENEDENII,—*Hincks,* Brit. Hydr. Zooph., p. 45, pl. ix, fig. 1.

TROPHOSOME.—HYDROCAULUS attaining a height of about one eighth of an inch, capillary irregularly ramified; PERISARC thin, transparent, slightly annulated. HYDRANTHS with about twelve tentacles.

GONOSOME.—GONOPHORES few in number, globular, on short peduncles borne by the hydranth at the base of the inferior tentacles. ACTINULÆ with four tentacles.

Colour.—Perisarc pale-yellowish.
Habitat.—Attached to the carapace of crabs and to various other bodies.
Locality.—Coast of Belgium, M. Van Beneden.[1]

The *Syncoryne pusilla* of Van Beneden is certainly not the *Coryne pusilla* of Gärtner, though the latter is cited by the Belgian zoologist under the synonymes. There is, moreover, some confusion between the *Syncoryne pusilla* of the 'Memoir on the Embryogeny of the Tubularians' and a hydroid to which Van Beneden refers this species in his later memoir ('Faune lit. de Belgique'). The species of the later memoir bears medusiform planoblasts, and would seem to be a true *Syncoryne,* though no description of it is given sufficient for diagnosis. M. Van Beneden declares that it would be difficult to say whether it differs really from the *Syncoryne decipiens* of Dujardin.

From the description and figures given by Van Beneden of the *Actinogonium pusillum* it is impossible to regard the body which has liberated itself from the sporosac as other than an actinula. Van Beneden describes it as resembling a minute cuttle-fish with four arms ("poulpe à quatre bras"), and he further compares it to the free planoblast described by M. de Quatrefages under the name of *Eleutheria.*

Through the kindness of M. Van Beneden I have received specimens of his *Syncoryne pusilla* preserved in spirits, but with the gonosome, unfortunately, in so imperfect a state as to render it impossible to demonstrate in it the important points described by the distinguished Belgian zoologist. Mr. Hincks, however, has been more fortunate, for in specimens supplied some time ago by M. Van Beneden to Mr. Alder, he has succeeded in confirming the presence of actinulæ. He has also detected in the walls of the sporosac four canals extending from the base to the summit.

The *Actinogonium pusillum* is thus one of the very few hydroids in which the development

[1] Johnston ('Brit. Zooph.,' pl. iv, figs. 1, 2) figures among British species a coryniform hydroid, which he refers, though not without doubt, to the *Syncoryne pusilla* of Van Beneden. We have not yet, however, evidence which can be accepted of the discovery of Van Beneden's hydroid on the British shores.

has been shown to take place through actinulæ, the only other genera which have as yet afforded evidence of this mode of development being *Tubularia*, *Myriothela*, and *Hydra*.[1]

SYNCORYNIDÆ.

TROPHOSOME.—HYDROCAULUS developed or not developed, HYDRANTHS with scattered, or partly scattered and partly verticillate capitate tentacles.

GONOSOME.—Gonophores in the form of medusiform PLANOBLASTS with four radiating canals and simple (rarely undeveloped) marginal tentacles.

SYNCORYNE, *Ehrenberg* (in part).

Name.—From σύν, indicating union, and κορύνη, a club, in allusion to the numerous club-shaped hydranths united into a common colony.

TROPHOSOME.—HYDROPHYTON consisting of a simple or branching HYDROCAULUS, with a creeping filiform HYDRORHIZA; the whole invested by a chitinous PERISARC. HYDRANTHS claviform, with scattered capitate tentacles.

GONOSOME.—PLANOBLASTS, developed upon the body of the hydranth. MEDUSA, at the time of liberation, with a deep bell-shaped umbrella; manubrium moderately large, destitute of oral tentacles; marginal tentacles four, with bulbous bases usually furnished with an ocellus; or the medusæ may never become free, the marginal tentacles remaining at the same time in an imperfectly developed state.

When Sars saw the necessity of reducing to some kind of zoological consistency the confused state into which the genus *Coryne* had fallen, he founded, as has been already said,[2] his genus *Stipula* for the reception of all the known claviform hydroids with scattered capitate tentacles. We have seen, too, that Ehrenberg's name of *Syncoryne* afterwards took the place of *Stipula*, and since then it has been by many authors adopted in its stead.

As the species thus included under *Syncoryne* increased in number by fresh discoveries, it became evident that very different plans of gonosome were to be found among them; we now know that some carry only sporosacs, while others give origin to medusæ, and still further these

[1] See Part I, p. 94. [2] *Vide* suprà, p. 265.

medusa-bearing forms present such differences in their gonosomes that it is impossible to comprise them all under a single genus.

I believe that our descriptive zoology of the HYDROIDA will be best served by retaining the name of *Syncoryne*, though in a more restricted and definite sense than that in which it has been generally employed. We shall thus avoid a further complication of synonymy, and preserve a sufficiently expressive and convenient name.

I shall thus employ Ehrenberg's name of *Syncoryne* for those hydroids which with a coryniform trophosome possess a gonosome which is referable to the form described above under the character of the genus.[1]

Among some species of the genus *Syncoryne* we find the very exceptional condition of the planoblast never detaching itself from the trophosome, although its well-developed umbrella completely fits it for free locomotion. Under these circumstances the manubrium becomes loaded with generative elements, sometimes to such an extent as completely to fill the cavity of the umbrella, while the marginal tentacles remain imperfectly developed. This condition of the planoblast is precisely that which is presented by the gonophores of certain SIPHONOPHORA.

*** 1. SYNCORYNE SARSII, *Loven*.

SYNCORYNE SARSII,—*Loven*, in Transactions of the Royal Swedish Academy of Sciences, 1835, translated in Wiegmann's Archiv, 1837, p. 323, tab. vi, fig. 25. Sars, Fauna lit. Norv., p. 2, tab. i, figs. 1—6.

TROPHOSOME.—HYDROCAULUS rising to the height of half an inch, slender, sparingly branched, nearly smooth. HYDRANTHS with from twelve to sixteen tentacles.

GONOSOME.—GONOPHORES developed among the tentacles on the body of the hydranth. Manubrium with the margin of the mouth slightly crenulated; marginal tentacles set with round wart-like clusters of thread-cells, and having a brownish-red ocellus in their bulbous bases.

Colour.—Hydranths pale rose colour, manubrium of medusa clear red.
Development of Gonosome.—May and June.
Habitat.—On Laminaria and other sea-plants.
Bathymetrical distribution.—Laminarian zone.
Localities.—Island of Floröe, Coast of Norway (Sars); The Cattegat (Loven).

I have never met with this species myself, and have drawn up the above diagnosis from Sars's description of a Norwegian hydroid which he refers to the *Syncoryne Sarsii*, figured and so

[1] I have already defined the genus *Syncoryne* in the sense here explained, "On the Construction and Limitation of Genera among the Hydroida," 'Ann. Nat. Hist.' for May, 1864.

named by Loven, but not described by him with sufficient detail for satisfactory diagnosis. In this determination I have followed Sars, though it must be admitted that, if Loven's observation as to the occurrence in his species of certain gonophores which occupy the position of a hydranth on the extremity of a branch be free from error, it is not easy to accept unhesitatingly the specific identity of the two hydroids. It is possible, however, to explain the peculiar position of the medusa in Loven's specimens by referring it to the atrophy of a hydranth which may at one time have terminated the branch, and by its subsequent disappearance have allowed the medusa, properly lateral, to assume an apparently terminal position.

The *Syncoryne Sarsii* is one of the hydroids which form the subject of Loven's famous Memoir, in which he shows the production of ova by medusiform buds, and is thus one of the first in which the production of medusa buds was noticed and described by a competent observer.

*** 2. Syncoryne Loveni, *Sars.*

Syncoryne racemosa,—*Loven,* in Trans. Roy. Acad. of Sciences of Sweden, 1835, translated in Wiegman's Archiv, 1837, Band i, p. 321, tab. vi, figs. 19, 20.

Syncoryne Loveni,—*Sars,* Fauna lit. Norv., p. 2, note.

TROPHOSOME.—Hydrocaulus much branched, forming intricate, flexuous, and shrubby growths, which rise to a height of an inch and a half. Hydranths with sixteen tentacles.

GONOSOME.—Planoblasts permanently attached, borne on short peduncles, which spring from the body of the hydranth, just behind the posterior tentacles. Umbrella elongate, bell-shaped, set with scattered thread-cells; marginal tentacles rudimental; manubrium, with its investing mass of ova, nearly filling the cavity of the umbrella, and with its mouth minute, and surrounded by a circle of rudimental tentacles.

Habitat.—On a rocky bottom among shells and sea-weeds.
Bathymetrical distribution.—Laminarian zone?
Locality.—Coast of Norway, Loven and Sars.

I have never met with this apparently well-marked species, and the diagnosis here given is framed from Loven's memoir.

Syncoryne Loveni possesses much historical interest as having, along with *Syncoryne Sarsii* and *Gonothyræa Loveni* (*Campanularia geniculata* of Loven), formed the subject of Loven's memoir, in which Ehrenberg's views of the zooidal and sexual nature of the egg-bearing bodies of the Hydroida were for the first time confirmed.

Loven names the species *Syncoryne ramosa,* believing it to be identical with the *Stipula* *ramosa* of Sars.[1] Sars, however, himself in a subsequent work[2] contends against this identification, and proposes for Loven's species the name of *Syncoryne Loveni*.

Syncoryne Loveni is one of the few hydroids in which the medusa, though provided with a well-developed umbrella, remains permanently attached to the trophosome, developing and discharging its generative elements at a comparatively early period of its existence, and then withering away without ever becoming free.

3. SYNCORYNE GRAVATA, *Strethill Wright*.

CORYNE GRAVATA,—*Strethill Wright*, in Trans. Roy. Physical Soc. Edin., 1857, p. 338, pl. xix, fig. 5.

TROPHOSOME.—HYDROCAULUS simple (?) rising to the height of about one quarter of an inch from a creeping stolon; PERISARC smooth. HYDRANTHS with from ten to twelve short tentacles.

GONOSOME.—MEDUSÆ permanently attached, long cylindrical, springing from among the tentacles on the body of the hydranth, umbrella with the marginal tentacles undeveloped, each being represented by a minute bulb; manubrium piriform, and with its mass of generative elements nearly filling the cavity of the umbrella.

Colour.—Hydranths and umbrella colourless, marginal bulbs of medusa brown, manubrium with its burden of spermatozoa milk white.

Development of Gonosome.—Spring.

Habitat.—On the sides of a rock-pool.

Bathymetrical distribution.—Litoral zone?

Locality.—North Berwick, Firth of Forth (Dr. T. S. Wright).

I have never met with this species. The above diagnosis, which has been drawn up from Dr. Strethill Wright's description, must be regarded as applying strictly only to the male, female specimens not having yet been observed. The growth of the large gonophore, with its voluminous mass of generative elements, occasionally causes the atrophy and almost entire disappearance of the hydranth from which it springs.

Syncoryne gravata is nearly allied to *Syncoryne Loveni*. It resembles it especially in its gonophores, which, though phanerocodonic, develop and discharge their generative elements without ever becoming detached from the trophosome.

[1] Sars, 'Bidrag til Söedyrenes Naturhistorie.'

[2] 'Fauna lit. Norv.'

*** 4. Syncoryne mirabilis, *Agassiz*.

Coryne mirabilis, — *Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 185, pls. xxvii—xx.
Clark, Mind in Nature, p. 77, figs. 40—42.

TROPHOSOME.—Hydrocaulus consisting of branching stems, which, without any distinctly differentiated hydrorhiza, adhere to some fixed object for a greater or less extent of their length, and then become free, forming irregularly ramified tufts, which usually attain a height of about half an inch; perisarc smooth. Hydranths with about sixteen tentacles.

GONOSOME.—Medusæ borne on the body of the hydranth, either from among the tentacles or from a point just behind the most posterior ones. They are of two forms, free and fixed; the free gonophores (produced in the earlier months of the year) have a wide umbrella, with well-developed marginal tentacles, set with irregular clusters of thread-cells, and provided with an ocellus in the basal bulb; manubrium of moderate size. The fixed gonophores (produced at a later period) have a deep thimble-shaped umbrella, imperfectly developed marginal tentacles without ocelli at the base, and a very large manubrium, which, with the generative elements developed in its walls, nearly fills the cavity of the umbrella, and even projects beyond it.

Development of Gonosome.—January to May.

Habitat.—Attached to rocks, sea-weeds, and floating timber in the sea and in the brackish water of the estuaries of rivers.

Locality.—Atlantic shores of North America, Agassiz and Clark.

I have compiled the above diagnosis from characters selected from the elaborate description of the species by Agassiz, whom, along with Professor Clark, I have followed in referring the two forms of gonophores described in the diagnosis to one and the same species. I cannot, however, but think that for so remarkable a fact, unsupported, as it is, by the analogy of other hydroids, stronger evidence is needed than any that has been adduced by the American zoologists. Until specimens shall be found in which the two kinds of gonophores exist simultaneously, or until these can be shown to be consecutively developed from one and the same colony confined in our aquaria, or otherwise subjected to continuous observation, we can scarcely accept the specific identity of the two forms as proved.[1]

[1] Mr. Hincks, however ('Brit. Hydr. Zooph.,' p. 54), not only adopts the views of Agassiz and Clark upon this point, but refers the *Syncoryne mirabilis*, Agas., to the *Syncoryne gravata*, Wright, regarding the latter as the arrested condition of the former.

Agassiz, however, is not only convinced of this identity, but he maintains that the two hydroids described by Loven under the names of *Syncoryne ramosa* and *Syncoryne Sarsii*, the one with fixed and the other with free phanerocodonic gonophores, are only different states of a single species,[1] a view which, in my opinion, is quite untenable.

Indeed, I am well inclined to keep all the forms with coryne-like trophosome and fixed phanerocodonic gonophores in a distinct group, generically separated from the true Syncorynes.[2] The chief argument against thus treating them is derived from the observations of Agassiz and Clark as to the production of fixed and free medusæ by the *Syncoryne mirabilis*. These observations, if verified, would be fatal to the proposed separation, but, as already said, I am by no means convinced of their being free from error.

The free medusa of *Syncoryne mirabilis* possesses at the time of its liberation a manubrium, which is but little extensile, and scarcely exceeds in length half the vertical diameter of the umbrella. Agassiz and Clark, however, believe that they have traced this medusa in the open sea through every stage of growth up to the condition of a true *Sarsia*, with its elongated and amazingly extensile manubrium loaded with generative elements, the very species which Agassiz had already described and figured under the name of *Sarsia mirabilis*.[3]

There can be no doubt that the changes which a phanerocodonic gonophore may undergo in the period between its detachment from the trophosome and its acquisition of a sexually mature state are frequently very great, and there is no reason why the medusa of *Syncoryne* should be exempt from them. The evidence, however, adduced by the American zoologists as to the ultimate form of this medusa cannot be regarded as conclusive. There is necessarily a want of direct and continuous observation, and the forms figured by Agassiz as progressive stages of development do not, in my mind, tend to remove the doubt. The proof has certainly not been yet given that the *Sarsia* form is that which the free medusa of *Syncoryne* must ultimately attain.

5. SYNCORYNE PULCHELLA, *Allman*.

Pl. VI, figs. 1—3.

SYNCORYNE PULCHELLA,—*Allman*, in Ann. Nat. Hist. for June, 1865.

TROPHOSOME.—HYDROCAULUS consisting of simple stems rising at short intervals from a creeping reticulated stolon, and attaining a height of about half an inch; PERISARC thin, and destitute of annulation, but showing some indistinct transverse rugæ. HYDRANTHS with from fifteen to twenty tentacles.

[1] Agassiz, 'Contr. Nat. Hist. U.S.,' vol. iv, p. 190, note.

[2] To the genus thus constituted the name of *Stauocodium* (σταυός, κώδων) might be conveniently given.

[3] Agassiz, "Contributions to the Natural History of the Acealephæ of North America," 'Mem. Amer. Acad. Nat. Sc.,' 1850, p. 224, pls. iv, v.

GONOSOME.—PLANOBLASTS borne on short peduncles in a dense cluster immediately below the tentacles. Umbrella with its transverse and vertical diameters nearly equal, its outer surface set with scattered thread-cells, and having two well-marked meridional furrows extending along the middle lines of two opposite interradial spaces from the summit of the umbrella to its margin, while two nearly obsolete furrows may occasionally be seen ocupying a similar position in the remaining two interradial spaces; marginal tentacles very extensile, nodulated with clusters of thread-cells, which give them a moniliform character when extended, one larger cluster terminating the tentacle; tentacular bulbs with a distinct ocellus.

Colour.—Body of hydranth deep orange, becoming paler when it passes into the pale orange stem; manubrium and tentacular bulbs of medusa deep orange.

Development of Gonosome.—April.

Habitat.—Rooted to the bottom of rock-pools near low-water mark.

Bathymetrical distribution.—Lower part of Litoral zone.

Locality.—Skelmorlie and Rothsie, Firth of Clyde (G. J. A.).

Syncoryne pulchella, though of humble habit, is yet conspicuous by the bright orange colour of the hydranths and medusa-buds. Paler varieties, however, may occur. It is nearly allied to the *Syncoryne decipiens* of Dujardin, with which it agrees in the form of the planoblast, and in the fact that these are all borne at the proximal side of the tentacula. From *Syncoryne decipiens*, however, it differs in its simple habit, and in the more ovate form and more numerous tentacles of the hydranth.

With *Syncoryne eximia* also the present species closely agrees in the form of the planoblast, though the position of these on the trophosomes of the two species are very different. The planoblasts, indeed, are scarcely distinguishable from one another, except in the fact that the longitudinal furrows of the umbrella do not exist in *Syncoryne eximia*.

*** 6. SYNCORYNE DECIPIENS, *Dujardin*.

SYNCORYNE DECIPIENS (trophosome), STHENYO (planoblast),—*Dujardin*, in Ann. Sci. Nat., 3ième sér., 1845, tome iv. p. 275, pl. xiv, fig. B.

TROPHOSOME.—HYDROCAULUS branched, attached by a creeping stolon, and invested by a smooth PERISARC. HYDRANTHS nearly cylindrical, with eight or nine tentacles.

GONOSOME.—PLANOBLASTS produced immediately below the tentacles of the hydranth; transverse and vertical diameters of umbrella nearly equal, a longitudinal furrow in the middle of each interval of the radiating canals; marginal tentacles moniliform, with clusters of thread-cells, and having an ocellus in the bulbous base.

Locality.—Lorient, Dujardin.

The *Syncoryne decipiens* possess an historic interest in being a species which had afforded material for some of the earliest observations on the production of free medusæ by the fixed trophosome, for it was studied by Dujardin, who has described it in his well-known memoir as presenting an example of this phenomenon.

It is not easy, however, to collect from Dujardin's description characters sufficient for a satisfactory diagnosis of the species; those given above may be gathered from his memoir, and are probably sufficient to secure this species from being confounded with any other.

Dujardin describes its medusa, which he names "Sthenyo" as undergoing some time after its escape from the trophosome, and while still in the confinement of his vases, certain remarkable changes, which consist chiefly in a complete retroversion of the umbrella. The changes noticed by Dujardin would seem to be very similar to those which I have myself observed in the nearly allied *Syncoryne pulchella*. (See above p. 203).

7. Syncoryne frutescens, *Allman*.

Plate VI, figs. 4—6.

TROPHOSOME.—Hydrocaulus much branched, rising from a creeping stolon, and attaining a height of from one to two inches; perisarc smooth. Hydranths oval, with about fourteen tentacles.

GONOSOME.—Planoblasts springing by short peduncles from the body of the hydranth at the proximal side of the tentacles; transverse and vertical diameters nearly equal; umbrella studded with scattered thread-cells; marginal tentacles with slightly elevated clusters of thread-cells, which render it verucose, but not properly moniliform; ocellus distinct; manubrium with the mouth surrounded by a ring of thread-cells.

Colour.—Hydranth light pink; manubrium of medusa, and basal bulbs of marginal tentacles light brownish red.

Development of Gonosome.—October.

Habitat.—On floating timber.

Locality.—Kingstown, Dublin.

I have only once met with this species, which approaches in many respects to the *Syncoryne decipiens* of Dujardin. From this species it is chiefly distinguished by its more oval hydranths and their more numerous tentacles, as well as by the less moniliform disposition of the groups of thread-cells in the marginal tentacles of the planoblast.

It was found attached to floating logs in a reservoir exposed to the tide, and constantly supplied by sea-water from Dublin Bay.

8. Syncoryne eximia, *Allman*.

Plate V.

Coryne Listerii,—*Alder*, Catal., p. 12.
Coryne eximia,—*Allman*, in Ann. Nat. Hist. for August, 1859. Alder, Suppl. Catal., p. 2. *Hincks*, Brit. Hydr. Zooph., p. 50, pl. ix, fig. 2.
Syncoryne eximia,—*Allman*, in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—Hydrocaulus much and irregularly branched, but with a tendency to a unilateral disposition of the ultimate ramuli, springing from an adherent stolon, and attaining a height of from two to three inches; perisarc for the most part annulated at the origin of the branches, the annulation gradually losing itself in shallow rugæ on the short ultimate ramuli. Hydranths much elongated, with twenty to thirty tentacles, the four distal tentacles forming a verticil.

GONOSOME.—Planoblasts scattered upon the body of the hydranth, where they are borne on rather long peduncles, which spring each from the axil of a tentacle; umbrella with the transverse and vertical diameters nearly equal, its outer surface studded with scattered thread-cells; marginal tentacles very extensile, when extended moniliform with spherical clusters of thread-cells, the terminal cluster the largest; basal bulbs with a very distinct ocellus; manubrium scarcely passing beyond the middle of the umbrella cavity, and having the mouth surrounded by thread-cells.

Colour.—Hydranths bright pink, cœnosarc pale pink, visible through the clear straw-coloured perisarc. Manubrium pale pink with bright rose-coloured base; basal bulbs of marginal tentacles rose-colour; ocellus deep carmine.

Development of Gonosome.—Summer.

Habitat.—Attached to rocks, the stems of Laminaria, &c., at extreme low water spring tides.

Bathymetrical Distribution.—Laminarian zone.

Localities.—Firth of Forth and Shetland Seas, G. J. A.; coasts of Northumberland and Durham, Mr. Alder and Mr. Hodge; south coast of Devonshire, Mr. Hincks.

Syncoryne eximia is perhaps the finest species hitherto met with of the beautiful genus to which it belongs. Its large size, the bright colour of its hydranths, often thickly set with budding medusæ, the graceful motions of those medusæ when, after freeing themselves from the trophosome, they sweep through the water in paths which the eye is never tired of following, their wonderfully extensile tentacles, like long strings of pearls streaming from the bell-margin in ever varying curves,—all contribute to render *Syncoryne eximia* one of the most singularly beautiful hydroids of our coasts. It is a lover of the laminarian zone, where the hunter at low water will easily recognise it by its large intricate straw-coloured tufts tinged with pink, and its terminal rose-coloured hydranths.

It is an abundant hydroid on the northern shores of Great Britain.

9. Syncoryne ferox, *Strethill Wright.*

Coryne ferox.—*Strethill Wright,* in Proc. Roy. Physical Soc. Edin. for Feb., 1863.
Hincks, Brit. Hydr. Zooph., p. 319.

TROPHOSOME.—Hydrocaulus "single, smooth." Hydranths with the "tentacles thick, short, having the capitate cluster of thread-cells scarcely larger than the width of the tentacle."

GONOSOME.—Medusæ "developed beneath the tentacles, similar to those of *Coryne decipiens.*"

I know nothing of this species except from Dr. Wright's description, which is chiefly occupied by a comparison of it with the *Syncoryne decipiens* of Dujardin, a hydroid which he informs us *Syncoryne ferox* "resembles in the shape and mode of development of the medusoids;" but from which it differs in its "more robust and clumsy habit." He notices also the existence on the hydranth itself of a delicate perisarcal investment ("coletoderm" of Wright), which "passes over the whole body and tentacles," causing the hydranth "to assume a dirty appearance, as it often seems to support a downy growth of very minute algæ."

It is probably a Firth of Forth species, though Dr. Wright makes no mention of either its habitat or locality.

*** 10. Syncoryne reticulata, *Alex. Agassiz.*

Syndictyon reticulatum,—*Alex. Agassiz,* in Agas. Contr. Nat. Hist. U.S., vol. iv, p. 34, and in Illustr. Catal., North American Acad., p. 177, figs. 290—297.

TROPHOSOME.—Hydrocaulus simple, or very sparingly branched, slender, not more than one tenth of an inch in height. Hydranths large; tentacles short, eight or ten in number.

GONOSOME.—Planoblasts developed from among the tentacles on the lower part of the body of the hydranth; umbrella of nearly uniform thickness throughout, with the transverse and vertical diameters nearly equal, and having its surface covered with large scattered thread-cells, between which long, narrow, superficial cells are so disposed as to give it a reticulated appearance; velum well developed; length of manubrium somewhat exceeding half the height of the umbrella cavity; marginal tentacles with large, spirally arranged, closely set clusters of very elongated thread-cells, the clusters increasing in size towards the extremity, where the tentacle terminates in a club-shaped cluster larger than the others; basal bulbs large, ovoid, each with an ocellus.

Colour of Medusa.—A very light metallic blue tinge; basal bulbs of tentacles light brown.
Habitat.—Growing on *Diphasia rosacea.*
Locality.—Massachusetts Bay, Alex. Agassiz.

For the hydroid just described Mr. Alex. Agassiz has instituted a new genus, under the name of *Syndictyon.* I can find, however, nothing in his description of the hydroid to justify its separation from *Syncoryne.* The peculiar network of superficial cells in the umbrella walls, which seems to have suggested both generic and specific names, is an interesting histological feature, but not in itself a character which can be employed in generic diagnosis.

Certain *Sarsia*-like medusæ found by A. Agassiz swimming freely in the open sea are regarded by him as the adult form of the medusa of the present species. They may be so, but the evidence is not sufficient to justify us in regarding the identity as proved.

PROVISIONAL AND DOUBTFUL SPECIES.

"Syncoryne Listerii," *Van Beneden.*

The following is Van Beneden's diagnosis of this species:—

"Tige cornée, annelée assez régulièrement dans presque toute sa longueur, ramifiée. Tentacules au nombre de seize environ." 'Recherches sur l'Embryogénie des Tubulaires,' p. 54, pl. III, figs. 11, 12.

He subsequently informs us that the medusæ "sont de forme sphérique et apparaissent à la hauteur du verticille inférieur;" and he adds, "ils portent pensons-nous, quatres cirrhes." 'Faune Lit. de Belg.,' p. 120, pl. V. fig. 5.

It is impossible to determine with precision the hydroid which Van Beneden had in view under the designation of *Syncoryne Listerii*, or, indeed, to construct from the characters which he assigns to it, a satisfactory diagnosis; and the difficulty is in no way diminished by the appended synonymes which certainly apply to a very different hydroid from that described and figured as *Syncoryne Listerii* in either of the memoirs cited above.

M. Van Beneden believes his *Syncoryne Listerii* to be identical with the hydroid which under the generic name of *Coryne*, but without a specific designation, has been described by Lister in the Philosophical Transactions for 1834. This is undoubtedly a wrong determination. The gonophore which M. Van Beneden assigns to his *Syncoryne Listerii* is phanerocodonic and apparently that of a true *Syncoryne*, though his figure shows it in too imperfectly developed a stage for accurate determination; while Lister's hydroid possesses simple sporosacs and is a true *Coryne*, almost certainly the *Coryne vaginata* of Hincks, and of the present monograph.

"SYNCORYNE JOHNSTONI," *Van Beneden.*

The hydroid to which M. Van Beneden gives the above name is described by him as follows:— "Les tentacules sont au nombre de douze, placés sur trois rangs, s'étendant pendant le repos de manière à dépasser la longueur du corp; le corp est légèrement brunâtre.

"La colonie est très-irrégulièrement ramifiée et rampante: on voit souvent des tiges droites et longues s'élever à peu de distance en dessous du corp des polipules.

"Le polypier même est transparent, d'un jaune doré plus ou moins tortueux." 'Recherches sur la Faune lit. de Belg.,' p. 120, pl. V, figs. 1—3.

Though neither figure nor description is given of the gonophore of this hydroid, we can gather from an allusion made to it by M. Van Beneden that it is medusiform. Without, however, a fuller description of the gonosome, the species cannot be regarded as otherwise than provisional.

"SYNCORYNE LOVENII," *Van Beneden.*

The hydranth in this species is described by M. Van Beneden as being very much elongated, and having its tentacles short, and arranged in four or five alternating verticils with four tentacles in each verticil; the colony ramified, with the branches appearing at rather regular intervals and never tortuous; the perisarc thin and of a golden-yellow colour. See 'Recherches sur la Faune lit. de Belg.,' p. 121.

If the verticillate arrangement of the tentacles were complete, this character would point to a relation with *Stauridium*, and would necessitate the removal of the hydroid from the genus *Syncoryne*. We often, however, meet with a tendency in the scattered tentacles of this genus to assume a verticillate disposition without forming true verticils, which is, perhaps, all that M. Van Beneden desires to assert by the phrase "tentacules en étages."

No mention is made of the size attained by this hydroid, nor is there any description of the gonosome. I have little doubt, however, that the species is distinct from any hitherto described, though we must wait for the discovery of the gonosome before we can refer it with certainty to its proper genus. It must, therefore, for the present be placed on the list of provisional species.

Under no circumstances, however, can it retain the name of *Syncoryne Lovenii*, this name having been already proposed by Sars for another species, the *Syncoryne ramosa* of Loven, who thus designated his hydroid under the belief that it was identical with the *Stipula ramosa* of Sars, an identification which Sars has since shown to be incorrect. See above, p. 276.

"CORYNE ROSARIA," *Alex. Agassiz.*

Under the name of "Coryne rosaria," Mr. Alex. Agassiz describes a large *Sarsia*-like medusa found swimming freely in the open sea on the Pacific coast of North America, and which he believes himself justified in referring to a corynoid trophosome, which he describes as profusely branched, attaining a height of from three to three and a half inches, and with its hydranths "slender and supported on remarkably long and attenuated stems." 'Illustr. Catal.,' p. 177.

His description of the adult medusa, which he tells us "attains an enormous size, measuring more than an inch in polar diameter," is very full, and is accompanied by a figure. He gives no figure, however, of the trophosome, and his description of it is hardly detailed enough for a sufficiently distinctive diagnosis, while he adduces no evidence to connect with it the free-swimming medusa.

CORYNITIS, *M'Crady*.

Name.—From κορύνη, a club, in allusion to the club-shaped hydranths.

HALOCHARIS, *Agassiz*.

TROPHOSOME.—HYDROCAULUS absent, so that the hydranths are sessile on the HYDRORHIZA.[1] HYDRANTHS cylindroid.

GONOSOME.—Planoblasts springing from the hydranth. MEDUSA (when fully developed) having a deep umbrella; manubrium massive, and destitute of oral tentacles; marginal tentacles four, each with a clavate extremity and with an ocellus on the bulbous base; roof of umbrella cavity rising in four overarched spaces, between the roots of the radiating canals.

The trophosome of the present genus was described and figured by Agassiz under the name of *Halocharis*.[2] He was unacquainted, however, with the gonosome, and he shortly afterwards changed this name to that of *Corynitis*, for he found that his *Halocharis* was identical with *Corynitis*, a genus which had been previously instituted by M'Crady[3] for a hydroid, whose gonosome, as well as trophosome, had been examined by this naturalist.[4]

The genus *Corynitis* comes very near to *Syncoryne*, from which it is separated chiefly by the undeveloped or rudimentary hydrocaulus, and to *Gymnocoryne*, so far, at least, as its trophosome is concerned, for the gonosome of *Gymnocoryne* has not yet been discovered. From the last-named genus *Corynitis* is distinguised mainly by the fact that its distal tentacles do not form a distinctly defined verticil.

[1] This character is adopted from Agassiz's description; it is highly probable, however, that a rudimental hydrocaulus will be found to exist as in *Clava*.

[2] 'Contrib. Nat. Hist. U.S.,' vol. iv, p. 239, pl. xx, f. 10.

[3] McCrady, 'Gymnoph.,' p. 131.

[4] It is true that the name of *Corynitis* had been already used by the botanist, for Sprengel had employed it to designate a genus of *Leguminosæ*. The *Corynitis* of Sprengel, however, is synonymous with *Coronella*, De Cand., and as this name has precedence in point of publication, *Corynitis* must give way to it, and becomes thus freed for appropriation by the zoologist.

*** Corynitis Agassizii, *M'Crady*.

Corynitis Agassizii,—*McCrady*, Gymnophthalmata of Charleston Harbour, p. 132, pl. ix, figs. 3—8. *Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 340.
Halocharis spiralis,—*Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 239, pl. xx, figs. 10—10 *c*.

TROPHOSOME.—Hydranth, when extended, having the form of a slender cylinder, with the spirally arranged tentacles successively increasing in size from below upwards.

GONOSOME.—Gonophores borne among the lower tentacles, or just below them. Medusa, when mature, conico-campanulate about three tenths of an inch in height; umbrella wall set with scattered clusters of thread-cells, and with its summit very thick; marginal tentacles thick, and nodulated with large pads of thread-cells, generative elements occupying about the proximal two thirds of the walls of the manubrium, which is thence continued as a more contracted tube towards the obscurely lobed mouth.

Colour of mature medusa.—Manubrium deep red, with the generative masses in its walls of a rich orange; basal bulbs and claviform terminations of marginal tentacles red.

Habitat.—"Growing on sponges a little above dead low water mark."—McCrady.

Bathymetrical distribution.—Laminarian zone.

Localities.—Charleston, South Carolina; McCrady.

The scattered tentacles of the hydranth assume in this species a more decided approach to a spiral arrangement than is generally met with in the members of its family.

The trophosome has been described by both McCrady and Agassiz. McCrady has further shown that the medusa, while still young, has only two marginal tentacles, and that at this period its umbrella walls are thin, and the overarched spaces in the roof of the umbrella cavity are absent. These overarched spaces are very striking in the fully developed medusa, and the manubrium has then the appearance of being suspended from them in such a way as to have led McCrady to compare it to "one of the massive pendants hanging from a gothic ceiling."

While there is every reason to believe that McCrady is right in referring to his corynoid trophosome the adult medusa whose description he has given, we must not lose sight of the fact that he has not traced it by continuous observation to the bitentacular form which the medusa presents while still attached to the trophosome; the evidence of identity being afforded by what he seems with justice to regard as intermediate stages of development, but which were seen only in specimens captured in a state of freedom in the open sea.

GYMNOCORYNE, *Hincks.*

Name.—From γυμνὸς, naked, and *coryne*, a genus of hydroids, in allusion to the absence of a chitine-clothed hydrocaulus.

TROPHOSOME.—Hydrocaulus undeveloped. Hydrorhiza a filiform stolon invested with a chitinous perisarc. Hydranths sessile on the hydrorhiza, with numerous tentacles, the distal tentacles disposed in a vertical round a conical hypostome, the others scattered over the body.

GONOSOME not known.

The genus *Gymnocoryne* was established by Hincks for a little hydroid which he obtained on the southern coast of Devonshire. Its most striking character by which it is distinguished from all other coryniform trophosomes except that of *Corynitis* consists in the non-development of a hydrocaulus.

It comes very near to the genus *Corynitis*, from which, indeed, in the absence of all knowledge of the gonosome, it is chiefly distinguished by the verticillate disposition of its distal tentacles, and though a tendency to this disposition is seen, according to Agassiz, in *Corynitis*, it does not seem to be there much more marked than it is in many species of *Coryne* and *Syncoryne*, while according to Mr. Hincks the oral verticil of tentacles in *Gymnocoryne* is so well marked and constant as to recall the characteristic verticil of capitate tentacles which surround the mouth in *Clavatella*.

Gymnocoryne coronata, *Hincks.*

Gymnocoryne coronata,—*Hincks*, in Ann. Nat. Hist., for Aug., 1871, pl. v, fig. 1.

TROPHOSOME.—Hydranth "very minute, slender, enlarging slightly upwards," with forty or more tentacles, eight or nine of which, thicker than the others, and with larger capitula, form a verticil, encircling the oral extremity; the others scattered over more than three fourths of the body.

GONOSOME not known.

Colour.—Central part of body reddish, hypostome opaque white.

Locality.—Salcombe Bay, Devonshire, Mr. Hincks.

This elegant little hydroid was found by Mr. Hincks inhabiting a deserted bivalve shell in Salcombe Bay, on the south coast of Devonshire. He informs us that the hydranths do not appear to measure more than one sixth of an inch in height. The verticillate tentacles are stout, and with their capitula large; the scattered tentacles are very slender, with small capitula; and decrease very markedly in size towards the base of the hydranth. The hydranths when fully extended become very slender. Hincks could not satisfy himself that a hydrocaulus was here present even in the rudimental condition of this part in *Clava*. It is probable, however, that its very imperfect development caused it to be overlooked.

GEMMARIA, *M'Crady*.

Name.—From *gemma*, a gem; so named from the sacs of gem-like thread-cells in the walls of the umbrella.

ZANCLEA,—*M'Crady*, Gymnophth.
GEMMARIA (provisionally),—*M'Crady*, id.

TROPHOSOME.—HYDROCAULUS developed, invested by a PERISARC, and rooted by a creeping filiform HYDRORHIZA. HYDRANTHS claviform, with scattered capitate tentacles.

GONOSOME.—PLANOBLASTS developed from the body of the hydranth. Umbrella at time of liberation deep bell-shaped; manubrium moderately developed, destitute of oral tentacles or lobes; marginal tentacles two, developed from the distal extremities of two opposite radiating canals, the alternate canals having each a small tentacular tubercle at the corresponding point; the tentacles commence each with a large bulbous dilatation destitute of distinct ocellus, and are for the remainder of their course set with pedunculated sacs filled with thread-cells; from the base of each tentacle and intermediate tubercle, a cœcal claviform tube, filled with thread-cells, extends for some distance in the walls of the umbrella, parallel to the corresponding radiating canal.

M'Crady captured in the open sea at Charleston, South Carolina, a medusa which he regarded as an immature specimen of a form referable to the genus *Zanclea* of Gegenbaur. Having some doubts, however, as to the correctness of this determination, he suggested the name of *Gemmaria* as a provisional designation to be used in the event of more conclusive observations failing to justify the allocation of the medusa in the genus *Zanclea*.[1]

[1] M'Crady, 'Gymnophthalmata of Charleston Harbour.'

Some time ago[1] I described the medusa of Alder's *Coryne implexa*, and afterwards[2] drew attention to the fact that this medusa was in all essential points similar to that described by M'Crady, whom I followed in referring the medusa to Gegenbaur's genus *Zanclea*. A more careful comparison, however, has since convinced me that while the American and British forms present no difference which could justify a generic separation from one another, they cannot be referred to *Zanclea*, and must therefore receive the generic name of *Gemmaria* proposed provisionally by M'Crady.

In thus substituting the name of *Gemmaria* for that of *Zanclea* I find myself in accordance with Mr. A. Agassiz, who has already recognised the difference between M'Crady's and Gegenbaur's medusæ.[3] Mr. A. Agassiz has also found in Massachusetts Bay another medusa which he regards as a second American species of *Gemmaria*. Neither of the American medusæ, however, has been traced to its trophosome.

GEMMARIA IMPLEXA, *Alder*.

Plate VII.

TUBULARIA IMPLEXA,—*Alder*, Catalogue Zooph., p. 18, pl. vii, figs. 3—6.
CORYNE PELAGICA,—*Alder*, Catal. Zooph., p. 13, pl. vii, figs. 1, 2.
CORYNE IMPLEXA,—*Strethill Wright*, Edin. New Phil. Journal. *Alder*, Suppl. Catal. Zooph., p. 3, pl. x, fig. 4.
CORYNE BRIAREUS,—*Allman*, in Ann. Nat. Hist. for July, 1859.
ZANCLEA IMPLEXA,—*Allman*, in Ann. Nat. Hist. for May, 1864, and June, 1864. *Hincks*, Brit. Hydr. Zooph., p. 59, pl. ix, fig. 3.

TROPHOSOME.—HYDROCAULUS consisting of simple or rarely branched offsetts from a creeping net-like HYDRORHIZA, springing at short intervals from the hydrorhiza, and attaining a height of about half a line; PERISARC, for some distance from the hydrorhiza, transversely corrugated and opaque, and then becoming abruptly transparent and smooth, and forming a cup-like dilatation, which is separated by a considerable interval from the contained cœnosarc, and extends as far as the base of the hydranth. HYDRANTHS, when extended, cylindrical, exceeding by many times the hydrocaulus in length, when contracted thickly club-shaped; tentacles numerous, forty or fifty.

[1] Notes on the Hydroid Zoophytes, in 'Ann. Nat. Hist.' for July, 1859. The hydroid is there named *Coryne Briareus*. Wright and Alder, however, maintain its identity with the *C. implexa*, Alder, and though neither Alder's nor Wright's description will apply in all points to my hydroid, I prefer to follow these zoologists in regarding the two hydroids as specifically identical, rather than run the risk of further confusing the descriptive zoology of the HYDROIDA by the retention of a doubtful species.

[2] 'Ann. Nat. Hist.' for May, 1864.

[3] A. Agassiz, 'Illustrated Catal.,' p. 184. Hincks, however, does not recognise a generic difference between the *Gemmaria* of M'Crady and the *Zanlcea* of Gegenbaur. 'Brit. Hydr. Zooph.,' p. 59.

GONOSOME.—Planoblasts shortly pedunculate, forming a more or less dense cluster, which surrounds the body of the hydranth in a plane which is much nearer to the proximal than to the distal limit of the tentacles; manubrium of medusa sub-cylindrical, extending through about one half the vertical diameter of the umbrella-cavity, receptacles of thread-cells in umbrella very superficial, extending from the circular canal over about one quarter of the entire height of the umbrella; thread-cell-bearing sacs of tentacles oval, carrying a pencil of long vibratile cilia on their free ends, and borne on very extensile peduncles.

Colour.—Hydranths white, with the gastric cavity very pale pink, perisarc on proximal portion of hydrocaulus brown, on distal portion colourless. Manubrium and tentacular bulbs of medusa brownish red.

Development of Gonosome.—April to June.

Habitat.—On stones in tide-pools, and on old shells, &c., from deep water.

Bathymetrical Distribution.—Litoral to deep water zone.

Localities.—Coast of Northumberland, Mr. Howse, Mr. Alder, and Mr. Hodge; Firth of Forth, Dr. T. S. Wright and G. J. A.; Coast of Forfarshire, G. J. A.

The short hydrocaulus and large many-tentacled hydranth, with its body long and cylindrical or short and thickly clubshaped, according to its state of extension or contraction, constitute marked features in this interesting hydroid. In every instance I found that those Hydranths which carry gonophores have the body shorter and the tentacles less developed than in those from which no gonophores are developed, but the arrest is comparatively slight, and in no case can it be regarded as reducing the hydranth to the condition of a blastostyle.

Alder describes the perisarc of the hydrocaulus as consisting of two distinct coats, separated by an interval from one another, the inner one annulated, the outer smooth. Nothing of this kind was seen in any of my specimens, in which the perisarc always became very thin and transparent for some distance below the hydranth, where it formed a wide tube, including a considerable interval between its walls and the cœnosarc which occupied its axis. This interval was traversed by numerous regularly disposed transverse fleshy processes, which radiated from the cœnosarc and became attached to the inner surface of the perisarc.

It would seem from Mr. Alder's description that the hydrocaulus is sometimes much more developed than in the specimen here figured. I have occasionally found specimens with a somewhat longer hydrocaulus, which might even send off a branch, but the difference was never so great as to justify our assigning to it a value greater than that of an unimportant variation.

The planoblasts have been described at length in a former part of this Monograph (Part I, p. 224), and it is these which will especially arrest the attention of the observer, whether he regards the curious piriform sacs filled with thread-cells which lie one over each radiating canal, or the pedunculated sacs, also loaded with thread-cells, which are borne in multitudes along the entire length of the marginal tentacles. The peduncles of these sacs are singularly extensile, and may sometimes be seen stretched out to a great length, carrying the sacs on their extremities, and giving to the tentacles the appearance under the naked eye of being covered with a dense growth of some parasitic mould. On being touched they immediately contract, and become closely aggregated along the tentacle. It is in this retracted state that the tentacular appendages have been represented by Alder in his figure of this species.

DICORYNIDÆ.

TROPHOSOME.—Hydrocaulus developed, invested by a perisarc. Hydranths with verticillate filiform tentacles.

GONOSOME.—Gonophores in the form of natatory ciliated sporosacs, with two simple, ciliated basal tentacles.

DICORYNE, *Allman.*

Name.—δίς, double, and κορύνη, a club; so called from its two club-shaped zooids—the hydranth and the blastostyle.

TROPHOSOME.—Hydrocaulus consisting of branched or simple stems, which arise at intervals from a creeping filiform hydrorhiza. Hydranths fusiform, with a single circlet of filiform tentacles surrounding the base of a conical hypostome.

GONOSOME.—Sporosacs developed upon blastostyles, detaching themselves as natatory planoblasts, ciliated over their entire surface, and having two filiform tentacles diverging from the proximal end.

The very remarkable sporosacs of *Dicoryne* separate it by a wide interval from every other genus. These sporosacs when mature become free, and lead a life as natatory as that of a medusiform planoblast. Natation, however, is effected not by the systole and diastole of an umbrella, but by the vibration of the cilia with which the entire surface of the sporosac is clothed. So important are these characters, that *Dicoryne* must become the type of a distinct family of gymnoblastic hydroids.

DICORYNE CONFERTA, *Alder*.

Plate VIII.

EUDENDRIUM ? CONFERTUM,—*Alder*, Catal., p. 13, pl. i, figs. 5—8.
DICORYNE STRICTA,—*Allman*, in Ann. Nat. Hist. for Nov., 1859.
DICORYNE CONFERTA,—*Allman*, in Ann. Nat. Hist. for August, 1861. *Alder*, Suppl. Catal., p. 4, pl. viii, figs. 1, 2. *Hincks*, Brit. Hydr. Zooph., p. 105, pl. xviii, fig. 1.

TROPHOSOME.—HYDROCAULUS composed of much-branched stems, which attain a height of about half an inch, with usually some short simple ones, all crowded on a creeping, closely reticulated HYDRORHIZA; branches subalternate, ascending at a very acute angle from the stem; PERISARC continued as a cup-like expansion for a very short distance over the base of the hydranth, marked by transverse though rather indistinct corrugations towards the hydrorhizal extremity of the stem. HYDRANTH with about sixteen tentacles alternately elevated and depressed in extension.

GONOSOME.—BLASTOSTYLES claviform, borne on the extremities of cylindrical stalks, which are covered with a perisarc, and spring, some from the main stem and its branches, others directly from the hydrorhiza. GONOPHORES oviform on short peduncles, densely clustered round the blastostyle; PLANOBLAST, with its two diverging tentacles, nearly equalling in length the rest of the zooid.

Colour.—Perisarc opaque earthy brown; hydranths ash-brown.
Development of Gonosome.—Summer and autumn.
Habitat.—Investing the shells of Buccinum and of other Gasteropoda.
Bathymetrical Distribution.—Laminarian and Coralline zones.
Localities.—Orkney Islands and Firth of Forth, G. J. A. Shetland Islands, Rev. A. M. Norman. Coast of Northumberland, Mr. Alder.

Some years ago I dredged from a depth of about three fathoms in the Orkney Seas an old Buccinum shell which was invested with a moss-like covering due to a hydroid which proved on examination to possess characters which excluded it from every previously defined genus. I accordingly assumed it as the type of a new genus, and named it *Dicoryne stricta*.

The same hydroid, however, had been previously described by Mr. Alder as a *Eudendrium* under the name of *Eudendrium confertum*, though with some doubt as to the correctness of referring it to this genus; and as his description was drawn up from imperfect specimens, no gonosome having been developed in them, I had overlooked the identity of his hydroid with mine. There can, however, as Mr. Alder afterwards ascertained, be no doubt of this identity, and though the generic name of *Dicoryne* must be retained, the specific name of *stricta* must yield to that of *conferta*.

The trophosome of *Dicoryne conferta* resembles that of *Heterocordyle Conybearei* so closely that it is difficult to find between them differences to which even a specific value can be attributed. It is, however, quite another thing with the gonosome. That of *Dicoryne* is widely different from that of *Heterocordyle;* for while the gonophores of *Heterocordyle* are constructed upon the common type of the sporosac, those of *Dicoryne* present a structure which is absolutely unique, having nothing like it in any other hydroid with which we are acquainted.

Dicoryne conferta resembles *Hydractinia echinata*, in the fact of its selecting for its habitat the surface of univalve shells. While *Hydractinia echinata*, however, is almost always found on dead shells, whose cavity has been taken possession of by a hermit crab, *Dicoryne* usually occurs on shells still occupied by their molluscan owners.

A more detailed account of *Dicoryne conferta* is given above (Part I, p. 226), where it has been made a subject of special anatomical study.

BIMERIDÆ.

TROPHOSOME.—Hydrocaulus developed and invested with a perisarc, or rudimental. Hydranths with the hypostome not abruptly differentiated; tentacles filiform in a verticil round the base of the hypostome.

GONOSOME.—Gonophores in the form of fixed sporosacs.

GARVEIA, *Strethill Wright.*

Corythamnion (provisionally),—*Allman.*

Name.—From *Inch Garvie*, one of the rocky islets in the Firth of Forth.

TROPHOSOME.—Hydrophyton invested with a conspicuous perisarc, and consisting of a branching hydrocaulus, rooted by a filiform hydrorhiza. Hydranths fusiform, with filiform tentacles, which are disposed in a single verticil round the base of a conical hypostome.

GONOSOME.—Sporosacs developed from the hydrophyton, where they are borne each on the summit of a short ramulus.

It was at low water spring tides on some of the small rocky islets of the Firth of Forth, that I first obtained the hydroid on which the genus *Garveia* has been founded. Not finding any published account of it I described it[1] as a new *Eudendrium*-like hydroid, but though I believed it entitled to rank as a distinct genus, I abstained from publishing it as such without further comparison, considering it safer to wait for the result of a critical examination of the various *Eudendrium*-like hydroids with which I was then engaged. I therefore recorded it simply as a new species, under the name of *Eudendrium baccatum*, suggesting for it provisionally the name of *Corythamnion*,[2] to be used in the event of its generic distinctness being established.

Simultaneously with the publication of my description of the new hydroid there appeared a paper by Dr. Strethill Wright,[3] in which the same animal was described under the new generic name of *Garveia*. As Dr. Wright's paper, however, purports to be a report of a communication made by him in the previous January to the Royal Physical Society of Edinburgh, I willingly yield to his claim of priority, and allow the name of *Garveia* to take precedence over that of *Corythamnion*.

One of the most remarkable characters of this curious genus is the position of the gonophores, each being borne on the summit of a true branchlet, where it takes the place of the hydranth on an ordinary branchlet.

The gonophore-bearing branchlets are much smaller than those which bear the hydranths, and at first sight might be mistaken for the mere peduncles of the gonophores. A little examination, however, will show that they are proper branchlets, not only invested by their perisarc like the rest of the hydrophyton, but quite distinct from the peduncle of the gonophore, which they support upon their summit. In the only representative of the genus as yet known, they are dilated at the summit exactly like the hydranth-bearing branchlets, and from this funnel-like dilatation the true peduncle of the gonophore springs.

GARVEIA NUTANS, *Strethill Wright.*

Plate XII, figs. 4—11.

GARVEIA NUTANS,—*Strethill Wright*, in Edin. New Phil. Journal for July, 1859, pl. viii, fig. 5. *Hincks*, Brit. Hydr. Zooph., p. 102, pl. xiv, fig. 4.

EUDENDRIUM BACCIFERUM [CORYTHAMNION BACCIFERUM provisionally], — *Allman*, in Ann. Nat. Hist. for July, 1859.

TROPHOSOME.—HYDROCAULUS attaining a height of about half an inch, much branched, with the ultimate branchlets for the most part regularly alternate; main stem fascicled; PERISARC slightly corrugated on the branches, but without proper

[1] 'Ann. Nat. Hist.' for July, 1859.

[2] κορύνη, a club, and θαμνίον a little shrub.

[3] 'Edinb. New Phil. Journal' for July, 1859.

annulation, and continued over the body of the hydranth in the form of a funnel-shaped cup; ultimate branchlets frequently bent abruptly to one side just below the hydranth. HYDRANTHS with about ten tentacles.

GONOSOME.—GONOPHORES large, oval, borne on long peduncles, which rise out of the summit of short, simple, funnel-shaped ramuli, which spring from the sides of the hydrocaulus.

Colour.—Hydranths and terminal portion of branchlets orange red; main stems and branchlets reddish-brown; gonophores deep orange.

Development of Gonosome.—May to July.

Habitat.—Attached to stones or growing on other hydroids or seaweeds, near the low-water limit of spring tides.

Bathymetrical Distribution.—Laminarian zone.

Localities.—Firth of Forth, Dr. Strethill Wright and G. J. A.; Morecambe Bay, Lancashire, G. J. A.

Garveia nutans, though a small hydroid, is eminently conspicuous among its more sombre associates by the bright orange red of its hydranths and of the younger portions of the hydrocaulus, and by its very large berry-like deep orange sporosacs; while the way in which the hydranth-bearing branchlets are frequently bent with an abrupt inflexion on themselves near their termination serves further to impress upon it a peculiar and characteristic physiognomy.

The tentacles of the hydranth are uniformly directed upwards, showing no tendency to the alternately elevated and depressed attitude so common in other genera.

The main stem is thickest near the root, and is here distinctly fascicled or composed of aggregated tubes. It becomes gradually attenuated as it gives off its branches, and finally both the main stem and the branches consist of a single tube.

The funnel-shaped extension of the perisarc which is continued over the body of the hydranth, nearly as far as the bases of the tentacles, reminds us of the hydrotheca in the calyptoblastic hydroids. It is, however, of a different morphological significance, and not being free like a true hydrotheca from the body of the hydranth, is incapable of receiving the tentacles and hypostome in contraction. In extreme retraction the body of the hydranth just below the base of the tentacles is forced over the edge of the funnel-shaped cup in the form of a projecting ring.

The gonophores are usually developed in great abundance, giving to the hydroid the appearance of being covered with orange-coloured berries. The short ramuli from whose summits they spring arise from the sides of the main stem and principal branches. From the edge of the funnel-shaped cup in which these little ramuli terminate there usually hang the shreds of a delicate chitinous membrane which had confined the gonophore in an early stage. Through this membrane the gonophore subsequently burst its way, as it continued to be carried up out of the cup on its elongating peduncle.

The gonophore, though not passing beyond the condition of a sporosac, possesses rudimental radiating canals, and is thus of much interest in its bearing on the general morphology of the hydroid gonosome. Its peculiarities have been referred to in the former part of the present monograph. See p. 14.

BIMERIA, *Strethill Wright.*

Name.—From *Inch Bimer,* one of the rocky islets in the Firth of Forth.

MANICELLA, *Allman.*

TROPHOSOME.—HYDROPHYTON invested with a conspicuous PERISARC, and consisting of a branched HYDROCAULUS rooted by a filiform HYDRORHIZA. HYDRANTHS fusiform, with a conical hypostome and a single circlet of filiform tentacles; PERISARC continued over the body and hypostome of the hydranth to within a short distance of the mouth, and forming a sheath on the proximal portion of each tentacle.

GONOSOME.—SPOROSACS developed from the hydrophyton.

In the Annals of Natural History for July, 1859, I described as a new genus, under the name of *Manicella*[1] a hydroid with the characters enumerated in the above generic diagnosis.

In the same month's number of the 'Edinburgh New Philosophical Journal,' Dr. Strethill Wright instituted under the name of *Bimeria* a new genus for a hydroid, which, notwithstanding some important points of discrepancy between Dr. Wright's description and my own (especially Dr. Wright's denial of the existence of a hypostome in his hydroid), is almost certainly the same species for which I had founded the genus *Manicella.* There is thus no actual priority of publication on either side; but Dr. Wright's paper is given as a report of a communication made some months previously to the Royal Physical Society of Edinburgh, and is the same as that in which, as already said (see above, p. 295), he characterises his genus *Garveia.* I therefore willingly concede to an esteemed collaborateur the right of naming the new genus, and accept *Bimeria* as its legitimate designation.

BIMERIA VESTITA, *Wright.*

Plate XII, figs. 1—3.

BIMERIA VESTITA,—*Wright,* in Edinburgh New Phil. Journ. for July, 1859, pl. viii, fig. 4. *Hincks,* Brit. Hydr. Zooph., p. 103, pl. xv, fig. 2.
MANICELLA FUSCA,—*Allman,* in Ann. Nat. Hist. for July, 1859.

TROPHOSOME.—HYDROCAULUS attaining a height of about half an inch, much branched, and having its ultimate ramuli disposed with a regularly pinnate arrange-

[1] A diminutive noun, from *manica,* the long Roman sleeve which performed the office of a glove: the allusion is to the extension of the perisarc over the body and tentacles of the hydranths.

ment; PERISARC spirally corrugated at the origin of the ultimate ramuli, and rendered opaque throughout by the accumulation in it of earthy particles and siliceous sand. HYDRANTHS with about sixteen tentacles, which are usually held with the alternate ones elevated and depressed in extension; the PERISARC continued over each tentacle for somewhat more than a third of its length, as well as over the greater part of the hypostome, on which it terminates abruptly at a short distance from the mouth.

GONOSOME.—SPOROSACS (male)[1] oval, with a ramified spadix, pedunculated, arising alternately along the length of the ultimate ramuli; perisarc extended over the entire peduncle and sporosac, spirally corrugated on the peduncle.

Colour.—The entire hydroid is of a dull brown colour.

Development of Gonosome.—June.

Habitat.—Attached to other hydroids, seaweeds, &c., near low-water spring tides.

Bathymetrical distribution.—Laminarian zone.

Localities.—Firth of Forth; Dr. Strethill Wright and G. J. A. Morecambe Bay, Lancashire; G. J. A. Coasts of Yorkshire and of South Devon; Mr. Hincks.

Bimeria vestita is rendered very remarkable by its faculty of excreting chitine from its surface to an extent unknown in any other hydroid. The chitinous sheaths which invest the bases of the tentacles confer upon the hydranths a very singular aspect, suggesting the idea of a half-gloved hand. The gonosome is completely covered, so that the only naked parts of the hydrosome are the terminal portions of the tentacles, and the hypostome for a short distance just below the mouth.

WRIGHTIA, *Allman.*

Name.—After Dr. *T. Strethill Wright.*

ATRACTYLIS,—*Wright.*

TROPHOSOME.—HYDROPHYTON consisting of a HYDROCAULUS in the form of simple funnel-shaped stems, developed at intervals from a creeping filiform HYDRORHIZA, the whole invested with a conspicuous chitinous PERISARC. HYDRANTHS retractile, fusiform, with filiform tentacles in a single circlet surrounding a conical hypostome.

[1] I have not yet had an opportunity of examining the female gonophores.

GONOSOME.—SPOROSACS springing directly from the sides of the hydrocaulus.

An important modification of Ehrenberg's genus *Eudendrium*, or rather of Van Beneden's amended form of this genus, was proposed some years ago by Dr. Strethill Wright, who drew attention to the existence in the genus as then generally accepted of two forms of hydranth, which he rightly considered as sufficiently distinct to justify the dismemberment of the genus.

In accordance with this view he instituted his genus *Atractylis* for such forms of the older genus as are characterised by a fusiform shape of the hydranth and a conical hypostome; the greater number of these species, moreover, presenting a more or less complete retractility within the summit of the hydrocaulus, though nothing like a proper hydrotheca is ever developed.

The forms, however, which Dr. Wright included under his genus *Atractylis* presented two generic types. One of these had already been characterised under the name of *Perigonimus* by Sars, who described both the trophosome and gonosome;[1] while another had, under the name of *Bougainvillia*, been long ago described by Lesson, who, however, was acquainted only with the medusa.[2] That the *Bougainvillia* of Lesson is the medusa of a hydroid whose type is found in the *Eudendrium ramosum* of Van Beneden (= *Atractylis ramosa* of Wright), has been shown both by Wright and Agassiz. To this hydroid and its allied species the name of *Bougainvillia* must accordingly be restored, and indeed we find Agassiz already arranging such forms partly under Lesson's name and partly under *Margelis*, Steenstrup's name for a medusa which can scarcely be regarded as distinct from *Bougainvillia*.

Some time afterwards a third form, distinct from both *Perigonimus* and *Bougainvillia*, obtained admission into Wright's genus *Atractylis*. This was the *Atractylis arenosa* of Alder, a form which, unlike *Perigonimus* and *Bougainvillia*, was now for the first time made known.

To Alder's *Atractylis arenosa*, which has been accepted by Wright as a genuine *Atractylis*, it would therefore be necessary to restrict the name *Atractylis*, if this name could under any circumstances be retained by the zoologist. Unfortunately, however, *Atractylis* cannot be admitted as the name of a zoological genus, for it had been long ago appropriated by the botanist, being an old Linnæan name for a genus of composite plants.

There is thus no alternative but to assign to *Atractylis arenosa* some other generic name, and that of *Wrightia* naturally suggests itself, as commemorating the labours of an original and able observer of the HYDROIDA.[3]

[1] Sars, 'Faun. lit. Norv.'

[2] Lesson, in 'Ann. des Sci. Nat.,' v, 1836.

[3] The name of *Wrightia* had been already employed by Agassiz as a generic designation for certain campanularian hydroids. The forms, however, which Agassiz would include under his genus *Wrightia* had been previously assigned by Van Beneden and Hincks to two new generic groups, under the names of *Campanulina*, Van Ben., and *Calycella*, Hincks. The *Wrightia* of Agassiz must therefore be suppressed in favour of the previously instituted genera of Van Beneden and Hincks. Mr. Alex. Agassiz has indeed already rejected the name of *Wrightia*, on the grounds that the forms to which Prof. Agassiz had applied it had been previously named. (See 'Illustr. Catal. N. A. Acal.,' p. 71.)

WRIGHTIA ARENOSA, *Alder*.

ATRACTYLIS ARENOSA,—*Alder*, Suppl. Catal., p. 7, pl. x, figs. 5—7. *Wright*, Quart. Journ. Mic. Sci., vol. iii, New Series, pl. iv, figs. 7—10. *Hincks*, Brit. Zooph., p. 88, pl. xvi, fig. 1.

TROPHOSOME.—HYDROCAULUS minute, simple, irregular in form, and with dilated trumpet-shaped summit, attaining a height of about one line, invested with particles of sand, mud, or other foreign matter. HYDRANTHS with about twelve long, slender, muricated tentacles, alternately elevated and depressed in extension; the entire hydranth retractile within the dilated summit of the trumpet-shaped hydrocaulus.

GONOSOME.—SPOROSACS (female[1]) oval, very large in proportion to the size of the hydroid.

Colour of Hydranths.—Milk white; Wright.

Development of Gonosome.—September; Wright.

Habitat.—On the under side of stones and the roots of Laminaria.

Localities.—Tynemouth and Cullercoats, Coast of Northumberland, Mr. Alder; Largo, Firth of Forth, Dr. Strethill Wright; Coast of Yorkshire, Mr. Hincks.

This remarkable little hydroid was first described by Mr. Alder, who, however, was unacquainted with its gonosome. He referred it to the genus *Atractylis* of Wright. It was subsequently found in its fully developed state by Dr. Strethill Wright, who was thus enabled to study the structure and development of the gonosome, and who, as has been mentioned in the former part of the present Monograph (see p. 49), has shown that the ova, after escaping from the sporosac, became enveloped in a gelatinous mass, which continues adherent to the ruptured sac. In this mass they undergo further development, and are ultimately liberated from it as planulæ.

Mr. Hincks informs us that it is very common under stones and on Laminaria roots at Filey Brig, Yorkshire.

[1] The male gonophores have not been observed.

HYDRANTHEA, *Hincks.*

Name.—From *Hydra*, a genus of hydroids, and ἄνθος, a flower.

TROPHOSOME.—Hydrophyton consisting of a rudimental hydrocaulus and a creeping filiform hydrorhiza, the whole invested by a chitinous perisarc. Hydranths fusiform, mouth surrounded by a circlet of filiform tentacles.

GONOSOME.—Sporosacs crowned by a ribbed cap, and developed from the hydrorhiza.

The genus *Hydranthea* has been instituted by Mr. Hincks for a little hydroid which he first described under the name of *Atractylis margarica*, but which he afterwards in a letter to myself referred to a new genus, which under the designation of *Hydranthea* he found it necessary to construct for it. There can be no doubt of the propriety of making this remarkable little hydroid the representative of a new genus. From the only form with which there is any chance of generically associating it—the *Wrightia* (*Atractylis*) *arenosa*, Alder—it is obviously separated by its rudimental hydrocaulus and by the peculiarity of its gonophores.

It is much to be desired that we had a more detailed account of the curious little hydroid on which the genus *Hydranthea* has been founded, and more especially of the cap-like appendage described as crowning the gonophores. Mr. Hincks further informs us that from the base of the gonosac there "proceed four much-branched vessels, terminating near the top of it in blind extremities, and immediately enclosing the ova, which fill with a dense mass the interior of the cavity." He further states that he could detect no trace of a spadix. There can be no doubt, however, that the branched cæcal tubes which embrace the ova represent a ramified spadix.

Hydranthea margarica, *Hincks.*

Atractylis margarica,—*Hincks*, in Ann. Nat. Hist. for Jan., 1863, pl. ix, figs. 3, 4.
Hydranthea maragarica,—*Hincks*, Brit. Hydr. Zooph., p. 100, pl. xix, fig. 2.

TROPHOSOME.—Rudimental hydrocaulus in the form of minute cup-like processes, which spring from the hydrorhiza, and support the hydranths and gonophores. Hydranths elongate, tentacles about twenty-four in number, alternately elevated and depressed in extension, every alternate tentacle having at its base a projecting cluster of bean-shaped thread-cells.

GONOSOME.—Sporosacs large, sub-globular, pedunculate, springing from cup-like processes of the hydrorhiza, which are situated singly or in pairs close to the base of a hydranth.

Colour of Hydranth.—White.
Habitat.—On *Flustra foliacea.*
Bathymetrical distribution.—Coralline zone.
Locality.—Ilfracombe, Rev. T. Hincks.

Mr. Hincks informs us that the most striking character in the present species "is the series of projecting bosses round the base of the tentacular ring. When examined with the microscope these are seen to consist of a number of elongate, bean-shaped thread-cells, which are piled together so as to form silvery-white prominences on the lower side of the tentacles." He believes that "they occur only on the alternate arms," where they "form a unique garniture."

The species was dredged from a depth of ten fathoms, where it occurrred exclusively on *Flustra foliacea.*

STYLACTIS, *Allman.*

Name.—From στῦλος, a column, and ακτὶς, a ray.

PODOCORYNE,—*Sars.*

TROPHOSOME.—HYDROCAULUS not developed. HYDRORHIZA formed by a network of anastomosing stolons invested with a chitinous PERISARC, but without a superficial layer of naked CŒNOSARC. HYDRANTHS sub-claviform or cylindrical, with the tentacles filiform, and arranged in a single circlet round the base of a conical hypostome.

GONOSOME.—SPOROSACS, borne on the hydranths at the proximal side of the tentacles.

I have found it necessary to constitute the genus *Stylactis* for the reception of two hydroids described by Sars, both of which he referred to the genus *Podocoryne,* while one of them was at first regarded by him as a mere form of *Podocoryne carnea,* though he afterwards expressed his belief in its specific distinctness from that hydroid.

They are both, however, distinct from *Podocoryne,* for, independently of other differences, the fact of their gonophores being in the form of simple sporosacs instead of medusæ renders it impossible to admit them into the medusa-bearing genus *Podocoryne.*

For an opportunity of examining living specimens of *Stylactis* I am indebted to Dr. Du Plessis, of Nice, and in these I was enabled to satisfy myself that not only is the gonosome different from that of *Podocoryne,* but that the hydrophyton is constructed on a plan entirely different from that of the hydrophyton of this genus, for it consists of a network of anastomosing tubes, invested with a chitinous perisarc, and without any superficial covering of cœnosarc, such as we meet with in *Podocoryne* and *Hydractinia.* (See woodcut, fig. 79, p. 306.)

In the *Stylactis* (*Podocoryne*) *fucicola* of Sars the hydrorhizal network sends off numerous chitinous spines, resembling those of the true *Podocorynes* and of *Hydractinia*. They appear to be simple processes of the chitinous perisarc.[1]

*** 1. Stylactis Sarsii, *Allman.*

Podocoryne carnea,—*Sars*, Faun. lit. Norv., 1846, p. 7, tab. ii, figs. 5—11.
Stylactis Sarsii,—*Allman*, in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—Hydranths with from twelve to thirty tentacles, those carrying gonophores quite similar in size and otherwise resembling those on which no gonophores have been developed.

GONOSOME.—Sporosacs globular, arranged in a verticil at about the middle of the body of the hydranth.

Colour.—Hydranths pale red, gonophores with yellowish-red spadix, ova crimson.
Development of Gonosome observed in March.
Habitat.—On empty univalve shells in the sea.
Bathymetrical distribution.—Coralline zone?
Locality.—Coast of Norway, Sars.

Notwithstanding the marked difference in the gonosome between this hydroid and the *Podocoryne carnea*, Sars, to whom alone our knowledge of it is due, believed it to be only a particular state of *Podocoryne carnea.* In this, however, he was certainly mistaken, as he himself afterwards admitted.[2] There is nothing to justify the belief that the same colony produces

[1] Hincks would apply Philippi's name of *Dysmorphosa* to the forms which, under the name of *Stylactis*, I separated generically from the true Podocorynes with which they were associated by Sars. Now, there is no doubt that *Dysmorphosa* has precedence, not only over *Stylactis*, but over *Podocoryne*. It was not, however, to the *Stylactis* form that Philippi intended his name *Dysmorphosa* to apply, for though his description is far from being as full as could be desired, it is sufficiently so to leave no doubt that he had before him either a true *Podocoryne* or a *Hydractinia*, and, it will apply just as well to one of those genera as to the other.

If we prefer to regard *Podocoryne* as the genus Philippi had in view, it is this name, and not *Stylactis*, that *Dysmorphosa* must supplant, and then the name of *Podocoryne* may be applied exclusively to the *Stylactis* forms included by Sars along with the others under the general name of *Podocoryne*. As the name of *Podocoryne*, however, has been already employed, for the medusa-bearing forms alone, it will be better not to introduce further confusion into the existing nomenclature by transferring this name to the sporosac-bearing *Stylactis* forms.

[2] 'Bidrag til Kunds. om Middelhavet's Littoral Fauna,' in which Sars expresses his belief that the hydroid here described is specifically distinct from *Podocoryne carnea*, though generically associated with it. I must here acknowledge my obligations to my friend Dr. Charles Wilson, of Edinburgh, to whose extensive acquaintance with the languages of Scandinavia I am indebted for translations of such portions of its zoological literature as are referred to in this monograph.

medusa at one time and sporosacs at another, a phenomenon of which no sufficient evidence is afforded by any hydroid, and the present form must accordingly be separated, not only specifically, but generically, from *Podocoryne carnea*.[1]

*** 2. STYLACTIS FUCICOLA, *Sars*.

PODOCORYNE FUCICOLA,—*Sars*, Middelhavets Litteral-Fauna, p. 10, tab. ii, figs. 6—13.
STYLACTIS FUCICOLA,—*Allman*, in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—HYDRORHIZA emitting at intervals from its free surface conical chitinous spines, about half a line in height. HYDRANTHS about one line and a half in height; those destitute of gonophores having eight to twelve tentacles, those carrying gonophores (proliferous hydranths) much more slender than the former, and with only from four to eight tentacles.

GONOSOME.—SPOROSACS globular, shortly pedunculated, three to seven on each hydranth, scattered or forming an imperfect verticillate group near the middle of the hydranth.

Colour.—Hydranths pale red, spadix of gonophore pale red.

Habitat.—Attached to sea-weeds a little below the surface of the sea.

Bathymetrical distribution.—Extending downwards to about a foot from the surface of the sea in the region of *Cystoseira*.[2]

Locality.—Messina, Sars.

[1] In that most pleasant and instructive book, the 'Sea-side Studies' of Mr. G. H. Lewes, it is stated that in *Aglaophenia myriophyllum*, a calyptoblastic hydroid, some of the corbulæ were found "filled with eggs, and some with medusæ" ('Sea-side Studies,' p. 296). So far as I can gather from the context, it would seem that it is the true phanerocodonic medusa which is here meant, and that the eggs did not proceed from these, but had their origin in sporosacs. There is nothing impossible in this, and coming, as the statement does, from so accurate and conscientious an observer, and so acute a reasoner as Mr. Lewes, who, moreover, has had the rare opportunity of examining living specimens of *Aglaophenia myriophyllum*, I should not feel justified in at once rejecting it. But for all this, I believe that there is here some error of interpretation. The structure of the HYDROIDA, and the nature and significance of their zooids, has since Mr. Lewes wrote become much better known; and if it were really as he supposes, we should have in this case the solitary instance which would invalidate some of the best established generalizations in the whole life history of the HYDROIDA.

[2] The genus *Cystoseira* replaces round a great part of the Mediterranean shores the *Laminaria* of our more northern latitudes, and I have named the Bathymetrical region, which is characterised by its growth, the "Region of *Cystoseira*." Unlike the Laminarian zone of our own seas, it is not necessarily exposed during any period of the limited tide-range of the Mediterranean.

The *Stylactis fucicola* was discovered by Sars in the haven of Messina, and referred by him to the genus *Podocoryne*, from which, however, for reasons already mentioned, it has been found necessary to separate it. The common basis, or hydrorhiza, spreads over the upper surface of sea-weeds, and is described by Sars as composed of creeping, horny, branched, minute tubes, often anastomosing with one another, and sending off here and there vertical, horny, conical processes, similar to those which occur in *Podocoryne carnea*, but longer and more numerous. He makes no allusion to the existence of a superficial naked layer of cœnosarc on the hydrorhizal network, as in *Podocoryne* and *Hydractinia*, and it is pretty certain that nothing of the kind exists.

Those hydranths which are destitute of sporosacs have usually, when adult, eight tentacles, which in extension are held alternately elevated and depressed. The hydranths which bear sporosacs are as long as the others, and, indeed, sometimes even longer, but they are always much more slender, while their tentacles are shorter and fewer, usually from two to six.

The sporosacs are situated low down on the body, at about two fifths of its length from the tentacular circlet.

Stylactis fucicola has never been found, like some allied forms, on the surface of empty shells, but always "on sea-weeds, especially on a little brownish-red, doubly pinnated species (*Fucus cartilagineus*, Cav., non L.) which grows in abundance on stones in the haven of Messina, close to or within a foot of the sea's surface."—Sars.

*** 3. Stylactis inermis, *Allman.*

Woodcut, fig. 79, page 306.

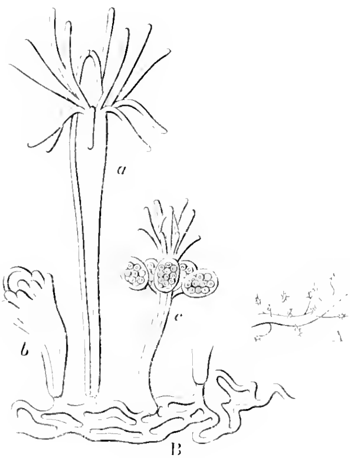
TROPHOSOME.—Hydrorhiza destitute of spines, and formed by a layer of closely approximated, tortuous, anastomosing tubes. Sterile and proliferous hydranths, differing in size; sterile hydranths about two lines in height, and with about twenty tentacles, arranged in two closely set, alternating series; proliferous hydranths about half the size of the sterile ones, and with about twelve tentacles, also disposed in two series.

GONOSOME.—Gonophores oval, shortly stalked, forming an irregular verticil at a short distance below the proximal tentacles.

Colour.—Hydranths and gonophores varying from a very pale pink to brownish.
Development of Gonosome.—April.
Habitat.—Spreading over the surface of sea-weeds.
Bathymetrical Distribution.—Region of *Cystoseira.*
Locality.—Nice, Dr. du Plessis.

I am indebted to Dr. du Plessis, of Nice, for the specimens which have enabled me to define the present species, and from which the accompanying woodcut has been made. They were developed in his aquarium, where they spread themselves over the surface of sea-weeds, which were obtained from the neighbouring shores at probably a slight depth from the surface of the sea. They afforded me the means of determining the real nature of the hydrophyton in the genus *Stylactis*, and to show that it is very different from that of *Podocoryne*, in which the surface of the hydrorhizal expansion is covered by a stratum of absolutely naked cœnosarc, a character which *Podocoryne* possesses in common with *Hydractinia*. The hydrophyton of *Stylactis*, on the other hand, while it is almost entirely reduced, as in *Hydractinia* and *Podocoryne*, to the condition of a hydrorhiza, is formed, like most other hydrorhizæ, on the common type of a network of anastomosing chitine-covered tubes.

Fig. 79.



Stylactis inermis.

A, a colony of the natural size, spreading over a piece of sea-weed.
B, portion of a colony magnified. *a*, hydranth, from which no gonophores are developed (sterile hydranth), extended; *b*, same contracted; *c*, gonophore-bearing (or proliferous) hydranth.

The hydranths of *Stylactis inermis* are surrounded at their origin by a narrow cup-like process of the hydrorhiza. They are very mutable in shape, and run through a range of forms depending on different states of contraction, similar to what we meet with in *Podocoryne* and *Hydractinia*. The tentacles, when in a semi-contracted state, assume a somewhat club-shaped form. The sporosacs, which are clustered round the body of the hydranth, at a little distance below the tentacles, varied from two to six in number. The more mature sporosacs were filled with ova at the time of examination.

HETEROCORDYLE, *Allman.*

Name.—From ἕτερος, dissimilar, and κορδύλη, a club; in allusion to the two kinds of club-shaped zoids, the hydranths and the blastostyles.

TROPHOSOME.—Hydrophyton composed of a simple or branching hydrocaulus rooted by a creeping filiform hydrorhiza, the whole invested by a chitinous perisarc. Hydranths fusiform, with a single circlet of filiform tentacles round the base of a conical hypostome.

GONOSOME.—Sporosacs borne upon blastostyles.

The genus *Heterocordyle* has been founded for a hydroid discovered on the southern coast of Ireland. Its trophosome is that of *Dicoryne*, but from this genus it is entirely separated by its very different gonosome.

Heterocordyle Conybearei, *Allman.*

Plate X, figs. 4—7.

Heterocordyle Conybearei,—*Allman*, in Ann. Nat. Hist. for May, 1864, and July, 1864, pl. ii. *Hincks*, Brit. Hydr. Zooph., p. 107, pl. xviii, fig. 2.

TROPHOSOME.—Hydrocaulus consisting of numerous stems crowded upon the creeping hydrorhiza, some much branched, and attaining a height of about four lines, others shorter and simple; perisarc transversely corrugated, extending for a short distance over the base of the hydranth. Hydranths with about twelve tentacles, usually held straight in extension, with the alternate ones elevated and depressed.

GONOSOME.—Blastostyles club-shaped, borne on the summit of very short erect processes, which spring from the hydrorhiza, and are invested with a chitinous perisarc; distal extremity of blastostyle thickly set with thread-cells. Sporosacs numerous, nearly sessile, densely crowded, commencing a little behind the distal extremity of the blastostyle, and thence extending to within a short distance of its base.

Colour.—Ash brown.

Development of Gonosome.—Observed in September.

Habitat.—On old univalve shells in the sea.

Bathymetrical distribution.—Laminarian and coralline zones.

Localities.—Glengariff Harbour, County of Cork, G. J. A.; Oban, Argyleshire, Rev. T. Hincks.

This very distinct hydroid, the only representative as yet discovered of its genus, was dredged in considerable abundance from a rather muddy bottom in the Harbour of Glengariff, on the south coast of Ireland. It was always found investing old gasteropodous shells, whose cavity was in every instance tenanted by a hermit crab. It so closely resembles *Dicoryne conferta* in form, colour, and general habit, that it was at first mistaken for this species, and it was only the closer inspection of its gonosome which showed how very widely it differed from it.

Heterocordyle Conybearei spreads itself in the form of a dense moss-like covering over the shell of which it has taken possession, extending in all directions by means of a reticulated stolon, which sends up at short intervals the stems of the trophosome and the blastostyles of the gonosome. The stems are for the most part well developed, and much, but rather irregularly, branched, while a few simple and much shorter stems, each carrying a hydranth on its summit, spring here and there from the creeping base. The tentacles, when extended, are held alternately elevated and depressed, indicating a composition of the tentacular circlet out of two closely approximated verticils. When partially contracted the tentacles frequently present a slight enlargement of their extremities, giving them a somewhat clavate form. The perisarc extends for a very short distance over the base of the hydranth, and then terminates abruptly by a defined edge.

The blastostyles are borne on the summits of very short stalks, which spring like the stems of the trophosome from the creeping stolon, and which, like them, are also invested with a chitinous perisarc. The blastostyles are clavate, but as they admit of considerable extension and contraction their form is a varying one. Their distal extremity is rounded, and thickly set with thread-cells.

The gonophores spring from the sides of the blastostyle, to which they are attached by peduncles so short as to render them almost sessile. They are crowded upon the blastostyle, a short space at its distal extremity and another at its proximal being the only parts free from them. They are oviform and constructed on the type of the simple fixed sporosac; the spadix is large, and in the female embraces a large solitary ovum, over which the endotheca extends as a well-marked layer, while a very distinct ectotheca, in which no evident structure can be detected, envelopes the whole.

The male gonosacs resemble the female in form, and in the mode in which they are grouped upon the blastostyle. The spermatogenous mass is developed round the spadix, and is confined by an exceedingly delicate investing membrane (endotheca), while the whole is surrounded by a distinct but apparently structureless ectotheeal sac.

It was in company with an accomplished microscopist, Henry Conybeare, Esq., during a dredging excursion in the beautiful Bay of Glengariff that this remarkable hydroid was first obtained, and I have yielded to the gratification of dedicating it to my friend, and thus connecting it with the name of a family to which the progress of natural science is largely indebted.

CIONISTES, *Strethill Wright.*

Name.—From κίων, a pillar, probably in allusion to the presence of blastostyles.

TROPHOSOME.—HYDROPHYTON consisting of a retiform HYDRORHIZA without developed HYDROCAULUS. HYDRANTHS sessile on the hydrorhiza, minute, with a single verticil of filiform tentacles.

GONOSOME.—SPOROSACS borne by BLASTOSTYLES, which spring from the hydrorhiza.

Cionistes is a genus constituted by Dr. Strethill Wright for a hydroid of which he met with a single specimen (male) in the Firth of Forth. It appears to be distinguished from *Heterocordyle* chiefly by the absence of a developed hydrocaulus.

CIONISTES RETICULATA, *Strethill Wright.*

CIONISTES RETICULATA,—*Strethill Wright*, in Ann. Nat. Hist. for August, 1861. *Hincks*, Brit. Hydr. Zooph., p. 135.

TROPHOSOME.—HYDRORHIZA "consisting of a close network of flattened tubes," from which the hydranths and blastostyles "spring at distant intervals." HYDRANTHS "minute, white, with a single row of short tentacles."

GONOSOME.—BLASTOSTYLES gradually enlarging from the base to the summit; SPOROSACS numerous, borne on the sides of the blastostyle.

Habitat.—"Growing on an old shell."
Locality.—Granton, Firth of Forth, Dr. S. Wright.

I have never seen this hydroid, which, judging from Dr. Wright's short description of it—scarcely full enough, however, for a complete diagnosis—must be a form of considerable interest. The only illustration which accompanies the description is a diagramatic outline of one of the blastostyles, with a male gonophore attached to it.

BOUGAINVILLIDÆ.

TROPHOSOME.—HYDROCAULUS more or less developed, invested by a conspicuous PERISARC. HYDRANTHS with the hypostome not abruptly differentiated; tentacles filiform, in a single circlet round the base of the hypostome.

GONOSOME.—GONOPHORES phanerocodonic, with four simple radiating canals, and with the marginal tentacles simple, and distributed either singly or in clusters.

The hydranths of all the species included in this family are distinguished from those of the *Eudendridæ*, which they otherwise closely resemble, by the hypostome not being abruptly differentiated, as in the latter, but, on the contrary, passing continuously into the body of the hydranth.

BOUGAINVILLIA, *Lesson.*

Name.—In commemoration of the distinguished circumnavigator, Admiral de Bougainville.

EUDENDRIUM,—*Van Beneden.*
ATRACTYLIS,—*Strethill Wright.*
HIPPOCRENE (planoblast),—*Brandt.*
MARGELIS (planoblast),—*Steenstrup.*

TROPHOSOME.—HYDROPHYTON consisting of a branching HYDROCAULUS, which is rooted by a filiform HYDRORHIZA. HYDRANTHS fusiform, with a conical hypostome.

GONOSOME.—PLANOBLASTS borne by the hydrocaulus, and having at the time of liberation a deep bell-shaped umbrella, with the manubrium shorter than the height of the bell-cavity, and with four simple labial tentacles, each of which carries at its extremity a little capitulum of thread-cells; radiating canals, each terminating at its junction with the circular canal in a bulb, from which two tentacles are developed, each tentacle having an ocellus at its base.

Before attaining maturity, the labial tentacles become dichotomously branched, and the marginal bulbs carry each a fascicle of numerous tentacles, every one of which has an ocellus at its base.

The genus *Bougainvillia* was founded by Lesson for a hydroid whose medusa, however, was the only part with which he was acquainted.

Forbes[1] had a suspicion that the medusa which he had himself described under the name of *Bougainvillia Britannica* was related to the *Eudendrium ramosum* of Van Beneden, while M'Crady[2] was also led to refer an allied American medusa to a *Eudendrium*-like trophosome. Strethill Wright[3] subsequently believed that he could trace the planoblast of Van Beneden's *Eudendrium ramosum* through intermediate stages into a medusa which closely resembled the *Bougainvillia Britannica* of Forbes, and the relation thus maintained received confirmation from a similar observation afterwards made by Alex. Agassiz[4] on the medusa of *Bougainvillia superciliaris*, an American species. Though the evidence from which Forbes's *Bougainvillia Britannica* might be referred to the *Eudendrium ramosum* of Van Beneden as its proper trophosome is hardly complete, the observations of Wright and Agassiz leave no doubt as to the planoblast of this trophosome being a true *Bougainvillia* medusa.

Wright, having shown that Van Beneden's *Eudendrium ramosum* cannot be retained in the genus *Eudendrium*, constructed for it that of *Atractylis*.[5] It must now be referred to Lesson's genus *Bougainvillia*, of which, indeed, it may be assumed as the type.[6]

1. Bougainvillia ramosa, *Van Beneden.*

Plate IX, figs. 5—7.

Hippocrene Britannica (planoblast),—*Forbes*, in Ann. Nat. Hist., 1841, vol. vii, p. 84, pl. i, fig. 2.

Eudendrium ramosum,—*Van Beneden*, Embryogenie des Tubulaires, p. 56, pl. iv, exclusive of synonymes. Faune lit. de Belg., p. 112, pl. vi, vii.

Bougainvillia Britannica (planoblast),—*Lesson*, Acalèphes, p. 291. *Forbes*, Naked-eyed Medusæ, p. 62, pl. xii, fig. 1.

Tubularia ramosa,—*Dalyell*, Rare and Remarkable Animals, p. 64, pl. xi.

Atractylis ramosa,—*Strethill Wright*, Proc. Roy. Phys. Soc. Edinb., vol. i, p. 169.

Margelis ramosa,—*Agassiz*, Contr. Nat. Hist. U. S., vol. iv, p. 344.

Bougainvillia ramosa,—*Allman*, in Ann. Nat. Hist. for May, 1864. *Hincks*, Brit. Hydr. Zooph., p. 109, pl. xix, fig. 2.

[1] 'British Naked-eyed Medusæ,' p. 68.

[2] "Gymnophthalmata of Charleston Harbour," 'Proc. Elliott. Sec.,' April, 1857.

[3] 'Proc. Roy. Phys. Soc. Edinb.,' April, 1858.

[4] Agas., 'Contr. Nat. Hist. U. S.,' vol. iv, p. 291.

[5] See above, p. 299.

[6] The generic name of *Margelis* was given by Steenstrup ('Vidensk. Medel.,' 1849, p. 43) to the medusa which Forbes has described under the name of *Bougainvillia Britannica*, and Agassiz has accepted the genus *Margelis*, believing that Forbes's *Bougainvillia Britannica* is generically distinct from the original *Hippocrene Bougainvillii* of Brandt, for which Lesson founded the genus *Bougainvillia*. I cannot, however, see in the differences between the two medusæ—differences which are to be found chiefly in the wider and more rounded form of the manubrium and in the more profuse bifurcation of the oral tentacles of Brandt's species—characters of sufficient importance for generic separation.

TROPHOSOME.—HYDROCAULUS attaining a height of from one to three inches, much branched, the ultimate branches for the most part alternate; main stem and principal branches fascicled towards the base; PERISARC with shallow annulations at the origin of the branches. HYDRANTHS with about twelve tentacles, which in extension are usually carried nearly straight, with every alternate one elevated or depressed; perisarc continued over the body of the hydranth as far as the roots of the tentacles, in the form of a cup-like extension, into which the hydranth, in extreme contraction, may be almost completely withdrawn.

GONOSOME.—GONOPHORES on moderately long peduncles, which spring from the ultimate ramuli, on which they occur either singly or in sub-verticillate groups of two, three, or more.

Colour.—Body of hydranth with manubrium and marginal bulbs of medusa pale pink, ocelli carmine, perisarc of hydrocaulus straw-colour.

Development of Gonosome.—Autumn.

Habitat.—Attached to rocks near low-water mark, and to other hydroids and old shells from the coralline and deep-sea zones.

Bathymetrical distribution.—Laminarian to deep-sea zones.

Localities.—Coast of Belgium, Van Beneden; Firth of Forth, Dr. S. Wright; Oban, Argyleshire, Rev. T. Hincks; south coast of Devonshire, Rev. T. Hincks and G. J. A.; coast of Northumberland, Mr. Alder.

Bougainvillia ramosa, in its complete form, presenting both trophosome and gonosome, was first described by Van Beneden, who, believing it to be identical with the *Eudendrium ramosum* of Ehrenberg, assigned to it this name. Ehrenberg's *Eudendrium ramosum*, however, is an entirely different hydroid, being identical with the *Tubularia ramosa* of Linnæus, the "small, ramified, tubular coralline" of Ellis. We now know, as has been just said, that the adult medusa of Van Beneden's *Eudendrium ramosum* is either the *Bougainvillia Britannica* of Forbes or a closely allied form. Were we sure of its identity with Forbes's medusa, the law of priority would compel us to assign to Van Beneden's hydroid, not only the generic name of *Bougainvillia*, but the specific name of *Britannica*. In the absence, however, of absolute proof of this specific identity it will be wiser to retain Van Beneden's specific name of *ramosa*, who, moreover, was the first to give a good drawing and description of the species.

Bougainvillia ramosa forms profusely ramified tree-like growths on the various bodies to which it attaches itself, and in the confinement of our aquaria will continue for many days to throw off successive crops of medusæ. The medusa, immediately on liberation, darts away through the surrounding water, the marginal tentacles being at the same time contracted and thrown back upon the umbrella in the form of short, thick, curved, somewhat club-shaped appendages. When it comes to rest the tentacles are extended, and when the medusa is floating passively on the water they are stretched out for some distance nearly horizontally, and for the rest of their length hang down vertically in the water.

I have not succeeded in getting the young medusæ to undergo in confinement the changes by which they become converted into the mature *Bougainvillia* form. Judging, however, from the observations of Wright and Agassiz, and from the condition of the *Bougainvillia Britannica* medusa, which is not improbably the adult planoblast of this species, the change consists mainly in three successive bifurcations of the labial tentacles, in the multiplication of the marginal tentacles, by which each basal bulb, instead of carrying only two tentacles, as at first, carries a fasciculus composed of many, and in the greatly increased thickness of the umbrella, whose cavity now occupies but a small portion of the entire volume. In this state the medusa has assumed a nearly globular form.

The labial tentacles of the medusa (Plate IX, fig. 8) to which the name of *Bougainvillia Britannica* has been assigned are not placed on a level with the mouth, but spring from a point some distance above it. Every ultimate branch of these tentacles terminates in a little cluster of thread-cells, which is not imbedded in the substance of the tentacle, but is elevated on the summit of a very short peduncle. The entire tentacle is solid and is composed of an external thin ectodermal layer, enclosing a distinctly cellular endodermal pith.

Each of the four fasciculi of marginal tentacles springs from a crescentic cushion-like projection of the umbrella margin. Every tentacle carries its ocellus on the inner side of the thickened base.

The generative elements are contained in four oval projections of the manubrium walls, which extend symmetrically from the base of the manubrium to within a short distance of the labial tentacles. These generative lobes, the labial tentacles, and the radiating canals with the marginal tentaculiferous cushions, do not alternate with one another, but are situated, each set in one and the same meridian plane.

When the medusa is floating on the water the marginal tentacles are usually extended and thrown back upon the umbrella, their slender extremities at the same time bending outwards in a graceful curve. In this position the basal cushions become everted, and the ocelli, now directed outwards, are fully exposed.

The manubrium, with its generative lobes, and the basal bulbs of the marginal tentacles, where they spring from their common cushion-like support, are of a fine golden-yellow colour.

The retractility of the hydranth in *Bougainvillia ramosa* is very great. In complete retraction the whole hydranth, to within a short distance of the tips of the tentacles, is withdrawn within the perisarc, which here forms a cup-like expansion. This cup, however, is nothing more than a thin extension of the perisarc over the body of the hydranth, to which it is more or less closely adherent, and during whose retraction it is thrown into transverse rugæ. It is thus entirely different from the hydrotheca of the campanularian and sertularian hydroids.

After the death and disappearance of the hydranth the ramulus which had supported it continues to bear the gonophores, and these may now be often seen to form umbel-like groups, terminating the branchlet.

In Van Beneden's original memoir on the present species a specimen is figured and described in which some of the branches carry on their sides groups of piriform bodies, which appear to bud one from the other in such a way as to acquire the form of fan-shaped clusters. I cannot offer any opinion as to the nature of these bodies. In a subsequent memoir,[1] M. Van Beneden suggests the probability of their being male gonophores, the female gono-

[1] 'Rech. sur la Faune lit. de Belgique,' p. 113.

phores showing themselves under the form of medusæ—a view, however, which, with the very imperfect knowledge we as yet possess of the bodies in question, cannot be entertained without further confirmation.

In the same figure a branch is represented which, instead of terminating in a hydranth, forms a large fusiform dilatation. We are reminded by it of a very similar condition occasionally presented by certain Syncorynes, and which is there due to the presence of a parasitical Pichnogonidan (see p. 200). Indeed, Van Beneden describes the dilated branch in his species as containing an oval body, which "avait bien l'air d'un parasite."

2. Bougainvillia fruticosa, *Allman*.

Plate IX, figs. 1—4.

Bougainvillia fruticosa,—*Allman*, in Ann. Nat. Hist. for July, 1864. *Hincks*, Brit. Hydr. Zooph., p. 110.

TROPHOSOME.—Hydrocaulus rising to the height of about two inches, much branched, with the main stems composed of aggregated tubes, branches sub-alternate; perisarc without annulation, but marked on the smaller branches by shallow transverse corrugations, which become obsolete on the larger branches and main stems. Hydranths with about fourteen tentacles, which are more or less curved in extension, with usually every alternate one elevated or depressed; body of hydranth nearly cylindrical in extreme extension, and with the perisarc continued over it for a short distance as a thin pellicle, which on extreme retraction appears as a membranous corrugated cup, investing the hydranth for about a third of its height.

GONOSOME.—Gonophores on moderately long peduncles, borne upon the ultimate ramuli, where they occur irregularly scattered along the length of the ramulus.[1]

Colour.—Hydranths pale red; manubrium and marginal bulbs of medusa, up to the period of liberation, pale red. Perisarc straw colour, becoming browner and more opaque on the older parts of the hydrocaulus.

Development of Gonosome.—Autumn.

Habitat.—Attached to buoys and floating timber.

Localities.—Mouth of Kenmare River, coast of Kerry, G. J. A.; Firth of Forth, G. J. A.

[1] In my original description of *Bougainvillia fruticosa* I assumed as a distinctive character the disposition of the gonophores, which I then believed were entirely confined to one side of the supporting ramulus. Subsequent examination has convinced me that this character is not the usual condition, and cannot be retained in the diagnosis.

Bougainvillia fruticosa is closely allied to *Bougainvillia ramosa*. It differs from it, however, in the more cylindrical and more slender form of the extended hydranth, and in the fact that the tentacles, when extended, are decidedly curved, while they are nearly straight in *Bougainvillia ramosa*, as well as in the considerably less extent to which the hydranth is invested by the membranous dilatation of the chitinous perisarc, and in the absence of distinct annulation at the origin of the branchlets. While in *Bougainvillia ramosa* the contracted hydranths are almost entirely concealed within the dilated perisarc, in *Bougainvillia fruticosa* the hydranths, in extreme retraction, have the whole of the tentacles and at least half the body exposed. Another difference will, perhaps, be found in the way in which the recently liberated medusa carries its marginal tentacles, which in *Bougainvillia fruticosa* I have never seen extended in the plane of the codonostome before bending vertically downwards, the habitual attitude of these appendages in *Bougainvillia ramosa*.

Whether the mature medusa differs in any respect from that of *Bougainvillia Britannica*, we have not yet facts to enable us to decide.

I first met with *Bougainvillia fruticosa* loaded with gonophores and growing in abundance on a large piece of floating timber in the estuary of the Kenmare River, Co. Kerry, and afterwards in less perfection, and without gonophores, on a buoy in the Firth of Forth. It is a singularly beautiful hydroid, and when first transferred from the sea to the zoophyte trough of the microscope, before its health and vigour have become impaired by the confinement of our jars, offers a spectacle unsurpassed in interest by any other species—every branchlet crowned by its graceful hydranth, and budding with medusæ in all stages of development, some still in the condition of minute buds, in which no trace of the definite medusa-form can yet be detected; others, in which the outlines of the medusa can be distinctly traced within the transparent ectotheque; others, again, just casting off this thin outer pellicle, and others completely freed from it, struggling with convulsive efforts to break loose from the colony, and finally launched forth in the full enjoyment of their freedom into the surrounding water. I know of no form in which so many of the characteristic features of a typical hydroid are more finely expressed than in this beautiful species.

⁂ 3. BOUGAINVILLIA SUPERCILIARIS, *Agassiz*.

HIPPOCRENE SUPERCILIARIS (medusa),—*Agassiz*, North American Acalephæ, part i, pl. i—iii.
BOUGAINVILLIA SUPERCILIARIS,—*Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 289, pl xxvi, figs. 1—7. *Alex. Agassiz*, Catal. North American Acalephæ, p. 153, figs. 232—240.

TROPHOSOME.—HYDROCAULUS attaining a height of about two inches, and forming clusters in which the branches are given off "rather irregularly, though more or less alternately or spirally," the principal branches and ramuli more or less distinctly annulated at their origin. HYDRANTHS with from fifteen to twenty tentacles, strongly marked by annular clusters of thread-cells; hypostome "very short, forming a mere conical papilla;" perisarc continued as a thin film over the posterior part of the hydranth.

GONOSOME.—GONOPHORES scattered irregularly on the ultimate ramuli. Mature MEDUSA with a broad and round manubrium, and with the abial tentacles profusely branched.

Habitat.—Attached to rocks, shells, and occasionally to seaweeds.
Locality.—Atlantic coast of North America.

The *Bougainvillia superciliaris* was first described by Agassiz, but only from the medusa, with which alone he was at the time acquainted, and whose structure he has made the subject of a laborious and exhaustive treatise.[1] He afterwards discovered the trophosome, which he figures in his 'Contributions to the Nat. Hist. of the United States,' while an effective woodcut of the adult medusa, as well as of the entire hydroid, is given by Alexander Agassiz in his 'Illustrated Catalogue of North American Acalephæ,' where he has traced the medusa from the period of its detachment from the trophosome to its fully developed state.

The mature medusa appears to belong to the form with a wide and rounded manubrium and with profusely branched labial tentacles, to which Agassiz would restrict the name of *Bougainvillia*, assigning to those with a more cylindrical manubrium and more sparingly branched labial tentacles Steenstrup's name of *Margelis*. I cannot, however, as already said, accept the generic value of this difference. (See above, p. 311.)

I have never met with *Bougainvillia superciliaris*. It has not been discovered on the European side of the Atlantic, and the diagnosis here given has been framed from Agassiz's description.

*** 4. BOUGAINVILLIA CAROLINENSIS, *M'Crady*.

HIPPOCRENE CAROLINENSIS,—*M'Crady*, Gymnoph. Charleston Harbour, p. 164, pl. x, figs. 8—10.

MARGELIS CAROLINENSIS,—*Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 344. *Alex. Agassiz*, Illustr. Catal, N.A. Acalephæ, p. 156, figs. 241—248.

TROPHOSOME.—HYDROCAULUS attaining a height of from eight to twelve inches; "the main stem is stout, and tapers gradually; the main branches begin close to the root, and thus form clusters, from which branch off irregularly secondary branches, which are quite slender and ramify but little."—*Alexander Agassiz.*

GONOSOME.—GONOPHORES "making their appearance all over the stem."—*A. Agassiz.* Mature MEDUSA with narrow manubrium, and with labial tentacles about three times bifurcated.

[1] 'Contributions to the Natural History of the Acalephæ of North America.'

Colour.—Main stem greyish green, hydranths delicate rose colour.

Habitat.—"Growing on *Fucus vesiculosus* in great abundance."—*A. Agassiz.*

Bathymetrical distribution.—Litoral zone.[1]

Localities.—Charleston Harbour, M'Crady; Naushon, Massachusetts, A. Agassiz.

A medusa obtained abundantly in Charleston Harbour was originally described by M'Crady under the name of *Hippocrene Carolinensis*, and referred by him to a *Eudendrium*-like trophosome from the same locality, but which he does not describe with sufficient detail for a satisfactory diagnosis.

The same medusa was subsequently traced by Alexander Agassiz to a trophosome of which he has given the description just quoted in the diagnosis of the species.

In the large size attained by the trophosome, *Bougainvillia Carolinensis* far surpasses every other species of *Bougainvillia* as yet discovered. It is, indeed, in this respect equalled by very few hydroids.

The position of the gonophores on the main stem, as well as on the branches, brings to mind, as Mr. A. Agassiz remarks, the condition of the same parts in the *Perigonimus muscoides* of Sars.

5. Bougainvillia muscus, *Allman.*

Plate X, figs. 1—3.

Perigonimus muscus,—*Allman*, in Ann. Nat. Hist. for January, 1863.
Bougainvillia muscus,—*Allman*, in Ann. Nat. Hist. for May, 1864. *Hincks*, Brit. Hydr. Zooph., p. 111.

TROPHOSOME.—Hydrocaulus consisting of numerous erect non-fascicled stems, which spring at intervals from a creeping stolon and attain a height of about half an inch; main stems sending off short branches, which are themselves for the most part without further ramification; perisarc slightly corrugated. Hydranths with about sixteen tentacles, alternately elevated and depressed in extension; body of hydranth invested with a thin continuation of the perisarc, which extends nearly to the base of the tentacles.

GONOSOME.—Gonophores borne on rather long peduncles, which spring singly or rarely in greater number from the hydrocaulus, at a short distance below the hydranths.

Colour.—Hydrocaulus light brown, hydranths light reddish brown, manubrium and marginal bulbs of medusa vermilion.

[1] Such, at least, I assume to be the area of its distribution in depth; the *Fucus vesiculosus*, on which it has been found by Mr. A. Agassiz, being eminently characteristic of the Litoral zone.

Development of Gonosome.—September.
Habitat.—In tide pools near low-water mark.
Bathymetrical distribution—Laminarian zone.
Locality.—Torquay, G. J. A.

The small size of the present species, its more simple ramification, and the fact that its stems consist of a single tube instead of being fascicled or composed of numerous tubes coalesced into a dense bundle, at once distinguish it from the other British species, while these features present a combination of characters which also prevent its being confounded with any non-British forms hitherto described.

Hincks ('Brit. Hydr. Zooph.,' p. 112) speaks of a form intermediate between *Bougainvillia muscus* and *B. ramosa,* having fascicled stems like the latter, but in other respects more closely resembling *B. muscus.* It is probably a variety of *B. ramosa.*

The medusa, on liberation, differs in no respect from that of *Bougainvillia ramosa* at the same period. We have as yet no evidence regarding its adult form, which probably resembles that of *Bougainvillia ramosa.*

PROVISIONAL SPECIES.

"Bougainvillia Mertensii," *Alex. Agassiz.*

Under the name of "*Bougainvillia Mertensii,*" Mr. Alexander Agassiz describes, but without any figure, a trophosome which, he informs us, "grows quite luxuriantly, attaining a height of nearly two and a half inches; the stems are very stout, particularly in the main branch, which, near the base, is exceedingly robust; the branches are, at least, three times as stout as those of the hydrarium (trophosome) of *Bougainvillia superciliaris,* which is slender and always branches quite loosely."[1]

The trophosome thus described is referred by its discoverer to a medusa which he regards as identical with that obtained by Mertens in Behring's Straits, and described by Brandt under the name of *Hippocrene Bougainvillii,* but for which Professor Agassiz proposes the name of "*Bougainvillia Mertensii.*"[2]

As, however, the medusa has not been traced to the trophosome, there is no direct proof of the relation between the two, and the species cannot, therefore, be yet regarded as established.

The medusa appears to belong to the form with rounded manubrium and very much branched labial tentacles. Both it and the trophosome were obtained upon the western coast of Mexico, and they are thus Pacific representatives of the *Bougainvillia* form as seen in other species on the east and west shores of the Atlantic.

[1] Alex. Agassiz, 'Illust. Catal.,' p. 152.
[2] Louis Agassiz, 'Cont. Nat. Hist. U.S.,' vol. iv, p. 314.

"EUDENDRIUM PULSILLUM," *Sars*.

Among provisional species must be here included a hydroid described by Sars, in his 'Middelhavet's Littoral-Fauna,' p. 15, tab. i, figs. 11—16, under the name of "*Eudendrium pusillum*." It is certainly, however, not a *Eudendrium*, and is probably either a *Bougainvillia* or a *Perigonimus*. The gonosome has not been observed, and though Sars gives a very full description of the trophosome, it is impossible, without a knowledge of the gonosome, to assign the hydroid to its proper genus.

The following is Sars's diagnosis:—

"*Eudendrium pusillum*. Surculis e tubulo repente filiformi ramoso lævi erectis humilibus, annulatis, hyalinis; ramis paucis (3—4), sparsis, brevibus, crassis, flexuosis seu tortis, annulatis, simplicibus aut dichotomis, apice instar tubæ aliquantum dilatato et a corpore seu capitulo animalis distante; capitulo animalium elongato, subcylindrico, non retractili, albo, tentaculis circiter 20 uniserialibus."

The species was found in the neighbourhood of Messina, tolerably abundantly growing a little below the surface of the sea on a brownish-red seaweed. It is quite a small form, attaining a height of only an eighth of an inch. The hydranths manifestly belong to the *Bougainvillia* or *Perigonimus* type, and not at all to that of *Eudendrium*. Sars's description is accompanied by some good figures of the trophosome.

DIPLURA, *Green*, in Lit.

Name.—From διπλος, double, and ουρά, a tail; in allusion to the two tentacles, which are developed like a tail from one of the marginal bulbs of the planoblast.

CORYNE,—*Steenstrup*.
STEENSTRUPIA,—*Agassiz*.

TROPHOSOME.—HYDROPHYTON solitary, rooted by a filiform HYDRORHIZA, and surmounted by a claviform HYDRANTH.[1]

GONOSOME.—PLANOBLASTS springing from the body of the hydranth at the proximal side of the tentacles. Umbrella deep bell-shaped; manubrium with simple or quadrilobate mouth; radiating canals terminating each in a marginal bulb, one of which, in the mature medusa, carries a pair of filiform tentacles, the others being destitute of tentacles.

[1] For the description here given of the trophosome I have no data beyond the figure which accompanies Steenstrup's memoir; and as this figure is evidently a mere sketch, and plainly inexact in its details, the above diagnosis founded on it is necessarily incomplete. Prof. Steenstrup's original specimens have unfortunately been lost, and we do not possess data sufficient for the determination of even the family to which *Diplura* ought to be referred. Its allocation to the *Bougainvillidæ* must, therefore, be accepted with reservation.

One of the many observations which Steenstrup so happily correlated in his famous treatise on the 'Alternation of Generations' was made on a little tubularian hydroid which he obtained off the coast of Iceland, and which, with its verticil of pendant medusa-bells, so closely resembled a plant of *Fritillaria imperialis*, with its verticillate cluster of drooping flowers, that the Danish zoologist gave to it the name of *Coryne Fritillaria.*

According to the views, however, by which we must now be guided in our classification and nomenclature of the HYDROIDA, Steenstrup's hydroid is no *Coryne*, nor is it referable to any other genus which had, up to the time when Steenstrup recorded it, been described.

Our knowledge of the trophosome is far from being as complete as could be desired. Indeed, we are not informed whether the hydrophyton is naked or clothed with a chitinous perisarc, and the disposition of the hydranth-tentacles can by no means be inferred with certainty from either the figure or description given by Steenstrup.

The gonosome, on the contrary, is described and figured with considerable detail, so that no difficulty is met with in obtaining such generic characters as may be afforded by this part of the hydroid.

Some years ago Professor J. R. Green discovered in the Bay of Dublin a medusa which so closely resembles that described by Steenstrup as developed from his *Coryne Fritillaria* that, though nothing is known of the trophosome from which Green's medusa was produced, we are justified in considering it for the present as congeneric with Steenstrup's hydroid.

Green described his medusa under the generic name of *Diplonema;* but as this had been already appropriated by the botanist, he subsequently substituted for it, in a letter to myself, the name of *Diplura.*

It was on these grounds that I had elsewhere[1] proposed that the name of *Diplura Fritillaria* should take the place of *Coryne Fritillaria.*

*** DIPLURA FRITILLARIA, *Steenstrup.*

CORYNE FRITILLARIA,—*Steenstrup,* Ueber den Generationswechsel, and Ray Society's Translation, p. 27, pl. i, figs. 41—46.
STEENSTRUPIA FRITILLARIA,—*Agassiz,* Cont. Nat. Hist. U.S., vol. iv.
DIPLURA FRITILLARIA,—*Allman,* in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—HYDROCAULUS attains a height of about half an inch, slender. HYDRANTHS with five or six tentacles.

GONOSOME.—GONOPHORES pendulous, arranged in a verticil of four round the base of the hydranth. Medusæ, at the time of their liberation, in the form of a quadrangular bell, with a single rudimental, knob-like, marginal tentacle; the two tentacles given off from the marginal bulb of the mature medusa very long and moniliform.

[1] 'Ann. Nat. Hist.' for May, 1864.

Development of Gonosome.—April and May.
Habitat.—On empty shells of *Balani*, &c., from the bottom of the sea.
Locality.—Off the town of Reikewig, in Iceland, Professor Steenstrup.

I take for granted that Steenstrup is correct in regarding as the mature form of the planoblast of his *Coryne Fritillaria* a medusa which he found swimming at large in the open sea, in the neighbourhood of the spot which afforded him his specimens of the trophosome, and both the generic and specific descriptions given above are based on this supposition. We cannot, however, shut our eyes to the fact that in this identification we are dealing with a mere inference, and that the free-swimming medusa has not been traced back by direct observation to the trophosome.

Steenstrup describes a lobed body as existing at the common base of the two marginal tentacles in his free medusa. He regards this as the generative organ of the medusa, a view which, however it may have been justified at the time when he wrote, will not be shared in by any one at present. There can, I think, be little doubt that the body in question is a cluster of young medusa-buds originating in a situation in which this form of gemmation is by no means rare among the HYDROIDA.

PERIGONIMUS, *Sars.*

Name.—From περὶ, around, and γονιμος, productive; so named from the disposition of the gonophores round the stem and branches of the trophosome.

ATRACTYLIS (in part),—*Strethill Wright.*

TROPHOSOME.—HYDROPHYTON consisting of a branching or simple HYDROCAULUS rooted by a filiform HYDRORHIZA. HYDRANTHS fusiform, with a conical hypostome.

GONOSOME.—PLANOBLASTS developed from the hydrophyton. Umbrella, at the time of liberation, deep bell-shaped, with the oral extremity of the manubrium either simple or more or less deeply lobed; marginal tentacles either two or four, not in clusters, and with bulbous bases, which are not furnished with distinct ocelli.

The genus *Perigonimus* was founded by Sars[1] for a hydroid which he obtained on the Norwegian coast. The position of its medusæ, scattered over the hydrocaulus, appeared to him to offer a feature so peculiar as to entitle this character to be assumed as one of the chief grounds for the establishment of a new genus, while it further suggested to him the generic name.

[1] 'Fauna lit. Norv.,' 1rste Liefer., p. 8.

This position of the gonophores, however, we now know to be equally a character of other genera, while still other characters of a specific rather than a generic value were also included by Sars in his diagnosis. Yet notwithstanding this, the hydroid on which the genus *Perigonimus* was founded is undoubtedly entitled to generic rank, and, with some slight modifications of the original diagnosis, *Perigonimus* must stand as an established genus.

The genus *Atractylis* of Wright, as already mentioned,[1] includes forms which are referable to the *Perigonimus* of Sars, and others which must be transferred to the *Bougainvillia* of Lesson, while, quite recently, Van Beneden[2] has instituted his genus *Dinema* for a form which cannot be generically separated from *Perigonimus*.

The only character on which the claims of *Dinema* to be separated from *Perigonimus* rest are found in the fact that at the time of liberation the medusa of *Dinema* has only two marginal tentacles, while that of the *Perigonimus muscoides* of Sars has four. This, however, is a very unimportant difference, for there can be no doubt that the tentacles increase in number with the age of the medusa, and that the two-tentacled *Dinema* acquires four or more tentacles as it advances towards maturity. I have accordingly already united[3] under the genus *Perigonimus*, not only forms in which the medusa, at the time of its liberation from the trophosome, has four tentacles, but those in which the number of tentacles at that period does not exceed two. The changes, indeed, which occur in the medusa as it approaches sexual maturity are to be chiefly sought for in the increase of the number of marginal tentacles, each new one being intercalated at the middle point between two older ones.

*** 1. Perigonimus muscoides, *Sars.*

Perigonimus muscoides,—*Sars,* Fauna Lit. Norv., erste Lieferung, p. 8, tab. i, figs. 19—21.

TROPHOSOME.—Hydrocaulus attaining a height of from two to three inches, much branched, the branches thinner than the main stem, and, as well as the main stem, sending off numerous short, scattered, simple hydranth-bearing ramuli; perisarc marked with longitudinal, somewhat undulating striæ, not annulated. Hydranths with a circlet of from eight to twelve tentacles in two closely approximated series.

GONOSOME.—Gonophores borne on short peduncles and scattered over the main stem and principal branches. Medusæ, on liberation, with four marginal tentacles.

[1] See p. 299.

[2] 'Recherches sur la Faune litt. de Belgique,' p. 127, pl. ix and x.

[3] "On the Construction and Limitation of Genera," &c., 'Ann. Nat. Hist.' for May, 1864.

Colour.—Perisarc greyish-yellow, hydranth vermilion, medusa with its manubrium reddish, and the basal bulbs of its marginal tentacles reddish-brown.

Development of Gonosome.—August.

Habitat.—Attached to other hydroids, the tests of large ascidians, &c.

Bathymetrical distribution.—Coralline zone?

Locality.—Coast of Norway, Sars.

I have never met with this species. The diagnosis given above is selected from the characters published by Sars. The species is historically interesting as affording the first-described example of a genus which we now know to be one of the richest in specific forms among the gymnoblastic hydroids.

2. Perigonimus repens, *Strethill Wright.*

Endendrium pusillum,—*Wright,* in Proc. Roy. Phys. Soc. Edin., vol. i, p. 231, pl. xi, figs. 8, 9.

Atractyles repens,—*Wright,* in Proc. Roy. Phys. Soc. Edin., vol. i, p. 450, pl. xxii, figs. 4, 5.

Perigonimus repens,—*Hincks,* Brit. Hydr. Zooph., p. 90, pl. xvi, fig. 2.

TROPHOSOME.—Hydrocaulus simple, or slightly branched, attaining a height of from one eighth to one quarter of an inch; perisarc dilated at the summits of the hydrocaulus. Hydranths partially retractile, with from four to twelve tentacles held in an alternately elevated and depressed position.

GONOSOME.—Gonophores nearly sessile on the hydrocaulus; umbrella thimble-shaped; marginal tentacles four, two opposite tentacular bulbs carrying very long ones, and the others very short ones.

Colour of hydranths white.

Habitat.—"Attached to sertularians, and to the back and legs of the spider-crab," Wright.

Localities.—Firth of Forth, Dr. Wright; Coast of Northumberland, Mr. Alder; Ilfracombe, Mr. Hincks.

I agree with Hincks in regarding the *Atractylis repens* of Wright as the same hydroid which he had previously described under the name of *Endendrium pusillum.* Indeed, it is impossible to find any characters of specific value by which the one may be distinguished from the other. Wright does not himself appear to recognise any difference between them, and while his change of the generic name is founded on legitimate zoological grounds, his change of the specific name, is probably a mere oversight. In order to avoid further confusion I have followed Hincks in adopting Wright's specific name of "repens."

I have never met with this species, and the diagnosis here given is framed from Dr. Wright's description.

3. Perigonimus minutus, *Allman.*

Plate XI, figs. 4—6.

Perigonimus minutus,—*Allman*, in Ann. Nat. Hist. for January, 1863.

TROPHOSOME.—Hydrocaulus consisting of simple stems which rise at intervals from a creeping stolon and attain a height of one eighth of an inch; perisarc smooth. Hydranths with seven or eight, rarely twelve, tentacles, which are held straight but very irregularly in extension; body of hydranth partially invested by a cup-like extension of the perisarc.

GONOSOME.—Gonophores borne upon long peduncles, which spring at various heights from the hydrocaulus. Medusa with the umbrella contracted towards the summit, so as to give it a conical form; two opposite marginal bulbs large, each carrying a very extensile tentacle, two alternate bulbs much smaller and without tentacles; manubrium short, with the margin of the mouth four-lobed.

Colour—Hydranth ash-brown, manubrium and marginal bulbs of medusa ash-brown, perisarc yellowish-brown.

Development of Gonosome.—August.

Habitat.—Forming a fringe round the operculum of *Turritella communis.*

Bathymetrical distribution.—Coralline zone.

Locality.—Busta Voe, Shetland.

The present species comes very near to the *Perigonimus* (*Atractylis*) *repens* of Wright, and, indeed, is regarded by Hincks as identical with it. It differs from it, however, in the irregular disposition of the tentacles of the hydranth, and in the form of the medusa, which in Dr. Wright's species shows no approach to the conical form of *Perigonimus minutus,* while it further differs from it in the long peduncles which support the gonophores.

The tentacles of the medusa are very extensile; when contracted they are, like many other species of *Perigonimus,* rolled into a spiral.

Perigonimus minutus was abundant in the only locality where it has been as yet obtained, and where it was entirely confined to the operculum of living Turritellas. Out of nearly thirty specimens of *Turritella communis* which I had dredged in Busta Voe and examined, not one was free from this remarkable little hydroid.

4. Perigonimus sessilis, *Strethill Wright.*

Eudendrium sessile,—*Wright*, in Proc. Roy. Phys. Soc. Edin., vol. i, p. 237, pl. xii, figs. 16, 17.

Atractylis sessilis,—*Wright*, id., p. 450.

Perigonimus sessilis,—*Allman*, in Ann. Nat. Hist. for May, 1864. *Hincks*, Brit. Hydr. Zooph., p. 93, pl. xvii, fig. 1.

TROPHOSOME.—Hydrocaulus obsolete or rudimental. Hydranthus sessile, on a creeping reticulated stolon, or slightly raised above it on the rudimental hydrocaulus, invested as far as the tentacles with a cup-like extension of the perisarc; tentacles attaining the number of eight, equal in length, straight in extension, and then carried alternately elevated and depressed.

GONOSOME.—Gonophores sessile on the creeping stolon. Medusa with the umbrella thimble-shaped, and having four marginal tentacles, alternately very long and very short.

Habitat.—On shells from deep water, and on rocks.
Locality.—Firth of Forth, Dr. Wright.

I have never met with this apparently well-marked species. The diagnosis here given has been extracted from Dr. Wright's description. Though the trophosome would seem to be very distinct from that of *Perigonimus pusillus*, the medusæ are described by Dr. Wright as differing in no respect from those of that species, either in size or form.

5. Perigonimus palliatus, *Strethill Wright.*

Atractylis palliata,—*Wright*, in Ann. Nat. Hist. for August, 1861, pl. iv, figs. 6, 7.

Parigonimus palliatus,—*Allman*, in Ann. Nat. Hist. for May, 1864. *Hincks*, Brit. Hydr. Zooph., p. 93, pl. xvii, p. 91.

TROPHOSOME.—Hydrocaulus but slightly developed, and consisting of short, closely set stems, which spring from a creeping reticulated stolon. Hydranthus very minute, enveloped in a thick gelatinous coat as far as the border of the mouth, tentacles eight, alternate.

GONOSOME.—Gonophores developed from the hydrorhiza; medusa thimble-shaped, with two marginal bulbs which carry long tentacles, and alternate with two smaller bulbs destitute of tentacles; manubrium with the oral margin four-lobed.

Colour of hydranths white.
Habitat.—On a shell inhabited by a hermit-crab.
Locality.—Firth of Forth, Dr. Wright.

I have never met with this remarkable little hydroid. "When first observed," says Dr. Wright, "its closely set and dense white polypes, surrounded by their gelatinous envelopes, were mistaken for a mass of minute ova."

6. Perigonimus vestitus, *Allman.*

Plate XI, figs. 1—3.

Perigonimus vestitus,—*Allman*, in Ann. Nat. Hist. for July, 1864. *Hincks*, Brit. Hydr. Zooph., p. 94.

TROPHOSOME.—Hydrocaulus consisting of numerous stems rising at short intervals from a reticulated stolon, and attaining a height of from half a line to two lines, becoming greatly dilated towards the summits where they pass uninterruptedly into the body of the hydranths, mostly simple, but occasionally with one or two short lateral branches; perisarc coarse, roughened by adherent particles of sand. Hydranths with from six to ten tentacles, which are rendered hispid by minute clusters of thread-cells, and are held straight in extension with the alternate ones elevated and depressed; posterior part of the body invested by the rough perisarc, which is thence continued as a delicate, smooth membrane over the remainder of the body nearly as far as the mouth.

GONOSOME.—Gonophores elevated on long peduncles, which spring from the hydrocaulus, and occasionally also from the hydrorhiza, the peduncle for about its proximal half covered by a continuation of the chitinous perisarc. Medusa, at the time of liberation, oviform, the cavity of the umbrella being very deep and the codonostome much contracted; umbrella-walls very thin, and with numerous scattered thread-cells immersed in them, two opposite marginal tentacles, and two intermediate marginal bulbs destitute of tentacles, manubrium with four shallow lips.

Colour.—Hydranths pale yellow, manubrium and marginal bulbs of medusa pale reddish, perisarc yellowish brown.

Development of gonosome.—June.

Habitat.—On an old Buccinum shell found in a rock-pool near low-water mark.

Bathymetrical distribution.—Laminarian zone?

Locality.—Firth of Forth, G. J. A.

Perigonimus vestitus was met with in the Firth of Forth in June, growing on an empty Buccinum shell, where it was associated with *Hydractinia echinata.* In the continuation of the perisarc over the body of the hydranth, as well as in general habit, it comes very near to the *Perigonimus palliatus* of Wright, from which, however, it differs, judging from Dr. Wright's description and figures, in its more developed hydrocaulus, in the thinner and more membranous character of the perisarcal investment of the hydranths, in the position of the gonophores—which are here borne almost exclusively on the hydrocaulus, only an occasional one being here and there developed from the hydrorhiza, while in *Perigonimus palliatus* they are described as being confined to the hydrorhiza—and in the form of the medusa whose contracted codonostome gives to the umbrella at the time of liberation an oviform shape, while in *Perigonimus palliatus* the umbrella does not become contracted towards the codonostome, and is accordingly nearly cylindrical in form.

In medusæ, about the tenth day after their liberation, the form had undergone considerable change, the umbrella having become nearly spherical. No increase, however, had taken place in the number of marginal tentacles.

The trophosome is rendered particularly striking by the great dilatation of the stems, which graduate into the body of the hydranths without any well-marked line of demarcation. In the medusa the tentacles, which are very extensive, become rolled into an elegant spiral when contracted.

7. Perigonimus serpens, *Allman.*

Plate XI, figs. 7—9.

Perigonimus serpens,—*Allman*, in Ann. Nat. Hist. for January, 1863. *Hincks*, Brit. Hydr. Zooph., p. 95, pl. xvi, fig. 3.

TROPHOSOME.—Hydrocaulus consisting of short, simple stems, rising at short intervals from a creeping reticulated stolon, and attaining a height of about two lines, clothed with a very delicate transparent perisarc, which is destitute of annulation, and loses itself at the base of the hydranths without forming distinct cup-like dilatations. Hydranths, with twelve or fourteen slightly alternating tentacles.

GONOSOME.—Gonophores elevated on long peduncles which are borne by the creeping stolon. Medusa dome-shaped, with the vertical and transverse diameters nearly equal; manubrium reaching to about half the depth of the bell; marginal tentacles two, opposite, very extensile, with large basal bulbs; two very small intermediate marginal bulbs.

Colour.—Hydranths and cœnosarc, as well as the manubrium and marginal bulbs of the medusa reddish orange.

Development of gonosome.—Autumn.

Habitat.—Growing on the stems of other hydroids.

Bathymetrical Distribution.—Coralline zone.

Locality.—Torbay, G. J. A.

This beautiful little hydroid was dredged from about twelve fathoms in Torbay, where it invested the stems of *Plumularia setacea.* Though small, it is rendered very conspicuous by the bright orange colour, not only of the hydranths, but of the cœnosarc, which is quite visible through the delicate transparent perisarc. When about to detach itself from the trophosome the medusa bursts through its membranous ectotheca, the remains of which may be usually seen after its rupture still attached to the top of the peduncle. At the same time, the two tentacles which had been previously folded back into the cavity of the umbrella become liberated from their confinement, and extend themselves in the surrounding water. The medusa, now divested of its ectotheca, still remains for some little time attached to the summit of the peduncle, until at length, after repeated convulsive efforts, it breaks loose from the trophosome, and henceforth leads the life of a free zooid in the open sea.

When the planoblast is at rest, or is floating listlessly in the water, the tentacles are usually extended to a great length, and hang in the form of threads of extreme tenuity from the umbrella margin; but, on the slightest irritation, each tentacle is instantly drawn up assuming a beautiful spiral in the act of contraction. The tentacles are also rolled into a spiral when the medusa, by the contractions of its umbrella, is propelling itself through the surrounding water.

8. Perigonimus linearis, *Alder.*

Atractylis linearis,—*Alder,* Suppl. Catal., p. 6, pl. x, figs. 1, 2, 3.

Perigonimus linearis,—*Allman,* in Ann. Nat. Hist. for May, 1864. *Hincks,* Brit. Hydr. Zooph., p. 96, pl. xvii, fig. 3.

TROPHOSOME.—Hydrocaulus consisting of unbranched (?) stems, which rise at short intervals to the height of a quarter of an inch from a reticulated stolon; perisarc destitute of annulation, but slightly wrinkled near the base of the stems.

HYDRANTHS slender, retractile, with eight long muricated tentacles, held alternately, elevated and depressed.

GONOSOME.—GONOPHORES pear-shaped, or sub-globular, borne by the hydrocaulus in groups of two or three together; MEDUSA "globose, slightly truncated below, with a contracted aperture; four moderately sized sub-clavate tentacles arising from four semicircular yellowish lobes at the margin of the umbrella; sub-umbrella small, with four radiating canals, the centre occupied by a mass of yellowish or orange granules, apparently ova; peduncle (manubrium) inconspicuous, branched at the base."—*Alder.*

Habitat.—On *Turritella communis* and other shells.
Bathymetrical distribution.—Deep-water zone.
Locality.—Coast of Northumberland, Mr. Alder.

It is with great hesitation that I refer this species to the genus *Perigonimus.* I have never seen it, and the characters given above are those assigned to it by Mr. Alder. So far as the trophosome is concerned, there is nothing to exclude it from *Perigonimus,* but if the medusa be correctly described, there is some reason for regarding it as belonging to a distinct generic group.

The characters of the medusa, however, are not given with sufficient detail and precision to afford material for the definition of a new genus. Indeed, it seems pretty evident that the medusæ of the specimen which furnished the subject of Mr. Alder's description and drawing were not in a perfect state, that they had undergone more or less change from exposure to unfavorable conditions, and that their essential characters had been thereby obscured. We must wait, therefore, until further observations shall have made us better acquainted with its gonosome, before we can venture upon a precise characterization of this curious little hydroid. Until then we may retain it in the genus *Perigonimus,* to which it appears to come nearer than to any other genus hitherto defined.

DOUBTFUL SPECIES.

The "ATRACTYLIS BITENTACULATA" of Wright ('Proc. Roy. Phys. Soc.,' Edin. for Feb., 1863, p. 43, pl. i, fig. 5), and the "ATRACTYLIS QUADRITENTACULATA" of Wright (*id.* fig. 6) are probably immature forms of some species of *Perigonimus.* In the absence, however, of all knowledge of the gonosomes it is impossible to assign them with certainty to any established genus.

They are very small forms. The "*Atractylis bitentaculata*" is described as consisting of minute, nearly sessile hydranths, springing from a retiform hydrorhiza, and furnished each with two erect tentacles. The hydranths "have a habit somewhat like that of *Lar,* of quickly bending down the body until the mouth is brought close to the surface on which the zoophyte grows." It was found on a pecten shell dredged in the Firth of Forth.

The other form, "*Atractylis quadritentaculata,*" is described as having its hydranths sessile, columnar, short, provided with four alternate tentacles, two of which are long and depressed, two short and nearly at right angles to the body of the hydranth. It "was found creeping along the the side of a large vessel containing shells and zoophytes dredged from the Firth of Forth."

EUDENDRIDÆ.

TROPHOSOME.—Hydrocaulus developed, invested with a perisarc. Hydranths with the hypostome abruptly differentiated from the body, and with a single set of verticillate filiform tentacles.

GONOSOME.—Gonophores fixed sporosacs.

The hypostome, of all the species included in the family of the *Eudendridæ,* is rendered very remarkable by being abruptly differentiated from the body of the hydranth instead of passing continuously into it as in other gymnoblastic hydroids. In this respect it resembles the hypostome of the *Campanularidæ* among the *Calyptoblastea.*

EUDENDRIUM, *Ehrenberg* (in part).

Name.—From εὖ, well (beautiful) and δένδρον, a tree, so named from the tree-like form of the trophosome.

Tubularia,—*Linnæus.*
Sertularia,—*Cavolini.*

TROPHOSOME.—Hydrophyton consisting of a branching hydrocaulus rooted by a creeping filiform hydrorhiza. Hydranths flask-shaped, or oval, with the hypostome expanded at its distal extremity so as to be more or less trumpet-shaped; tentacles forming a verticil just below the hypostome.

GONOSOME.—SPOROSACS developed from the body of the hydranth at the proximal side of the tentacles, or from the hydrocaulus. Male sporosacs polythalamic, female sporosacs monothalamic.

Ehrenberg,[1] perceiving that the *Tubulariæ* of the earlier authors included more than one generic form, proposed to distribute them under two genera. The dismemberment to which the old genus *Tubularia* was thus subjected must be regarded as an important step in the classification of the HYDROIDA; but Ehrenberg scarcely recognised the true grounds of the division, for he based it on the simple or branched condition of the trophosome, leaving the simple forms in the genus *Tubularia*, and bringing the ramified forms into a new genus, to which he assigned the name of *Eudendrium*.

The characters thus selected are of minor value, and the genus *Eudendrium*, as defined by Ehrenberg, included not only forms which are properly separated from *Tubularia*, but also true *Tubulariæ*, such as *Tubularia larynx*. The celebrated Prussian microscopist, however, did not allow the more important characters, such as those derived from the disposition of the tentacles, entirely to escape him, though he merely pointed to them as possibly affording to future observers grounds for further generic distinction.

Van Beneden[2] seems to have been the first who felt the necessity of restricting the genus *Eudendrium* to such forms as had their tentacles arranged in a single verticil, and of restoring to the genus *Tubularia* those in which the hydranth is provided with two verticils of tentacles, regardless of the simple or branched condition of the trophosome.

Still later, Sars[3] founded the genus *Perigonimus* for certain species which continued to be included in the restricted genus *Eudendrium*, assuming as his chief grounds of separation the position of the gonophores, which he believed to be confined to the hydranths in the true Eudendriums, but distributed along the stems and branches in *Perigonimus*. This character, however, is of comparatively little value, a much more valid one being found in the form of the hydranth, as was first distinctly shown by Dr. Strethill Wright. (See general remarks on the genus *Wrightia*, given above.)

The genus *Eudendrium* must now be understood as limited by the characters assigned to it in the diagnosis just given. All the species hitherto discovered are ramified, and there are no hydroids on which the plant-like physiognomy is more decidedly impressed than we find it to be on the various species of this beautiful genus.

The peculiar form of trophosome described above in the generic diagnosis has as yet been found associated with only one form of gonosome. Until, therefore, some new observations shall come to invalidate our generalization, we shall be justified in referring any trophosome with the characters above enumerated to the genus *Eudendrium*, whether the gonosome be known or not.

This is in striking contrast with certain other hydroid trophosomes, such as the corynoid trophosome, which may belong to at least three genera, and that of *Perigonimus*, which, as we have already seen, may also have such different forms of gonosome associated with it as to render it impossible, without this last element, to decide on the genus of the hydroid.

1 "Corallenthiere," 'Abhandl. der Berlin. Akad.,' 1832, p. 297.

2 'Recherches sur l'Embryogenie des Tubulaires.'

3 'Fauna lit. Norveg.,' Erste Liefer, p. 8.

1. EUDENDRIUM RAMOSUM, *Linnæus*.

Plate XIII.

CORALLINA TUBULARIA GRACILIS ET RAMOSA, AXILLIS RAMULORUM CONTORTIS. "Small ramified tubular Coralline."—*Ellis*, Corall., p. 31, pl. xvi, fig. *a*; xvii, fig. *a* A.
TUBULARIA RAMOSA,—*Linn.*, Syst. Nat., edit. x.
TUBULARIA TRICHOIDES,—*Pallas*, Eleuchus, p. 84.
EUDENDRIUM RAMOSUM,—*Ehrenberg*, Corallenthiere, Abhandl. Berl. Akad., p. 296. *Johnston*, Brit. Zooph., 2nd edit., p. 46, pl. vi, figs. 1—3. *Hincks*, Brit. Hydr. Zooph., p. 82, pl. xiii.

TROPHOSOME.—HYDROCAULUS much branched, fascicled at its base, and attaining a height of four inches or more; primary ramification irregular, after which the branches become regularly alternate and mostly distichous in their arrangement, giving off all along their length, from their upper or distal sides, short, usually simple ramuli, which support the hydranths on their summits; PERISARC firm, annulated at the origin of the branches, or even along the entire length of the smaller branches. HYDRANTHS usually with about twenty tentacles, frequently atrophied in the male.

GONOSOME.—SPOROSACS, in the male, composed of two spherical receptacles, and springing from the body of the hydranth in a verticil behind the tentacles, which, however, often become atrophied and disappear. SPOROSACS in the female, piriform, scattered, springing, some from the body of the hydranth at the proximal side of the tentacles, and some from the hydrophyton just below the hydranth.

Colour.—Hydranths vermilion, perisarc dark reddish brown, in the older parts of the colony often nearly black; male gonophores with vermilion spadix modified to rose colour as seen through the pale imperfectly transparent contents of the receptacles; female gonophores orange red.

Development of gonosome.—April.

Habitat.—Attached to oyster-shells, stones, &c., in the sea.

Bathymetrical distribution.—Coralline zone.

Localities.—On the Kentish shore, Ellis; Morecamb Bay, Lancashire, G. J. A.; south coast of Devonshire, Rev. T. Hincks.

The beautiful hydroid just defined may be conveniently assumed as the type of the genus *Eudendrium*. There can be no doubt that it is identical with the "small ramified tubular coralline" of Ellis, and that it is, therefore, the original *Tubularia ramosa*, this being the binary designation by which the descriptive phrase of Ellis was superseded in the 'Systema Naturæ.' It is consequently a very different hydroid from the *Eudendrium ramosum* of Van Beneden.

It was first described and figured by Ellis from specimens obtained upon the coast of Kent, but without any reference to the gonosome, an omission which may be explained by the fact that Ellis's specimens had been gathered in August, and therefore after the gonophores had disappeared.

The hydranths, which are of a fine vermilion colour, are very conspicuous even to the naked eye, while the beauty of the male colonies is greatly enhanced by the presence of the gonophores. These are two-chambered and spring in a regular verticil from the body of the hydranth, about half way between the origin of the tentacles and the summit of the supporting branch.

The hydranth in the male colonies is at first, while it continues to retain its full development, embraced by its circlet of gonophores from whose midst the tentacles rise in a graceful campanulate plume. Frequently, however, the hydranth, as if starved by the growing gonophores, and their increasing demand for nutrition, becomes atrophied, the tentacles entirely disappear, and the whole becomes changed into a short column, which carries the gonosacs in an umbel on its summit. With the atrophy of the tentacles the mouth seems also to disappear, and the hydranth has thus assumed all the characters of a blastostyle. It is a blastostyle, however, merely from atrophy, and must not be confounded with a true blastostyle, which, though strictly homologous with a hydranth, belongs, from its origin, to a special and independent morphological modification.

In the female colonies the gonophores are without the symmetrical arrangement so striking in the male, and, instead of being disposed in a regular verticil, are scattered on the body of the hydranth, and on the distal end of the branch. They are of a reddish-orange colour, and increase in maturity as we trace them downwards on the branch. The tentacles of the hydranth are here, also, as in the male, often dwindled; but I have never met with that complete atrophy which is of such frequent occurrence in the male.

The perisarc constitutes a firm, elastic, horn-like covering. The hydrocaulus in full-sized specimens is about half a line in thickness towards its base, and here presents a fascicled structure formed by the mutual adhesion of several simple capillary stems. It soon, however, loses this condition, and then continues as a singled branched tube for the rest of its course. The comparatively small diameter of the stem, even at that part where the fasciculated condition exists, and the fact that the fasciculation is confined to those parts which are near to the attached end of the hydrosoma, has caused this character to be overlooked in the description given by Ellis, while Pallas ascribes to the species an absence of fasciculation as one of its leading diagnostic characters. This error has doubtless been strengthened by the fact that many of the specimens which have been found entangled in the lines of the fishermen, or otherwise detached from their place of growth, have been so torn away as to leave most or the whole of the fascicled portion behind them.

2. Eudendrium rameum, *Pallas*.

Tubularia ramea,—*Pallas*, Elenchus, p. 83. *Dalyell*, Rare and Remarkable Animals, vol. i, p. 5, pls. vi, vii, viii, ix.

Eudendrium rameum,—*Johnston*, Brit. Zooph., 1847, p. 45, pl. v, figs. 1, 2. *Hincks*, Brit. Hydr. Zooph., p. 80, woodcut fig. 8.

TROPHOSOME.—Hydrocaulus profusely branched, attaining a height of from three to six inches, fascicled in the main stem and principal branches; main stem attaining a thickness of more than a quarter of an inch, and as well as the principal branches very irregularly ramified; branches ultimately losing their fasciculation, and then consisting of single capillary tubes, which may continue to branch before the emission of the ultimate or hydranth-bearing ramuli, which are regularly alternate in their disposition; perisarc rigid, occasionally marked with nearly obsolete annulations on the smaller branches. Hydranths with about twenty tentacles, frequently atrophied in the male after the production of gonophores.

GONOSOME.—Male sporosacs two-chambered, borne upon the body of the hydranth in a verticil immediately below the tentacles; female sporosacs oval, scattered on the hydrocaulus for some distance below the hydranth.

Colour.—Hydranths rose colour, hydrocaulus reddish brown, female gonophores brownish orange.

Habitat.—Attached to stones, old shells, &c., in the sea.

Bathymetrical distribution.—Deep-sea zone.

Localities.—Mediterranean, Pallas; coast of Norway, Sars; Firth of Forth, Sir J. G. Dalyell and G. J. A.; coast of Northumberland, Dr. Johnston and Mr. Alder; Shetland Islands, Firth of Clyde, coasts of Lancashire and Cornwall, and east coast of Ireland, Mr. Hincks.

Eudendrium rameum, with its massive trunk and boughs, sending off smaller and smaller branches, until these, in the wonderful profusion of their ramification, terminate in the delicate hydranth-bearing twigs, is perhaps the most tree-like of all our hydroids, and might well have suggested the generic name under which it is associated with other tree-like forms of these beautiful animals.

It is certainly very nearly allied to the *Eudendrium ramosum* of Linnaeus, more nearly, indeed, than has been suspected by the systematic writers who have described it, and who have followed Pallas in regarding its fascicled stems as affording the main grounds of distinction between it and the species just named. *Eudendrium ramosum*, however, is also a fascicled form, and the chief difference between the two species will be found in the much more massive stems and main branches of *Eudendrium rameum*, and in its more irregular ramification and rigid habit. The rigidity of the whole hydrophyton is such that, on removal from the water, all the branches, even to the finer twigs, retain their form and directions as completely as if the hydroid were still immersed.

The first description of the present species is that given by Pallas, whose specimens were obtained from the Mediterranean. It is a frequent hydroid on the Scottish coast, where it is often brought up upon the lines of the fishermen from deep water.

Though I have many times seen specimens of this fine species, I have unfortunately not had an opportunity of making a drawing from the living hydroid, which has, therefore, no place among the plates of the present volume. The figures of Johnston, Dalyell, and Hincks, however, referred to in the synonyms, will afford to the zoologist good aid in his determination of the species.

3. Eudendrium capillare, *Alder*, sp.

Plate XIV, figs. 1—3.

Eudendrium capillare,—*Alder*, Catal., p. 15, pl. i, figs. 9—12. *Hincks*, Brit. Hydr. Zooph., p. 84, pl. xiv, fig. 2.
Corymbogonium capillare,—*Allman*, in Ann. Nat. Hist. for August, 1861.
Dicoryne capillaris,—*Alder*, Suppl. Catal., p. 6.

TROPHOSOME.—Hydrocaulus forming small bush-like growths, much and irregularly branched, rising to a height of from one half to three quarters of an inch, and given off at intervals from a creeping anastomosing stolon; stems and branches capillary, invested with a thin perisarc, which is annulated at the origin of the branches. Hydranths with about twenty-four or twenty-six tentacles.

GONOSOME.—Male sporosacs two-chambered, supported in radiating, somewhat corymbose clusters upon the bodies of hydranths from which the tentacles and hypostome have disappeared by atrophy, the stalks which carry them constituting either ultimate ramuli of the hydrocaulus or simple stems, which spring directly from the hydrorhiza. Female sporosacs piriform, in clusters similar to those of the male, and borne in the same way on the remains of atrophied hydranths whose supporting stalks are carried either by the hydrocaulus or directly by the hydrorhiza.

Colour.—Hydranths and male gonophores a pale greyish olive, female gonophores reddish orange; perisarc light brown, becoming darker in the older parts.

Development of Gonosome.—June to September.

Habitat.—On rocks near extreme low-water mark, and on other hydroids, old shells, and the tunics of Ascidians.

Bathymetrical distribution.—Laminarian and Coralline zones.

Localities.—Coast of Northumberland, Mr. Embleton; Plymouth, Mr. Alder; Torbay, Devonshire, Rev. T. Hincks; Firth of Forth and Torbay, G. J. A.

The first description of *Eudendrium capillare* is that given by Mr. Alder, who drew up its characters from a specimen preserved in spirits. Some time after this I dredged the same hydroid in the Firth of Forth from a depth of about five fathoms. The complete atrophy of the gonophore-bearing hydranths led me to regard it as the representative of a new genus, which I accordingly described under the name of *Corymbogonium*. A more thorough investigation of the genus *Eudendrium*, however, has since convinced me that this genus may present in the hydranths which carry the gonophores, even in one and the same colony, every degree of atrophy, from the fully developed hydranth to the mere remnant of this body after mouth, hypostome, and tentacles have entirely disappeared. The blastostyle-like condition of the hydranth, therefore, in the genus *Eudendrium* is a character of little importance, and can in no way justify a generic separation. The genus *Corymbogonium* must accordingly be absorbed into the older genus *Eudendrium*, in which Alder had originally placed it.

The *Eudendrium capillare* is a small but elegant hydroid. It is abundant at extreme low-water spring tides in some parts of the Firth of Forth, where it may be found attached to the outer coarse tunic of some of the common Ascidians. Its distribution in Britain is a wide one, for it is also abundant on the Devonshire coast, where I have dredged it from a depth of about four fathoms, growing on *Hydrallmania falcata* and other common hydroids.

4. Eudendrium arbuscula, *Wright.*

Eudendrium arbuscula,—*Strethill Wright*, in Edin. New Phil. Journ. for July, 1859, pl. ix, figs. 5, 6. *Hincks*, Brit. Hydr. Zooph., p. 84, pl. xiv, fig. 1.

TROPHOSOME.—Hydrocaulus "forming a bushy tree of adnate stems; branches ringed near their insertions." Hydranths "white, terminal, on very slender and transparent branches, and with numerous alternate tentacles; base of body surrounded by a ring of large thread-cells."

GONOSOME.—Male sporosacs "borne in clusters on short stems springing at right angles from the branches. Summit of the double capsule with a tubercle containing barbed thread-cells."—*Strethill Wright.*

I have never met with this species. It is described by Dr. Strethill Wright from a single specimen, which he states to have been about two inches in height, and to have been obtained at Queen's Ferry, Firth of Forth, in the month of September.

5. Eudendrium insigne, *Hincks.*

Plate XIV, figs. 4—6.[1]

Eudendrium humile,—*Allman,* in Ann. Nat. Hist. for January, 1863.
Eudendrium insigne,—*Hincks,* in Ann. Nat. Hist. for August, 1861; Brit. Hydr. Zooph., p. 86, pl. xiv, fig. 3.

TROPHOSOME.—Hydrocaulus much and irregularly branched, rising to a height of about three quarters of an inch; perisarc distinctly annulated throughout. Hydranths with a shallow circular groove near their base. Tentacles twenty or twenty-three, with the alternate ones usually elevated and depressed in extension.

GONOSOME.—Male sporosacs two-chambered, forming a verticil round the body of the hydranths, and springing each by a short stalk from the circular groove which passes round the hydranth near its base. Female sporosacs piriform, borne both by the body of the hydranth and by the hydrocaulus immediately below it.

Colour.—Hydranths yellowish vermilion. Male gonophores pink; female gonophores reddish orange. Perisarc reddish brown.

Development of Gonosome.—September.

Habitat.—Rock pools near low-water spring tides.

Bathymetrical distribution.—Laminarian zone.

Locality.—Torbay, Mr. Hincks and G. J. A.; Ilfracombe and Swanage, Mr. Hincks.

Some years ago I described as a distinct species, under the name of *Eudendrium humile,* a little hydroid from Torquay. I was aware at the time that Mr. Hincks had already described, under the name *Eudendrium insigne,* a species of *Eudendrium* which, judging from his description, resembled in some points my *E. humile,* though in other more important ones it differed from it so widely as to forbid the association of the two in a single species.

Subsequent observations have induced Mr. Hincks ('Brit. Hydr. Zooph.,' p. 85) to correct his original description, and in its present form it will easily apply to my *Eudendrium humile.* I am therefore willing to accept Mr. Hincks' view, that the two species are identical, and to suppress the name of *humile* in favour of *insigne.*

I met with this pretty little *Eudendrium* on the rocky shore of Torbay, where it occurred rooted to the bottom of the clear pools near the limit of the lowest tides. Mr. Hincks found it in the same place, and in some other parts of the southern shores of England.

[1] The species is there figured under the name of *Eudendrium humile.*

*** 6. Eudendrium dispar, *Agassiz.*

Eudendrium dispar,—*Agassiz,* Contr. Nat. Hist. U. S., vol. iv, p. 285, pl. xxvii. *Alex. Agassiz,* Illustr. Catal. of North American Acalephæ, p. 159.

TROPHOSOME.—Hydrocaulus irregularly branched, slender and flexile, attaining a height of about two inches; perisarc ringed throughout. Hydranth with twenty-eight tentacles.

GONOSOME.—Male sporosacs two- or three-chambered, springing from the body of the hydranth in an irregular verticil just below the tentacles. Female sporosacs globular, scattered over the body of the hydranth and the distal portion of the stem.

Development of Gonosome.—May to September.
Bathymetrical distribution.—Deep-sea zone.
Locality.—Shores of Massachusetts, Agassiz.

The diagnosis here given is derived from Agassiz's description of the species. In this description, however, the author seems chiefly to have had in view its distinctive points when compared with *Bougainvillia,* so that generic rather than specific characters are for the most part referred to, and it is by no means easy to find characters available for a technical specific diagnosis. Those selected above, however, will, I think, be sufficient to secure the American *Eudendrium* from being confounded with any of the other species of the present Monograph.

The same species is referred to by Alexander Agassiz in his 'Illustrated Catalogue of North American Acalephæ,' where he tells us that "the male and female communities are readily recognised by the different colour of the medusa-buds (sporosacs), the male medusa-buds being of a bright orange, while the female are of a dull pink."

No mention is made of the atrophy of the gonophore-bearing hydranths, so common in other species.

7. Eudendrium annulatum, *Norman.*

Eudendrium annulatum,—*Norman,* in Ann. Nat. Hist. for January, 1864, pl. ix, figs. 1—3. *Hincks,* Brit. Hydr. Zooph., p. 83, pl. xv, fig. 1.

TROPHOSOME.— Hydrocaulus shrubby, attaining a height of about four inches, main stems fascicled, very thick, smaller branches extremely numerous, composed of a single tube, which is closely and regularly ringed throughout. HYDRANTHS with sixteen to twenty tentacles.

GONOSOME.—Female GONOPHORES in spike-like clusters borne round the body and stalk of atrophied hydranths. Male gonophores not yet observed.

Habitat.—In rock pools and caves at low water.
Bathymetrical distribution.—Laminarian zone.
Locality.—Burraforth, Shetland, Rev. A. M. Norman.

I have never met with this fine species. It was discovered by the Rev. Alfred Merle Norman at Burraforth, in North Unst, the most northern of the Shetland Islands, where it was found attached to the perpendicular sides of a cavern about a foot beneath the water at the lowest spring tides, as well as in some adjacent rock pools. Its dense shrubby habit, deeply annulated branches, and the spike-like groups of gonophores on atrophied hydranths in the female colonies, form a combination of characters which distinguish it from all other described species.

The outermost portion of the fascicled stem appears to consist of a layer of remarkably contorted tubes, which are figured by Mr. Norman, and referred to by him in his description of the species.

The male gonophores have not been observed.

8. EUDENDRIUM VAGINATUM, *Allman.*

Plate XIV, figs. 7 and 8.

EUDENDRIUM VAGINATUM,—*Allman*, in Ann. Nat. Hist. for January, 1863. *Hincks*, Brit. Hydr. Zooph., p. 86.

TROPHOSOME.—HYDROCAULUS much and irregularly branched, rising to about one inch and a quarter in height; PERISARC rigid, deeply and regularly annulated throughout. HYDRANTHS with about eighteen tentacles, and having the body as far as the origin of the tentacles enveloped in a loose corrugated membranous sheath, which loses itself below on the hydrocaulus.

GONOSOME.—Not yet observed.

Colour.—Hydranths vermilion, perisarc deep reddish brown.
Habitat.—In rock pools at extreme low-water spring tides.

Bathymetrical distribution.—Laminarian zone.
Locality.—Shetland Islands, G. J. A.

This beautiful little *Eudendrium* is conspicuous by its large, bright-vermilion hydranths. It occurred in considerable abundance on the "Out Skerries," and other exposed rocky islets of Shetland, but was found only at the extreme edge of low spring tides, where it grew rooted to the bottom of shallow rock pools.

It was in the month of August that I met with it, but its season of greatest perfection must have been then passed, for in none of the specimens could any trace of the gonosome be found, while in many of them the hydranths themselves had disappeared from the summits of the ramuli.

*** 9. Eudendrium tenue, *Alex. Agassiz.*

Eudendrium tenue,—*Alex. Agassiz*, Illus. Catal. N. A. Acalephæ, p. 160, fig. 220.

TROPHOSOME.—Hydrocaulus slender, profusely and irregularly branched, rising to the height of an inch and a half; perisarc annulated on the ultimate ramuli.

GONOSOME.—Male gonophores in clusters upon the remains of atrophied hydranths.

Colour.—General colour light pinkish.
Development of Gonosome.—June.
Locality.—Massachusetts Bay, Mr. A. Agassiz.

The diagnosis given above is derived from Mr. A. Agassiz's account of the species, aided by the woodcut which accompanies his description, and which represents a male specimen of this hydroid. He adds that the "species can at once be distinguished from the *Eudendrium dispar*, Agass., by its large clusters of medusæ (sporosacs), while in the *Eudendrium dispar* the medusæ-buds are always somewhat scattered and never clustered together, as in *Eudendrium tenue*."

I can scarcely understand this passage, as the male gonophores of *Eudendrium dispar* have been described and figured by Professor Agassiz as forming a verticillar cluster round the base of the hydranths, the female gonophores only being scattered—the usual condition in *Eudendrium*. It would seem as if Mr. A. Agassiz had by some confusion compared the male gonophores of his *Eudendrium tenue* with the female gonophores of *Eudendrium dispar*.

Eudendrium tenue is evidently a form closely allied to the *Eudendrium capillare* of the European side of the Atlantic. From this species, indeed, it would seem to differ chiefly in its larger size, and in the fact (judging from Mr. A. Agassiz's figure) that the annulation of the perisarc is not confined to the origin of the branches. There are slight differences, and I am by no means convinced that the American hydroid is specifically distinct from the British.

*** 10. EUDENDRIUM RACEMOSUM, *Carolini*, sp.

SERTULARIA RACEMOSA,—*Carolini*, Mem. dei Pol. Mar., Sprengel's German translation, p. 73, tab. vi, fig. 1, &c.

TROPHOSOME.—HYDROCAULUS much and irregularly branched, attaining a height of six or seven inches; PERISARC annulated on the ultimate ramuli for some distance just below the hydranths. HYDRANTHS with about thirty tentacles.

GONOSOME.—Male GONOPHORES three-, four-, or five-chambered in umbel-like clusters on atrophied hydranths; female gonophores scattered in racemose groups on the stems of atrophied hydranths.

Colour.—Hydranths reddish; perisarc reddish brown; female gonophores purplish red.
Development of Gonosome.—Spring and summer.
Habitat.—On submerged rocks.
Locality.—Caves of Gajola, Bay of Naples, Cavolini.

After Trembley and Ellis there is no naturalist of the last century whose claims as an original and accurate observer of the HYDROIDA rank so high as those of Filippi Cavolini; for like Ellis he studied the animals in their native haunts along the sea-shore, and described and drew them, not from dead and desiccated specimens, but in all the perfection and marvellous beauty of their living forms.

Among the hydroids studied by the celebrated Neapolitan naturalist was the present species, of which he has given us a careful and elaborate description and excellent figures. It is true that in some points he falls into errors of interpretation, as may well be expected when we bear in mind the state of hydroid zoology at the period when he wrote. Thus, having observed in his hydroid both male and female gonophores, and, in accordance with the general views of the zoologists of that day, believing those bodies to be eggs, he describes the species as producing eggs of two kinds—eggs in racemes and eggs in umbels. His description, however, leaves little to be desired. It is from it that I have selected the characters out of which the diagnosis here given has been framed.

There can be no doubt that *Eudendrium racemosum* is closely allied to the *Eudendrium ramosum* of Linnæus, the "small ramified tubular coralline" of Ellis. It would appear to differ from it chiefly by its more irregular ramification, and by the more numerous chambers of the male gonophores.

INDETERMINABLE SPECIES.

Under the name of "EUDENDRIUM CINGULATUM," Stimpson ('Marine Invertebrate Fauna of Grand Manan,' p. 9) gives the following description of a hydroid from the Atlantic shores of North America:

"Polypidom small, very irregularly branched, somewhat as in *Eudendrium rameum*, but not so thickly; branchlets strongly ringed sometimes throughout their length, always near their origin; polypes small, with long tentacles and broad blunt proboscis. It differs from *Eudendrium rameum* in the mode of branching."

"Dredged in twenty fathoms on a shelly bottom off Duck Island."

The description is unaccompanied by a figure, and it is otherwise too vague for an adequate diagnosis. It is not even apparent whether it is intended to apply to a true *Eudendrium* or to one of the other genera with which *Eudendrium* was at that time confounded.

HYDRACTINIDÆ.

TROPHOSOME.—HYDROPHYTON forming a continuous adherent expansion, its deeper parts consisting of freely intercommunicating tubes of CŒNOSARC, each invested by a chitinous PERISARC, and all adnate to one another by their sides, its free surface overspread by a layer of naked CŒNOSARC. HYDRANTHS with filiform verticillate tentacles.

GONOSOME.—GONOPHORES in the form of fixed SPOROSACS.

HYDRACTINIA, *Van Beneden.*

Name.—A compound of the two generic names *Hydra* and *Actinia*, so named from a supposed union of the external features of both these genera.

ECHINOCHORIUM,—*Hassall.*
SYNHYDRA,—*De Quatrefages.*
DYSMORPHOSA (?),—*Philippi.*

TROPHOSOME.—HYDRANTHS claviform, developed at intervals from the free naked surface of the HYDROPHYTON; tentacles filiform, forming a single circlet round the base of a conical hypostome.

GONOSOME.—SPOROSACS supported on BLASTOSTYLES, which arise like the hydranths from the free naked surface of the hydrophyton, each carrying round its distal extremity globular clusters of thread-cells, which take the place of the tentacles in the hydranth.

The generic name of *Hydractinia* without a specific designation was given by Van Beneden in 1841 to a hydroid obtained on the coast of Ostend.[1] The short memoir in which this name is thus for the first time used contains no zoological description of the hydroid, beyond what is involved in an account of the gonophores, to which the description is confined, and which, in accordance with the views generally entertained at that period, are regarded as eggs. A figure, however, is given of one of the hydranths, as well as of a blastostyle loaded with its gonophores, and there is therefore little difficulty in identifying the animal to which the name of *Hydractinia* was intended to apply.

Nearly at the same time Dr. Hassall obtained in Dublin Bay specimens of a production with which zoologists had been familiar, as forming a horny spinous crust on the surface of empty univalve shells, and which Fleming, De Blainville, and Johnston, had regarded as the horny ectocyst of a polyzoon. Hassall, however, from an examination of living specimens, became aware of the incorrectness of this interpretation, and, recognising its hydroid affinities, assigned to it the name of *Echinocorium clavigerum*.[2] We now know that the *Echinocorium* of Hassall is the animal to which Van Beneden had just before given the name of *Hydractinia*.

In 1842 Dr. A. Philippi[3] noticed under the name of *Dysmorphosa conchicola* a hydroid from the Bay of Naples. He tells us nothing of the gonosome, and his description, so far as it goes, will apply in all points to the *Hydractinia* of Van Beneden; but it is also just as applicable

[1] 'Bul. de l'Acad. Roy. de Brux.,' t. viii, 1841.
[2] 'Ann. Nat. Hist.,' 1841, vol. vii.
[3] 'Wiegman's Archiv,' 1842.

to another genus, namely, *Podocoryne*, shortly afterwards instituted by Sars, and we have at present no clue to enable us to say which of these two forms was intended.

In the following year the *Hydractinia* of Van Beneden became the subject of an elaborate and beautifully illustrated memoir by M. de Quatrefages, in which this animal was described under the name of *Synhydra parasites*.[1] De Quatrefages here shows that the zooids which support the gonophores are destitute of mouth, and are otherwise of a different form from the alimentary zooids of the colony. It is true that Van Beneden, in the memoir just referred to, has figured a gonophore-bearing zooid as deprived of tentacles, but he has made no allusion to it in the text, while De Quatrefages has not only fully described it, but has insisted on its constancy and its value as affording a character of generic importance. De Quatrefages must therefore be fairly regarded as the first who has made us properly acquainted with the occurrence of a blastostyle among the Tubularian hydroids, a form of heteromorphism of great importance in its bearing on the morphology of this group of animals.

De Quatrefages' memoir, notwithstanding some erroneous views, which could scarcely have been avoided in the state of hydroid zoology when he wrote, contains by far the best account which had up to that time been given of this interesting hydroid, and is perhaps the most valuable which had appeared on any hydroid since the publication of Loven's famous memoir on *Campanularia* and *Syncoryne*.[2] The name of *Synhydra*, however, must yield to that of *Hydractinia*, whose acceptance among zoologists has been secured by the fact of its prior publication.

In 1844 Van Beneden defined for the first time his genus *Hydractinia*, under which he included two species with the names of *Hydractinia rosea* and *Hydractinia lactea*.[3] He has since, however, admitted that these two forms are only different sexes of one and the same species. Indeed, there is no reason for supposing that the animal on which Van Beneden founded his genus *Hydractinia* is other than the *Alcyonium echinatum* of Fleming; and notwithstanding Fleming's entire misapprehension of the affinities of this animal, his specific name must stand instead of either of those assigned to the hydroid by Van Beneden, a change to the justice of which the distinguished Belgian naturalist himself assents in a subsequent memoir.

In 1856 an excellent account of *Hydractinia echinata* was published by Dr. Strethill Wright.[4] His observations on its structure are very full and accurate, and his memoir supplements in many important points what had hitherto been published on this hydroid. He calls attention to the curious spiral zooids which occur near the margin of the colony, structures with which I had myself become acquainted several years before, though Dr. Wright was the first to publish an account of them.

In 1862 Agassiz described under the name of *Hydractinia polyclina* a North American representative of this genus, which differs very slightly from the European form. He makes it the subject of one of the elaborate and finely illustrated memoirs in his great work on the natural history of the United States.[5]

Finally, in 1866, Van Beneden gives us a second and more extended description, with new

[1] 'Ann. des Sc. Nat.,' 1843, vol. xx.
[2] 'Wiegman's Archiv,' 1837.
[3] 'Recherches sur les Tubulaires.'
[4] 'Edin. New Phil. Journ.,' April, 1857.
[5] 'Contr. Nat. Hist. U.S.,' vol. iv, p. 227.

figures of his genus *Hydractinia*, which, however, he mixes up with *Podocoryne*.[1] He replaces his former specific names of *lactea* and *rosea* by Fleming's name of *echinata*, while he describes from imperfect data what he regards as three new species of the genus. Whatever these may be, there are no grounds for referring them to *Hydractinia* in the sense in which this genus is limited in the present Monograph, though in the wider sense in which it is understood by Van Beneden, they may legitimately find a place in it.

1. Hydractinia echinata, *Fleming*.

Plate XV, and Plate XVI, figs. 10 and 11.

Alcyonium echinatum,—*Fleming*, British Animals, 1828. *Blainville*, Actinologie, p. 525.
Alcyonidrum echinatum,—*Johnston*, British Zooph., 1838, p. 304, pl. xlii, figs. 3, 4.
Coryne squamosa, var.,—*Johnston*, British Zooph., 1838, pl. ii, figs. 4, 5.
Hydractinia, sp.,—*Van Beneden*, Bul. de l'Acad. Roy. de Brux., tom. viii, 1841.
Ecinochorium clavigerum,—*Hassall*, Ann. Nat. Hist., 1841, vol. vii, p. 371, pl. x, fig. 5.
Dysmosphosa conchicola (?),—*Philippi*, Wiegman's Archiv, 1842.
Synhydra parasites,—*De Quatrefages*, Ann. des Sci. Nat., 1843, vol. xx, p. 230, pls. 8, 9.
Hydractinia lactea et H. rosea,—*Van Beneden*, Rech. sur l'Embryogénie des Tubulaires, Mém. de l'Acad. Roy. de Brux., tom. xviii, p. 104, pl. ix.
Hydractinia echinata,—*Johnston*, Brit. Zooph., 1847, p. 34, pl. i, figs. 4, 5. *Strethill Wright*, Edinb. New Phil. Journ., April, 1857. *Van Beneden*, Recherches sur la Faune littorale de Belg., 1866, p. 134, pl. xl, figs. 1—8 (exclusive of synonymes). *Hincks*, Brit. Hydr. Zooph., p. 23, pl. iv.

TROPHOSOME.—Hydranths crowded on the surface of the hydrophyton, and attaining a height of about half an inch; tentacular circlet formed by two or more closely approximated series, the tentacles of the distal series being longer, and when extended carried more erect than those of the proximal series. Cylindrical spirally contractile appendages developed from the common basis of the colony near its margin. Common basal expansion attaining a thickness of about a line and a half, closely set with blunt conical spines which attain a height of about one line, and which are traversed from base to apex by longitudinal jagged ridges.

GONOSOME.—Blastostyles shorter and thinner than the hydranths; sporosacs oval, almost sessile on the blastostyle, near whose distal extremity they are borne in a cluster more or less dense.

[1] 'Rech. sur la Faune lit. de Belg.,' p. 131.

Colour.—Various shades of brownish red.

Development of Gonophores.—March to November.

Habitat.—Investing the surface of dead univalve shells, chiefly such as are inhabited by hermit crabs, but occasionally occurring on other submerged bodies.

Bathymetrical distribution.—Littoral to deep-water zone.

Localities.—Atlantic shores of France and Belgium, Van Beneden, De Quatrefages. Generally distributed round the shores of the British Isles.

Hydractinia echinata is the only well-established European species of *Hydractinia*. It is an abundant hydroid in the British seas, and may be easily kept alive in the confinement of our tanks. Among some hundreds of specimens which have come under my observation, I have never met with it except upon some gasteropodous shell, and then always with the shell inhabited by a hermit crab; or, if empty, affording evidence by abrasions of its surface that it had at one time been similarly tenanted. Van Beneden, however, has found it attached to pieces of timber.

In the singular structure of its hydrophyton, and in the polymorphism of its zooids, it possesses a deep significance for the student of hydroid morphology.

The spiral zooids constitute a very striking feature in a colony of *Hydractinia echinata*. They occur close to the margin of the colony, and may be easily watched in a living specimen, when they will be seen in a constant state of activity, rolling and unrolling themselves, and bending backwards and forwards on the slightest irritation. Besides these Wright has described certain long, contractile, non-spiral tenticula-like filaments, which also spring from the cœnosarcal base near its margin. These have been also described by Hincks, but they are certainly not constant in their occurrence, and I regard them as an abnormally modified form of some of the other zooids.

Wright's description of sporosacs, borne directly by the basal expansion without the intervention of blastostyles, I regard as founded on an error of observation, Dr. Wright having been, as I believe, deceived by the shortness of the blastostyle which carried them.

I have made *Hydractinia echinata* the subject of one of the special studies of hydroid anatomy given above (Part I, p. 220), where these and other morphological features of the hydroid are discussed at length.

Gegenbaur figures under the name of Hydractinia a hydroid in which the sporosacs are borne on ordinary hydranths instead of on blastostyles.[1] I believe that there is here some confusion between *Hydractinia* and *Stylactis*.

[1] Gegenbaur, 'Grundzüge der vergleich. Anatomie,' p. 90.

2. Hydractinia polyclina, *Agassiz.*

Hydractinia polyclina,—*Agassiz*, Contrib. Nat. Hist. U.S., vol. iii, pl. xvi, and vol. iv, p. 227, pl. xxvi, fig. 18.
Hydractinia echinata,[1]—*Leidy*, Mar. Invert. of New Jersey, &c., p. 3, pl. xi, fig. 35.

TROPHOSOME.—Hydrocaulus crowded on the surface of the hydrophyton, tentacles tapering, equal or sub-equal; margin of the colony carrying cylindrical spiral appendages. Common basal expansion set with blunt conical spines traversed by longitudinal jagged ridges.

GONOSOME.—Blastostyles with conspicuous hypostome and mouth. Sporosacs forming a more or less dense cluster near the distal end of the blastostyle.

Development of Gonosome.—July to February.
Habitat.—On univalve shells inhabited by hermit crabs, and on rocks in tide pools.
Bathymetrical distribution.—From litoral to probably deep-water zone.
Locality.—Atlantic shores of North America, Agassiz.

It is not without great hesitation that I regard the *Hydractinia polyclina* of Professor Agassiz as distinct from the European *H. echinata.* I have in vain sought in the description given by Agassiz for characters sufficiently well marked to remove all doubt as to the justice of the separation. The strongest are included in the above diagnosis, which I have compiled from Agassiz's description, and these will hardly be deemed altogether satisfactory. The apparently more tapering form of the tentacles when extended, the greater equality in their length, and the more decided development of an oral orifice in the blastostyle, are all that we can find; and even these do not agree with the characters expressed in Leidy's figure of a species which Mr. A. Agassiz regards as distinct from the European form to which Leidy had referred it, and identical with the *Hydractinia polyclina* of the American coast.

Professor Agassiz informs us that the *H. polyclina* is not only found on the shells of gasteropods inhabited by hermit crabs, but that it occurs in great abundance in tide pools, where it covers the rocks "for several square feet with a rosy, velvet-like carpet, presenting a delicacy

[1] It is on the authority of A. Agassiz ('Illustr. Catal.,' p. 198) that I include the *Hydractinia echinata* of Leidy among the synonymes of *Hydractinia polyclina.* I take for granted that Mr. A. Agassiz, who refers all the recorded North American species to the *H. polyclina*, has compared Leidy's hydroid with the true *H. polyclina* of Prof. Agassiz, and has satisfied himself of the identity of the two forms. I must confess, however, that I can find nothing either in the description or in the figure given by Leidy to justify a belief that the *H. echinata* of this zoologist is distinct from our European form.

and vividness of tint which can hardly be described." This habit is certainly so different from that of our European form as to give support to the view which would regard the two as specifically distinct.

PODOCORYNIDÆ.

TROPHOSOME.—Hydrophyton a continuous adherent expansion formed by adnate and inosculating canals; the deeper part with its component canals invested by a chitinous perisarc while a layer of naked cœnosarc spreads over the free surface. Hydranths with verticillate filiform tentacles.

GONOSOME.—Gonophores phanerocodonic.

PODOCORYNE, *Sars* (in part).

Name.—From ποῦς, a foot, and *Coryne*, a genus of hydroids, in allusion to its broad basal expansion.

Hydra,—*Rud. Wagner.*
Dysmorphosa (?),—*Philippi.*
Hydractinia,—*Chr. Loven.*

TROPHOSOME.—Hydranths claviform, with a single circlet of filiform tentacles surrounding the base of a conical hypostome.

GONOSOME.—Gonophores phanerocodonic, borne on the body of the hydranth at the proximal side of the tentacles. Planoblast with a deep bell-shaped umbrella, a small four-lipped manubrium, four radiating canals, and four or eight marginal tentacles with bulbous bases which are destitute of ocelli.

We are indebted to Sars for the institution of the genus *Podocoryne*, founded on a hydroid which he discovered in the Norwegian seas. The peculiar condition of its hydrophyton, consisting as this does in its fully developed state of a continuous hydrorhizal expansion, formed by adnate chitinous tubes, but covered superficially by a naked layer of cœnosarc, constitutes one of its most remarkable characters, a character, however, which it has in common with *Hydractinia*.

Sars believes that the hydroid described a short time previously by Philippi,[1] under the name of *Dysmorphosa conchicola*, is identical with his *Podocoryne carnea*; and the same view is entertained by Krohn.[2] This may be true, but, as already said, Philippi's description will just as closely apply to *Hydractinia*.[3]

1. Podocoryne carnea, *Sars*.

Plate XVI, figs. 1—9.

Podocoryne carnea,—*Sars*, Fauna lit. Norvegiæ, 1846, p. 4, pl. i, figs. 7—18. *Krohn*, Wieg. Arch., 1851, p. 263. *Allman*, in Ann. Nat. Hist., July, 1859.

Podocoryne albida,—*Sars*, Fauna lit. Norvegiæ, 1846, p. 7.

Hydractinia echinata,—*Chr. Loven*, Öfversigt af Kong. vet. Akad. Förhandl., 1757, p. 305, tab. iv.

Podocoryne tubulariæ,—*Sars*, Middelhavets Litoral Fauna, p. 36, note.

TROPHOSOME.—Hydrorhizal expansion forming a thin layer, from whose free surface minute blunt chitinous spines project at intervals. Hydranths springing at short distances from one another over the surface of the hydrorhiza, and presenting two different conditions of development; those destitute of gonophores attaining a height of about two lines, and having usually about twelve tentacles, while those which carry gonophores are about half the size of the former, and possess no more than from four to six tentacles.

GONOSOME.—Gonophores on very short peduncles, forming a verticillate cluster at a little distance below the tentacles of the smaller hydranths; medusa with the outer surface of the umbrella dotted with scattered thread-cells, velum well developed; lips of manubrium narrow, each terminated by a little pencil-like cluster of stalked thread-cells.

Colour.—Hydranths varying from white to flesh colour, medusa with the manubrium and bulbous bases of marginal tentacles brownish red.

Development of Gonosome.—May to August.

[1] 'Wiegmann's Arch.,' 1842, p. 37.

[2] Id., 1851, p. 263.

[3] See the general remarks on the genus *Stylactis* given above. p. 303, note.

Habitat.—On stones in the sea and on old shells, chiefly of *Gasteropoda.*

Bathymetrical distribution.—Litoral to deep-sea zone.

Localities.—Coast of Norway, Sars; Bay of Naples, Krohn, Sars, Costa; Firth of Forth, G. J. A.

A hydroid which, in all respects, except in colour, resembles that described by Sars as *Podocoryne carnea,* was found by me in the Firth of Forth growing on stones in rock pools a little above low-water mark, and also on old Buccinum shells in similar situations, and on others brought up from deeper water on the lines of the fishermen.

My specimens, instead of being pale red, like the *Podocoryne carnea* of Sars, were nearly colourless; but I consider this difference of colour as only varietal, and I believe that a white *Podocoryne* described by Sars as a distinct species under the name of *Podocoryne albida* is, like mine, only a variety of his *Podocoryne carnea.*

Sars' account of his *Podocoryne carnea* is very full, and possesses a special interest in having been given at a time when as yet but few instances were known of the production of free medusæ by fixed trophosomes.

Hincks notices the occurrence in *Podocoryne carnea* of spiral appendages, like those of *Hydractinia echinata,* and describes them as occupying the same position near the margin of the colony as the corresponding bodies do in the latter hydroid. He also observed on certain parts of the basal expansion tentacula-like slender filaments, which he compared to similar filaments which have been described in *Hydractinia.*

Neither kind, however, was present in any of the specimens that came under my observation. Whatever be the nature of the spiral bodies observed by Hincks, they certainly do not possess the constancy which characterises the spiral appendages of *Hydractinia,* and it is difficult not to regard both the spiral bodies and the tentacula-like filaments observed by Hincks in *Podocoryne* as merely abnormal alterations of some of the ordinary hydranths. In well-preserved spirit specimens of a *Podocoryne* from the Bay of Naples, for which I am indebted to Professor Costa, and which I am unable to distinguish from *P. carnea,* very delicate capillary filaments existed here and there on the cœnosarcal base. These were, however, undoubtedly vegetable growths, though, without careful examination, they might easily have been mistaken for component parts of the colony.

Krohn, in his account of *Podocoryne carnea,* published some years after that given by Sars, informs us that the medusæ in his specimens had attained to sexual maturity, and that the generative elements, male and female, had been developed in the walls of the manubrium even before the liberation of the medusa from the trophosome; while a similar observation as to the early sexual maturity of the medusa was made by Chr. Loven in the specimens described by him.

Neither in the specimens examined by Sars nor in those which had come under my own observation was there any trace of generative elements. I should feel tempted to regard this difference as indicating a difference of species, but, as no other characters are mentioned by either Krohn or Loven which would justify the separation, I believe it will be better for the present to consider the difference in question as depending on local circumstances, favorable in the one case and not so in the other to an advanced development of the medusa.

The shells on which *Podocoryne carnea* is found are, like those selected by *Hydractinia,* inhabited in almost every instance by a hermit crab.

In a note to his account of *Stylactis* (*Podocoryne*) *fucicola*, contained in his 'Litoral Fauna of the Mediterranean,' Sars describes under the name of *Podocoryne Tubulariæ* a species which he discovered on the Norwegian coast, where it occurs in abundance on the stems of *Tubularia indivisa* from a depth of between thirty and forty fathoms. There is nothing, however, in Sars' description of this species to distinguish it from *Podocoryne carnea*.

2. Podocoryne proboscidea, *Hincks*.

Podocoryne proboscidea,—*Hincks*, Brit. Hydr. Zooph., p. 317, pl. xxiii, fig. 1.

TROPHOSOME.—Hydranths "tall and rather stout, with a very long and somewhat columnar proboscis, and with about fourteen tentacles, some of which are tall and erect, and others short and borne at right angles to the body." "No apparent difference between the prolific and barren" hydranths.

GONOSOME.—Gonophores "forming a large collar round the polypite (hydranth) at a short distance below the tentacles, disposed in two rows, and borne on small tubercles;" planoblasts permanently attached, umbrella deep bell-shaped, with the marginal tentacles in the condition of eight short conical processes, manubrium surrounded by the mass of generative products very large, and projecting beyond the codonostome.

Colour.—Hydranths orange brown, with opaque-white proboscis; manubrium of planoblast (male) surrounded by its generative elements orange with purplish base.

Development of Gonosome.—September.

Habitat.—On Laminaria roots and the stones in rock pools.

Bathymetrical distribution.—Laminarian zone.

Locality.—Ilfracombe, Rev. T. Hincks.

Podocoryne proboscidea is stated by Mr. Hincks to be a larger species than *P. carnea*, and to be at once known by its long, cylindrical, and very conspicuous proboscis, which has the appearance of being fluted down the sides. The planoblasts develope their generative elements while yet attached to the trophosome, and, in accordance with the general rule in such cases, appear somewhat arrested, the marginal tentacles presenting the form of small tubercles. Hincks regards this condition of the planoblasts as depending on the season of the year during which they are produced, and believes that, if observed in an earlier month, they would be found to be of the usual form. I cannot see, however, any evidence in favour of this view, and must regard the condition in which Hincks has witnessed the gonosome in the present species as its constant one.

No observations were made as to the nature of the common hydrorhizal expansion, and it is taken for granted that it belongs to the podocorynal type.

3. Podocoryne aculeata, *Rud. Wagner*, sp.

Hydra aculeata,—*Rudolph Wagner*, in Iris, 1833, p. 256, pl. xi, figs. 1—10.

TROPHOSOME.—Those hydranths which are destitute of gonophores attaining a height of about two lines, and with usually from eight to twelve tentacles; those which carry gonophores smaller, and with about five tentacles.

GONOSOME.—Gonophores on short peduncles springing in an imperfect verticil from the hydranth at a little distance below the tentacles; medusa never attaining complete development, having a broad, flattened summit and four stunted marginal tentacles.

General colour.—Yellowish.
Development of Gonosome.—Observed during May.
Habitat.—Investing various univalve shells in the sea.
Bathymetrical distribution.—Litoral zone.
Locality.—Adriatic Sea, near Trieste, Rud. Wagner.

Towards the end of the last century Cavolini described the medusa of a *Pennaria* as loaded with ova while still attached to the trophosome,[1] and though the Neapolitan zoologist failed to recognise the true import of this observation, a phenomenon of vast significance in the life-history of the Hydroida became thus for the first time recorded.

From that period to the time when Rudolph Wagner discovered his *Hydra aculeata* no further observations were made tending to show that the medusiform buds of the fixed hydroids were destined to reproduce the species by the formation of fertilised ova.

Wagner, however, saw that the medusæ of his hydroid had, before attaining their freedom, given rise to ova, which, after a time, were discharged into the surrounding water; and though, just as in the case of Cavolini's observation, the state of our knowledge of the Hydroida at that time caused the real significance of this fact to escape him, it was capable of affording to succeeding observers a strong argument in favour of the new views of hydroid development—views which soon began to exert their influence throughout the whole study of the Hydroida.

That the "*Hydra aculeata*" of Wagner is a true *Podocoryne* there can be little doubt. Its chief difference from the *Podocoryne carnea* is to be found in the fact that its medusa, though referable to the same type as that of the species on which Sars founded his genus, appears to be somewhat arrested in its development.

For the description given above I have no authority beyond the original account of the

[1] Cavolini, 'Mem. Polyp.,' Sprengel's translation, p. 65, tab. 5.

hydroid published by Wagner. As may be easily expected, no notice is taken in that account of certain points which are now found to be necessary for a satisfactory diagnosis, and the species has not been met with by any one since it was found by Wagner, many years ago, on the shores of the Adriatic.

4. Podocoryne areolata, *Alder*, sp.

Hydractinia areolata,—*Alder*, Suppl. Catal., p. 1, pl. ix, figs. 1—4.
Rhizocline areolata,—*Allman*, Ann. Nat. Hist. for May, 1864.
Podocoryne areolata,—*Hincks*, Brit. Hydr. Zooph., p. 32, pl. vi, fig. 1.

TROPHOSOME.—Common basis of the colony set with "simple linear spines in irregular[1] groups." Hydranths attaining a height of about one tenth of an inch, sub-cylindrical, with from six to ten tentacles.

GONOSOME.—Gonophores sessile on the common basal expansion, large, globular, or slightly pear-shaped. Radial tentacles of medusa rather short, three still shorter tentacles developed in each inter-radial space of the margin; manubrium with each of its four lips supporting a tuft of thread-cells.

Colour.—Hydranths white; radiating canals of medusa golden yellow.
Habitat.—On dead univalve shells.
Localities.—Coast of Durham, Mr. Alder; Shetland, Rev. A. M. Norman.

Some years ago, when attempting a revision of the genera of tubularian hydroids, I saw that it was impossible to retain the hydroid named *Hydractinia areolata* by Alder in the genus to which this naturalist had assigned it, and, not being able to find a place for it in any published genus, I constituted for it a new one under the name of *Rhizocline*.

I do not, however, desire to insist upon the retention of the genus *Rhizocline*. It is highly probable that the basal expansion in Mr. Alder's hydroid resembles that of *Hydractinia*, and that its true nature had been overlooked when he described it as "consisting of a solid chitinous expansion, from which arise simple chitinous spines." I have further satisfied myself that there is no essential difference between the common base of *Hydractinia* and that of *Podocoryne*; and then the only distinction between Alder's hydroid and the admitted forms of *Podocoryne* will be found in the position of the gonophores, which in the former are sessile on the common base. This can hardly amount to a generic difference, though its very exceptional character might lead us to expect such a difference in other parts of the hydroid. We have accordingly—though as

[1] In Alder's description the word is "regular," but this is plainly a misprint.

yet by no means sufficiently acquainted with the "*Hydractinia areolata*"—no alternative but to allow the absorption of *Rhizocline* into *Podocoryne*. This view is taken by Hincks, and the present state of our knowledge will justify it. It is possible, however, that a fuller acquaintance with Mr. Alder's hydroid may require the restoration of the genus *Rhizocline*.

The resemblance between the medusa of *Podocoryne areolata* and that of *Podocoryne carnea* has been noticed by Alder. Indeed, the two medusæ scarcely differ from one another, except in the fact that while the medusa of *Podocoryne carnea* has at the time of its liberation only one marginal tentacle in each inter-radial space, that of *Podocoryne areolata* has at the same period three inter-radial tentacles between each of the radials. The middle one of these three inter-radial tentacles is longer than that placed at each side of it, the latter being as yet scarcely developed beyond the condition of a mere tubercle.

Of the two specimens which had come under Mr. Alder's observation, one "was obtained parasitical on a dead shell of *Natica Alderi*, brought in by the fishing boats at Cullercoats." The other was "a dead and rather worn specimen upon *Natica Grœnlandica* among the zoophytes collected in Shetland by the Rev. A. M. Norman."

CORYNOPSIS, *Allman.*

Name—κορύνη, a club, and ὄψις, face (resemblance), in allusion to the club-like form of the hydranths.

PODOCORYNE,—*Hodge.*

TROPHOSOME.—HYDRANTHS claviform, with a single circlet of filiform tentacles round the base of a conical hypostome.

GONOSOME.—PLANOBLASTS borne on the body of the hydranth at the proximal side of the tentacular circlet. MEDUSA deep bell-shaped; manubrium having its mouth surrounded by four short capitate tentacles; radiating canals four, each terminating distally in a bulb, from which are developed two tentacles, each with a distinct ocellus at its base.

We are indebted to Mr. Hodge for the first notice of the hydroid on which the genus *Corynopsis* has been founded. He described it, however, as a *Podocoryne*, under the name of *Podocoryne Alderi;* and though he does not give any definite description of the common base, we may assume, until further observation proves the contrary, that this is similar to that of the true *Podocorynes*. Taking for granted that there is no error of observation in Mr. Hodge's account of his *Podocoryne Alderi*, it is plain, however, that this hydroid must be separated from *Podocoryne*, for the medusa which he assigned to it is of an entirely different type from that of the latter genus. It cannot, indeed, at the time of its liberation, be distinguished from that of *Bougainvillia* at the same stage of its development. The further progress of the *Corynopsis* medusa has not been traced, but it is highly probable that it corresponds to that of the medusa of *Bougainvillia*, and that we have thus two genera with similar gonosomes, though with different trophosomes.

Corynopsis Alderi, *Hodge*, sp.

Podocoryne Alderi,—*Hodge*, in Trans. Tyneside Nat. Field Club., vol. v, pl. ii, figs. 10—15.

Corynopsis Alderi,—*Allman*, in Ann. Nat. Hist. for May, 1864. *Hincks*, Brit. Hydr. Zooph., p. 34, pl. vi, fig. 2.

TROPHOSOME.—Hydranths attaining a height of from one quarter to half an inch, gradually tapering from the distal to the proximal extremity, tentacles six to twelve in number.

GONOSOME.—Medusæ springing from the hydranths in an imperfect verticil at a short distance behind the tentacular circlet.

Colour.—Hydranth pale pink, medusa having its manubrium pale green, and tentacular bulbs red.

Development of Gonosome.—August and September.

Habitat.—On shells from deep water.

Bathymetrical distribution.—Deep water zone.

Locality.—Seaham Harbour, Coast of Northumberland, Mr. Hodge.

Considering how large an amount of caution is necessary in order to avoid referring to their wrong trophosomes the free medusæ developed in our aquaria, it is impossible not to wish for further observations which might tend to verify Mr. Hodge's reference of a *Bougainvillia*-like medusa to a trophosome, so very different as that of his *Podocoryne Alderi* is from the trophosome to which this form of medusa had been hitherto traced. Coming, however, as the account does from an observer so trustworthy as Mr. Hodge, we should not be justified in refusing to accept it. This assent is all the more easy when we recollect that the present is not the only case of the kind which has been recorded, for Hincks has shown that the medusa of *Stauridia producta* cannot be distinguished, at least at the time of its liberation, from that of *Coryne eximia*.

CLADONEMIDÆ.

TROPHOSOME.—HYDROCAULUS developed, invested by a PERISARC. HYDRANTHS with two kinds of tentacles, one filiform, the other capitate.

GONOSOME.—GONOPHORES phanerocodonic with the radiating canals, more than four, and with the marginal tentacles ramified.

CLADONEMA, *Dujardin.*

Name.—From κλάδος, a branch, and νημα, a thread; so named from the branching tentacles of the planoblast.

CLADONEMA (planoblost), STAURIDIE (trophosome),—*Dujardin.*

TROPHOSOME.—HYDROPHYTON consisting of a branching or simple HYDROCAULUS arising from a creeping filiform HYDRORHIZA, the whole invested with a chitinous PERISARC. HYDRANTHS clavate with two verticils of tentacles, each verticil consisting of four tentacles disposed in a cross,—the tentacles of the proximal verticil filiform, those of the distal verticil capitate.

GONOSOME.—PLANOBLASTS developed from the body of the hydranth. Mature PLANOBLAST with a deep bell-shaped umbrella; manubrium with the mouth surrounded by five lips; radiating canals, eight or ten, each continued at the umbrella-margin into a tentacle with a bulbous base which carries an ocellus; branches of tentacles of two kinds, one kind very extensile and destitute of suctorial organs, the other situated at the proximal side of these, scarcely extensile, and provided with terminal suctorial capitula.

The beautiful observations of Dujardin on the production of free medusæ from their hydroid trophosomes were among the first which made us acquainted with this remarkable phenomenon, and among these his observations on *Cladonema* are perhaps the most interesting.[1]

[1] 'Ann. des Sc. Nat.,' vol. xx, 1843, p. 370, and vol. iv, 1845, p. 271, pls. xiv and xv.

When Dujardin wrote the nomenclature of the HYDROIDA had not yet acquired that definiteness which subsequent investigations had conferred upon it, and the French zoologist designated the trophosome of the present genus "Stauridie" (*Stauridium*), while to the medusa which he observed to be budded from his *Stauridium* he gave the name of *Cladonema*.

Dujardin observed not only the gemmation of the medusa from trophosome, but he saw its manubrium become loaded with eggs, which were afterwards deposited on the sides of his vase, where they became developed into young *Stauridium*-trophosomes. This is the first observation by which the whole life series of a hydroid from trophosome to medusa by gemmation, and back again by true generation to the trophosome, has been directly followed.

The observations of Dujardin were afterwards confirmed and supplemented in some important details by Krohn.[1]

CLADONEMA RADIATUM, *Dujardin*.

Plate XVII, figs. 1—10.

CLADONEMA RADIATUM (planoblast),—*Dujardin*, in Ann. Sci. Nat., vol. xx, 1843, p. 370; and vol. iv, 1845, p. 271, pls. xiv and xv. *Krohn*, in Müller's Archiv, 1853, p. 420, pl. xiii. *Gegenbaur*, in Zeitschr. f. Wissensch. Zool., vol. viii, 1857, p. 230. *Van Beneden*, Faune lit. de Belg., p. 159, pl. xii. *Keferstein* and *Ehlers*, Zool. Beitr., p. 85, pl. xiii, fig. 5.

STAURIDIE (trophosome),—*Dujardin*, loc. cit.

CORYNE STAURIDIA (trophosome), *Gosse*, Devonshire Coast, p. 257, pl. xvi, figs. 1—6.

CLADONEMA RADIATUM,—*Allman*, in Ann. Nat. Hist. for May, 1864. *Hincks*, Brit. Hydr. Zooph., p. 62, pl. xi.

TROPHOSOME.—HYDROPHYTON in the form of a very slender, creeping, ramified filament, from which short, simple hydranth-bearing branches about one tenth of an inch in height are given off at intervals, or presenting a free branching, slender stem, which attains a height of half an inch or an inch; PERISARC smooth. HYDRANTH with the tentacles of the proximal verticil much smaller than those of the distal.

GONOSOME.—PLANOBLAST (when mature) with the vertical and transverse diameters of its umbrella nearly equal, and with a slightly prominent boss upon its summit; velum very wide, oral appendages, in the form of short cylindrical processes, terminated each by two or three small spherical clusters of thread-cells, the marginal tentacles with about four extensile branches nodulated with clusters of thread-cells,

[1] 'Müller's Archiv,' 1853, p. 420, pl. xiii.

and terminated each by a spherical cluster larger than those which are borne along their length; the sucker-bearing appendages, usually three in number, smooth.

Colour.—Body of hydranth very pale reddish; perisarc light yellowish brown; manubrium of medusa very pale reddish, marginal tentacles and their branches crimson brown; ocellus deep crimson.

Development of Gonosome.—Spring and summer.

Habitat.—Attached to stones, &c., in the sea.

Bathymetrical distribution.—Unknown, probably confined to the litoral zone.

Localities.—Northern shores of France, Dujardin; Coast of Belgium, Van Beneden; Coast of Devonshire, Mr. Gosse; Coast of Kent, Mr. Dowker; Messina, Krohn, Gegenbaur, Kefferstein and Ehlers.

I take for granted that the synonymy given above refers to one and the same species, namely, the original *Cladonema radiatum* of Dujardin, because, though some slight differences may be noticed between the descriptions, these do not appear to be sufficiently marked to justify our regarding them as of specific value. In some cases they are certainly the results of mere differences of age.

Though the medusa of the present species has been occasionally met with in the open sea, the trophosome has as yet been found only in the confinement of tanks appropriated to the preservation of living marine animals, and in all those cases it has shown itself spontaneously without any attempt being made to introduce it. Whether the form of the trophosome has undergone any change in consequence of the artificial conditions to which it has been thus exposed it is impossible to say. It presents itself, at all events, under two modifications; in one the hydrophyton runs over the supporting surface as a very slender branching filament, from which equally slender simple branches, about one tenth of an inch in height, are given off at intervals, each carrying a hydranth; in the other form (that represented in the plate) there is a free branching, slender stem, which attains a height of from half an inch to an inch.

Since Dujardin the principal original observers of this hydroid have been Mr. Holdsworth and Mr. Hincks in this country (see Hincks, *loc. cit.*), and M. Van Beneden on the Continent. Some years ago I obtained specimens of the trophosome from one of the tanks belonging to the zoological survey of London, in which it had appeared in abundance, but no planoblasts were developed from them. I am indebted, however, to Mr. Dowker, of Stourmouth House, Kent, for living specimens of *Cladonema radiatum*, presenting both trophosome and gonosome. They showed themselves in a large tank filled with water from the neighbouring coast, and have afforded me an opportunity of making a careful study of this remarkable hydroid (see above, page 216).

There can be little doubt that Van Beneden is right in regarding a medusa, which made its appearance in an aquarium supplied with water from the coast of Belgium, as the medusa to which Dujardin gives the name of *Cladonema*; but it is not easy to say why he could have thought himself justified in referring it to a naked *Hydractinia*-like trophosome, which he noticed at the same time in his aquarium.[1] In favour of this association there are not the slightest

[1] 'Faun. lit. de Belgique,' p. 110.

grounds, and the true trophosome has been entirely overlooked by the learned Belgian zoologist. Van Beneden's description of the medusa, however, is a valuable contribution to our knowledge of the species. He has shown that the marginal tentacles are at first comparatively simple, and that their ramification increases up to a certain point with the age of the medusa—statements which I can confirm from my own observations.

The three smooth appendages which are given off near the base of the tentacle serve the medusa as organs of attachment, the terminal capitula of these appendages having the power of adhering, sucker-like, to any surface to which they may be applied, and the little medusa may be often seen attaching itself by means of them to the sides of the glass jar in which it is confined.

It is impossible to grow tired of watching this beautiful little medusa; sometimes while dashing through the water with vigorous systole and diastole, it will all at once attach its grapples to the side of the vessel, and become suddenly arrested in its career, and then after a period of repose, during which its branched tentacles are thrown back over its umbrella, and extended into long filaments which float, like some microscopic seaweed in the water, it will once more free itself from its moorings and start off with renewed energy.

When the medusa is in the act of swimming, the tentacles are contracted and curved upwards round the margin of the umbrella. In this state the smooth appendages of attachment undergo little or no contraction, but the nodulated appendages are strongly contracted, and assume the appearance of short thick clubs.

The development of *Cladonema* is through planulæ, as has been shown by Krohn. Dujardin has also seen the stauridioid trophosome developed from the egg of the medusa, but he overlooked the intermediate stage of planula.

Dujardin has noticed a retroversion and ultimate absorption of the umbrella near the time when the ova are about to be deposited, and this observation has been, according to Mr. Hincks, confirmed in great part by Mr. Holdsworth. The phenomenon may be compared to what has been noticed above in *Syncoryne pulchella* (see p. 203), while similar observations have been made by Hincks and others on the medusæ of *Podocoryne* and of *Turris* (see Hincks, op. cit., Introduction, p. xxix).

Dujardin informs us that he has seen the ova of Cladonema adhering to the glass vessel in which the medusæ were confined, and he states that he has seen the medusa remove the ova from the cavity of its manubrium by means of its marginal tentacles, which are introduced into the mouth for this purpose; while he further describes these tentacles as employed in glueing the ova to the glass—statements which there can be little doubt are founded on some deceptive observation.

NEMOPSIDÆ.

TROPHOSOME.—Hydranths with a proximal and distal circlet of filiform tentacles.[1]

GONOSOME.—Gonophores medusiform planoblasts, with four radiating canals, and with the marginal tentacles clustered and dissimilar.

NEMOPSIS, *Agassiz.*

Name.—From νῆμα, a thread, and ὄψις, eye-sight; in allusion to the resemblance of the two clavate tentacles in each marginal cluster of the planoblast to the eye-bearing tentacles of a snail.

TROPHOSOME.—Hydrophyton not known. Hydranth conical; the proximal circlet of tentacles surrounding the base of the hydranth, the distal one situated at a short distance behind the mouth.

GONOSOME.—Planoblasts borne by the hydranth between the proximal and distal circlets of tentacles. Medusæ, when mature, deep bell-shaped; umbrella-walls thick; radiating canals, terminating each at the margin of the umbrella in a bulb which supports one of the clusters of tentacles; two of the tentacles in each cluster clavate and but slightly contractile, every tentacle carrying a distinct ocellus at its root; manubrium with four dichotomously branched oral tentacles; generative elements produced in four lobes, whose basis of attachment partly rest on the walls of the manubrium, and partly extend for a greater or less distance along the length of the radiating canals.

The genus *Nemopsis* was founded by Professor Agassiz[2] for a medusa captured on the

[1] The hydrophyton of this family has not yet been discovered.

[2] 'North American Acalethæ,' part i, p. 289.

Atlantic shores of North America. He knew nothing, however, of the trophosome, while he fell into the mistake of supposing that the two clavate tentacles which occur in every marginal cluster of the medusa, carry each an ocellus on its summit, an error which was afterwards rectified by M'Crady, to whom we are also indebted for having been the first to make us acquainted with the trophosome of a congeneric species.

A medusa, nearly allied to the *Nemopsis* described by Agassiz, was believed by M'Crady to be developed by budding from a free hydranth which he captured in the open sea, and he was thus led to the belief that *Nemopsis* presented the very exceptional condition of possessing a free floating trophosome. I feel, however, almost sure that the body here regarded by M'Crady as the entire trophosome of *Nemopsis* is only a hydranth detached from its stem. We know that this phenomenon is common in *Tubularia*, in which we find the hydranth periodically detached from the hydrocaulus, carrying with it its burden of gonophores, and continuing for some time to live in this detached condition; and I consider it highly probable that not only the free hydranth of *Nemopsis*, but the supposed free trophosome of Stimpson's *Acaulis*, affords merely another example of this phenomenon.

M'Crady appears to entertain no doubt that the medusa to which he gives the name of *Nemopsis Gibbesii*, and which he found free in the open sea, is derived from this free trophosome, which, at the time of its capture, carried numerous medusa-buds; but here again, though there is no reason against the truth of this conclusion, the evidence is not complete, for it does not seem that M'Crady traced directly the development of the medusa-buds into the adult *Nemopsis*-medusa, but that he merely inferred the relation of the buds to the adult form from the observation of intermediate stages, which he discovered in the open sea, and through which he convinced himself that the free adult medusa could be connected with the buds detached from the trophosome. Coming, however, as this opinion does from so excellent and conscientious an observer as M'Crady, we may, with all safety, accept it in anticipation of further confirmation.

The presence of two different kinds of tentacles in each marginal cluster of the medusa is an interesting feature in the genus; and another very important one is the way in which the generative lobes, which are at first confined to the walls of the manubrium, gradually extend down the radiating canals towards their marginal termination.[1]

The medusa of *Nemopsis* is intimately allied to that of *Bougainvillia*, which it especially resembles in the fact of each marginal bulb carrying a cluster of tentacles with ocelli, in that of the mouth being provided with bifurcating tentacles, and in the great thickness of the umbrella walls.

[1] See above, p. 63, where the significance of this character is discussed.

Nemopsis Gibbesii, *M'Crady.*

Nemopsis Gibbesii,—*M'Crady*, Gymnophthal. of Charleston Harbour, p. 160, pl. x, figs. 1—7.

TROPHOSOME.—Hydranths having the form of an elongated cone; tentacles about ten (?) in the proximal circlet, and six (?)[1] in the distal; those of the proximal circlet in two closely approximate alternating series.

GONOSOME.—Medusa-buds on short, simple peduncles, which are scattered irregularly over the space between the proximal and distal sets of tentacles. Planoblast, at time of liberation, with three or four tentacles in each marginal cluster, and with its manubrium destitute of oral tentacles. Mature medusa with its vertical slightly exceeding its transverse diameter; sixteen filiform and two clavate tentacles in each marginal cluster; oral tentacles very much branched, springing from a point at some distance above the mouth; generative lobes extending from the manubrium along the radiating canals for about two thirds of the length of the canal.

Development of Gonosome.—Winter.
Habitat of detached (?) hydranth.—Free, floating at large in the open sea.
Locality.—Charleston Harbour, M'Crady.

Our sole knowledge of the hydroid just described is derived from the observations of M'Crady, no other naturalist having yet met with it. It is full of interest, even though we may be permitted to doubt the normal freedom of the complete trophosome. "The appearance of the medusa," says M'Crady, "is at once singular and beautiful. The conspicuous crescentic outline of the pale orange-coloured sexual ribbons, the vivacious movements of the mouth and its appendages, the graceful waving outline of the flapping disc, with the clavate tentacula carried erect, as if always on the watch, the others floating in various curves, or lightly curled at their extremities, make it an unusually remarkable object even in this remarkable group."

The ocelli of the two clavate marginal tentacles of the medusa are, according to M'Crady, "carried on their lower surface turned somewhat inwards, that is, towards each other; the ocelli of the other tentacles on their inner surface."

M'Crady believes that he has been able to follow the development of the medusa from an early condition as a bud still attached to the trophosome to that state in which the generative lobes have attained their complete form; and his observations have been repeated and in many respects confirmed by A. Agassiz in planoblasts captured at large in the open sea. He has

[1] M'Crady makes no mention of the number of tentacles; the numbers here given are such as appear to be indicated by his figures.

shown that at first the marginal tentacles are few, and consist of the filiform tentacles alone, the clavate not making their appearance until a later period, while the oral tentacles are also entirely absent in the earlier stages. When first noticed these were in the condition of bifid filaments, and then gradually assumed the greatly ramified form which ultimately distinguished them. He has also shown that as development proceeds the generative lobes gradually extend themselves from the base of the manubrium downwards along the length of the radiating canals.

Only one specimen of the trophosome has been observed. "It was floating at large, and taken with the dip-net. It lived five days, developing medusæ, but never fixed itself, only gradually dwindling away as the medusæ were developed. The tentacula were all at last retracted, especially those around the broad base. In its first activity it was incessantly moving about by means of its tentacula, mouth downwards."[1]

Nemopsis Bachii is the name given by Agassiz to the medusa on which he founded the genus *Nemopsis*. As we know nothing of its trophosome, it does not come within the range of the systematic portion of the present monograph.

PENNARIDÆ.

TROPHOSOME.—Hydrocaulus developed or not. Hydranths with two kinds of simple tentacles, one filiform, the other capitate.

GONOSOME.—Gonophores [where known] medusiform planoblasts, with four radiating canals, and one or four more or less developed simple marginal tentacles.

Pennaria, *Goldfuss.*

Name.—From *penna*, a feather; in allusion to the symmetrical, feather-like disposition of the branches of the trophosome.

Sertularia,—*Cavolini.*

TROPHOSOME.—Hydrophyton composed of a symmetrically ramified hydrocaulus, rooted by a creeping filiform hydrorhiza, the whole invested with a chitinous

[1] M'Crady, op. cit., p. 163.

PERISARC. HYDRANTHS flask-shaped, with the filiform tentacles constituting a proximal set, and arranged in a single verticil round the base of the hydranth, and the capitate tentacles a distal set scattered on the body of the hydranth.

GONOSOME.—GONOPHORES developed in a more or less perfect verticil between the proximal and distal sets of tentacles. Umbrella deeply ovate; manubrium large, destitute of oral appendages; marginal tentacles four, rudimental, no ocelli.

The genus *Pennaria* was constituted by Goldfuss for the *Sertularia pennaria* of Cavolini, a well-marked generic form, so well marked as to justify its assumption as the type of a distinct family of Gymnoblastic hydroids

*** 1. PENNARIA CAVOLINII, *Ehrenberg.*

Woodcut, fig. 80.

SERTULARIA PENNARIA,—*Carolini*, Mem. Pol. Mar., Sprengel's trans., p. 61, tab. v.
PENNARIA DISTICHA,—*Goldfuss*, Handbuch der Zool., p. 89.
PENNARIA CAVOLINII,—*Ehrenberg*, Corallenthiere, Abhandl. Akad. Berlin, 1832, p. 297.
Kölliker, Zeitschr. f. Wiss. Zool., vol. iv, 1853, p. 303.

TROPHOSOME.—HYDROPHYTON attaining a height of six or seven inches; main stem slightly zig-zag, and with a uniform and gentle curve from base to apex; branches given off alternately from each side, with a regular distichous arrangement, PERISARC annulated at the origin of the branches, and on the ultimate hydranth-bearing ramuli. HYDRANTHS borne on the summits of the main stem and primary branches, and on those of very short simple nearly cylindrical ramuli, which spring at regular intervals from the distal side of the primary branches; body of hydranth tumid at the base, and thence rapidly tapering to the mouth, so as to assume the form of a flask; filiform tentacles about twelve, terminating in blunt, slightly swollen extremities, and springing from a zone at some distance above the base of the hydranth; capitate tentacles about twenty, much shorter than the filiform.

GONOSOME.—MEDUSÆ long ovate, borne on short peduncles, and springing from the body of the hydranth just within the base of the verticil of filiform tentacles; marginal tentacles in the form of four small tubercles.

Colour of hydrocaulus brown, becoming paler at the apices of the branches; thick basal portion of hydranth white, speckled with brown; thin apical portion white; gonophores pale rose red. (Cavolini.)

Development of Gonosome.—Observed during the summer (Cavolini) and autumn (Kölliker).

Habitat.—Attached to rocks in the sea.

Bathymetrical distribution.—Zone of *Cystoseira* or Laminarian zone.

Localities.—Bay of Naples, Cavolini; Messina, Kölliker. Gulf of Genoa, Trinchesi.

Though the specific name of *disticha* assigned by Goldfuss to Cavolini's hydroid may lay claim to priority, I have not hesitated to retain that of *Cavolinii*, by which Ehrenberg designated the species; not only because this name has already obtained acceptance, but because Goldfuss's name is manifestly faulty, for, while claiming to possess a specific significance, it is founded on a character which cannot be regarded as specifically distinctive. And in this I feel myself all the more justified, as the name of one of the most original and accurate observers of the HYDROIDA thus remains connected with an important hydroid form, which he was the first to make known to the zoologist.

FIG. 80.

Fragment of a colony of *Pennaria Cavolinii*, from a specimen preserved in spirits. Magnified about eight diameters.

The species of *Pennaria* are rendered very remarkable by the regular distichous disposition of their primary branches, conferring on the hydrosoma that symmetrical plume-like form which, though the usual condition among the Sertularians, is quite exceptional among the Tubularians.

I have never had an opportunity of seeing a living example of this fine hydroid, of which there has been no complete original description since that of Cavolini, who found the species growing upon submarine rocks in the Bay of Naples. I am indebted, however, to Professor Trinchesi, of the University of Genoa, for a well-preserved spirit specimen of what I have no doubt is Cavolini's hydroid. It was obtained in the Gulf of Genoa, and has enabled me, by supplementing the description left us by Cavolini, to frame the diagnosis just given. It has also afforded me the subject from which the accompanying woodcut has seen made.

Cavolini saw and described the medusiform gonophores, with their umbrella, radiating canals, and manubrium, though he overlooked their relation to free medusæ, and thus failed to recognise the importance of an observation which nearly half a century later became an essential element in all true conceptions of hydroid morphology.

The filiform tentacles are very remarkable in the possession of blunt swollen extremities. This condition did not escape Cavolini, who has represented it in his figure, and it was very distinct in Professor Trinchesi's specimen. It is plainly a persistent feature indicating an approach to true capitate terminations, and must not be confounded with the temporary enlargement frequently noticed in other hydroids as the result of certain states of contraction. It is here, on the contrary, connected with a difference of structure, the enlarged extremity being loaded with minute thread-cells as in a true capitulum. A very similar condition is presented by the proximal circlet of tentacles in the Actinulæ of *Tubularia*.

The body of the hydranth is borne on a little disc, which intervenes between it and the summit of the supporting ramulus, whose diameter the disc but slightly surpasses.

Though the gonophores of *Pennaria Cavolinii* are truly phaneroeodonic, it is probable that they never become free. Those described by Cavolini were female, and were seen to be loaded with ova while still attached to the trophosome, and the same was the case in the specimen examined by myself. The codonostome is very much contracted, and the ova appear to be retained within the cavity of the umbrella for some time after their escape from the walls of the manubrium. Indeed, it would seem from Cavolini's figure that they undergo their change into planulæ before liberation from the medusa. The male gonophore has since been described by Kölliker,[1] from specimens obtained at Messina. According to him, the codonostome in these is like that of the female provided with marginal tentacles in the form of four short lobes. No notice is taken of these processes by Cavolini; they were, however, very evident in Prof. Trinchesi's specimen, which, like that figured by Cavolini, was a female, and there is little doubt that the rudimental tentacles have been overlooked by the Neapolitan zoologist.

*** 2. Pennaria gibbosa, *Agassiz*.

Pennaria gibbosa,—*Agassiz*, Contr. Nat. Hist. U.S., vol. iii, pl. xv, figs. 1 and 2, and vol. iv, p. 278.

TROPHOSOME.—Hydrocaulus attaining a height of at least four inches; main stem slightly zig-zag, and with a long and gentle curve from its base to its summit, branches given off alternately at regular intervals from each side with a distichous arrangement; main stem annulated at its base, and with a few annulations in each interval between the branches; primary branches annulated at their base and summit, and with a few annulations at the distal side of the point of origin of each ultimate ramulus. Hydranths borne on the summits of very short ultimate ramuli, and on

[1] 'Zeitschr. f. Wiss. Zool.,' 1853, p. 303.

those of the main stem and primary branches, the ultimate ramuli given off at regular intervals from the distal side of the branch, each ramulus increasing in thickness from its base to its summit, and annulated in its entire length; the hydranths which terminate the main stem and primary branches larger than the others; body of hydranth bulging obliquely on one side, very tumid at the base, and thence rapidly thinning away towards the mouth in the form of a flask; filiform tentacles twelve, springing in a verticil from the extreme base of the hydranth; capitate; tentacles much shorter than the filiform, about thirty-two in the mature hydranth.

GONOSOME.—Gonophores springing just within the verticil of filiform tentacles, each borne on a short peduncle. Medusæ oval oblong, with four globular papillate marginal tentacles.—*Agassiz.*

Habitat.—Growing on submarine objects.
Bathymetrical distribution.—Laminarian zone?
Locality.—Gulf of Florida, Agassiz.

I have never seen a specimen of this hydroid, and have compiled my diagnosis from the description published by Agassiz, who has, moreover, given us a beautiful figure of it, and there can be no doubt that the characters which he assigns to his hydroid must separate it from the European species. It will be seen that while in Cavolini's hydroid the long filiform tentacles spring from a zone, separated by some distance from the summit of the supporting ramulus, they are described as springing from the extreme base of the hydranth in the American species. Agassiz refers to the termination of these tentacles in slightly globular lips, but no indication of this is given in his figure, so that it can scarcely be so well marked as in *P. Cavolinii.* It will be further noticed that while in *P. Cavolinii* the ultimate hydranth-bearing ramuli are nearly cylindrical, being but a very little contracted at their origin; in the American species they rapidly increase in thickness from the base to the summit.

A remarkable want of symmetry is described by Agassiz as existing in the hydranths of his *P. gibbosa,* for he tells us that these "bulge to such an extent on the side facing towards the main stem as to render them strongly gibbous;" a feature, however, which is scarcely represented in his figure.

The oldest gonophores observed by Agassiz had four marginal, rudimental, knob-like tentacles, but as the generative elements had not made their appearance we have no evidence of the sex of the gonophores. On each of the radiating canals, near their distal extremities, Agassiz describes a fusiform swelling, which he regards—though not without some hesitation—as generative sacs like those of the Campanularian medusæ. There can be no doubt that these bodies are nothing of the kind; what they really are, however, it is impossible, with our present knowledge of them, to say. A comparison with the enigmatical swellings already described on the radiating canals of *Slabberia,* and which have also been erroneously taken for generative sacs, will suggest itself.

HALOCORDYLE, *Allman.*

Name.—From ἅλς, the sea, and κορδύλη, a club; in allusion to the club-like form of the hydranths.

Globiceps,—*Ayres.*
Eucoryne,—*Leidy.*

TROPHOSOME.—Hydrophyton composed of a symmetrically ramified hydrocaulus rooted by a creeping filiform hydrorhiza, the whole invested with a chitinous perisarc. Hydranths flask-shaped, with the filiform tentacles forming a single verticil at the base of the hydranth, the capitate much shorter than the filiform, arranged in one or more distinct verticils towards the distal extremity of the hydranth.

GONOSOME. — Gonophores phanerocodonic, developed between the filiform tentacles and the proximal verticil of the capitate tentacles. Umbrella deeply ovate, manubrium large, destitute of oral apendages; marginal tentacles four, rudimental; ocelli absent.

For the institution of the present genus we are indebted to Ayres, who founded it on a hydroid discovered by him upon the eastern shores of North America. To his new genus he gave the name of *Globiceps.*

Shortly afterwards, without any knowledge of the previous observations of Ayres, the genus was defined by Leidy, under the name of *Eucoryne,* with an excellent figure of the only species as yet known. As Agassiz, however, has pointed out, both these names had already been appropriated, *Globiceps* being in use for a genus of hymenopterous, and *Eucoryne* for one of coleopterous insects. There is, therefore, no alternative but to employ some other generic designation for Ayres' and Leidy's hydroid, and as Agassiz proposes none, the name of *Halocordyle* has here been substituted.

Halocordyle has close affinities with *Pennaria,* from which, however, it is at once separated by the verticillate arrangement of its capitate tentacles, which in *Pennaria,* instead of being verticillate, are scattered on the body of the hydranth.

*** HALOCORDYLE TIARELLA, *Ayres.*

GLOBICEPS TIARELLA,—*Ayres*, in Proc. Bost. Soc. Nat. Hist., 1852, vol. iv, p. 193.
EUCORYNE ELEGANS,—*Leidy*, Marine Invert. Fauna of Rhode Island and New Jersey, 1855, p. 4, pl. x, figs. 1—5.
PENNARIA TIARELLA,—*M'Crady*, Gymnophthal. Medusæ, Proc. Elliott Soc. Nat. Hist., vol. i, 1857, p. 153. *Alex. Agassiz*, Illustr. Catal., p. 187, figs. 311—315.

TROPHOSOME.—HYDROCAULUS attaining a height of four or five inches, main stem nearly straight, alternately branched, branches distichous, sending off short, simple, or slightly branched ramuli from their distal side; main stem and branches annulated at intervals, the ultimate ramuli annulated at their origin and termination. HYDRANTHS with about twelve filiform tentacles, in two verticils, having about six tentacles in each.

GONOSOME.—GONOPHORES on short peduncles, developed just within the verticil of filiform tentacles. Umbrella deep and narrow, marginal tentacles in the form of four short conical processes.

Colour.—Main stem and primary branches shining black, ultimate ramuli ochre-yellow; body of hydranth between the filiform and capitate sets of tentacles pink, encircled by two red bands, the thin distal portion of the body translucent white. Medusæ with the external surface of the umbrella marked by four longitudinal red bands, each band lying directly over a radiating canal; manubrium deep opaque red.

Development of Gonosome.—Observed in August.

Habitat.—Attached to Fuci shells, &c., in the sea.

Bathymetrical distribution.—Laminarian zone.

Locality.—Atlantic shores of North America, Ayres, Leidy, M'Crady, and A. Agassiz.

Leidy has published an excellent description and figure of this beautiful hydroid. I have never seen a specimen of it, and have availed myself of Leidy's memoir in drawing up the diagnosis here given. A very complete description of the medusa is also given by M'Crady, who, however, refers the species to the genus *Pennaria*, in which he is followed by A. Agassiz, who has also fully described the medusa and given us figures of it and of the hydranth. For reasons already stated I cannot agree with M'Crady and A. Agassiz in referring it to *Pennaria;* I agree, on the other hand, with Professor L. Agassiz[1] in believing that it must constitute a

[1] 'Contr. Nat. Hist. U.S.,' vol. iv, p. 281.

distinct genus. Indeed, the principles which have guided us in the definition of genera among the HYDROIDA would not justify the association of the present hydroid, in a single genus, with the "*Sertularia pennaria*" of Cavolini.

As in *Pennaria Cavolinii*, the generative elements are not only developed in the walls of the manubrium, but the ova may even attain the condition of planulæ before the liberation of the medusa. M'Crady, however, has seen the medusa become free before the escape of the planulæ.

STAURIDIUM, *Dujardin*.

Name.—From σταυρὸς, a cross; in allusion to the cross-like disposition of the tentacles in the hydranth.

TROPHOSOME.—HYDROPHYTON consisting of a simple or irregularly branched HYDROCAULUS arising from a creeping filiform HYDRORHIZA, the whole invested with a PERISARC. HYDRANTHS clavate, with one or more verticils of capitate tentacles, and one verticil of filiform tentacles, the tentacles in each being four in number and disposed in a cross; the verticil of filiform tentacles placed at the proximal side of the others.

GONOSOME.—PLANOBLASTS developed from the body of the hydranth. Umbrella deep bell-shaped; manubrium with the mouth simple; marginal tentacles four, nodulated with clusters of thread-cells, and having a distinct ocellus on the basal bulb.

The name *Stauridium* is the same as "*Stauridie*" of Dujardin, only with its termination altered so as to adapt it to the ordinary form of zoological nomenclature, a form in which Dujardin's name has been used by subsequent writers, as Krohn, Gegenbaur, and Wright.

Dujardin and the writers who have followed him have given this name to a hydroid whose trophosome is distinguished by the characters just enumerated; but as it has been shown by Hincks that this form of trophosome may have two very different forms of gonosome,[1] it is necessary to break up Dujardin's genus into two, one of which may retain his original name for the trophosome, while to the other we may give the name of *Cladonema*, that employed by Dujardin for the only form of medusa which he succeeded in tracing to a Stauridioid trophosome.

We are indebted to Hincks for a description of the medusa of the present genus. He has called attention to the important morphological fact that it is in every respect identical with that of the very different hydroid, *Syncoryne eximia*.[2]

[1] Hincks, in 'Ann. Nat. Hist.' for Dec., 1862.

[2] Loc. cit.

The filiform tentacles are less contractile and somewhat more rigid than is usually the case with the tentacles of the HYDROIDA. This character they possess in common with the similarly formed tentacles in the hydranth of *Cladonema*. Hincks names them "false tentacles," but their structure does not essentially differ from that of the filiform tentacles of most other marine hydroids.

STAURIDIUM PRODUCTUM, *Wright.*

Plate XVII, figs. 11 and 12.

STAURIDIA PRODUCTA,—*Strethill Wright*, in Proc. Roy. Phys. Soc of Edin. for April, 1857, pl. xix, figs. 7—9.
STAURIDIUM PRODUCTUM,—*Hincks*, Brit. Hydr. Zooph., p. 58, pl. xii, fig. 1.

TROPHOSOME.—HYDROPHYTON attaining a height of about a quarter of an inch; HYDROCAULUS simple, or with a few irregularly disposed branches, shorter than the hydranth, and springing at intervals from a creeping filiform HYDRORHIZA. HYDRANTHS cylindrical, the capitate tentacles in three verticils, the filiform tentacles tapering to a blunt point.

GONOSOME.—GONOPHORES developed at "the base of the lower capitate tentacles;" umbrella of MEDUSA set with scattered thread-cells, marginal tentacles with the terminal cluster of thread-cells larger than the others.

Colour.—Hydranth white, perisarc pale yellowish-brown; manubrium and marginal bulbs of medusa rose coloured.

Development of Gonosome.—Summer.

Habitat.—Rock pools.

Bathymetrical distribution.—Litoral zone.

Localities.—Firth of Forth, Dr. S. Wright; Ilfracombe, Rev. T. Hincks; Penzance, G. J. A.

This elegant little hydroid is rendered very remarkable by the symmetrical disposition of its tentacles in crucial verticils, situated at nearly equal distances from one another along the cylindrical body of the hydranth. I met with it at Penzance during the autumn in considerable abundance, attached to the bottom of shallow rock pools, a little above low-water mark, but neither my specimens nor those originally described by Dr. Wright carried gonophores, while

Mr. Hincks's specimens, obtained during the summer in the north of Devonshire, were furnished with them.[1]

Wright and Hincks describe the filiform tentacles which compose the proximal verticil as directed away from the hydrorhiza. In my specimens they always pointed towards the hydrorhiza—a difference, however, which may not be constant, and cannot in itself be regarded as specific.

VORTICLAVA, *Alder*.

Name.—From *vortex*, a whorl, and *clava*, a genus of hydroids; so called from the verticillate disposition of the tentacles.

TROPHOSOME.—HYDROCAULUS simple, destitute of a conspicuous PERISARC; HYDRORHIZA a filiform stolon. HYDRANTH claviform, with two verticils of tentacles; tentacles composing the proximal verticil filiform, those composing the distal verticil shorter and capitate.

GONOSOME.—Unknown.

The genus *Vorticlava* was founded by Alder for a small hydroid, which he discovered in a rock-pool on the coast of Northumberland. It seems to be a well-constituted genus, but as nothing is yet known of the gonosome, we are compelled to regard it as, to a certain extent, provisional. In the form of the hydranth, with its two dissimilar sets of tentacles, there is a strong affinity between *Vorticlava* and the genera *Acharadrium*, *Heterostephanus*, *Stauridium*, *Cladonema*, *Halocordyle*, and *Pennaria*. The absence of a distinct perisarc, however, separates *Vorticlava* from all these genera except *Heterostephanus*.

1. VORTICLAVA HUMILIS, *Alder*.

VORTICLAVA HUMILIS,—*Alder*, Catal. Zooph., p. 10, pl. i, figs. 1—3. *Hincks*, Brit. Hydr. Zooph., p. 132, pl. xxiii, fig. 1.

TROPHOSOME.—HYDROSOME attaining a height of about two tenths of an inch,

[1] Though without the gonophores, the identification cannot be considered as absolute, the resemblance of the trophosomes is so close as to justify our assuming, with a certain provisional reserve, an identity of species.

gradually tapering from its attached to its distal end. Hydranth with five distal and ten proximal tentacles, the proximal tentacles about three times the length of the distal.

GONOSOME.—Unknown.

Colour.—White.

Habitat.—In a rock pool attached to Corallina officinalis.

Bathymetrical Distribution.—Litoral zone.

Localities.—Coast of Northumberland, Mr. Alder; Felixstowe, on the Suffolk coast, Mr. Busk.

Though Mr. Alder regards the solitary condition of the single specimen on which he founded his genus *Vorticlava* as a permanent character, Mr. Hincks believes that this condition indicates only an immature state of the hydroid. Hincks founds this view on a specimen of an undetermined species of Vorticlava, which he obtained on the southern coast of Devonshire, and which consists of two hydranths, one fully grown, the other immature, and both united by a common adherent base.

I have never seen a specimen of *Vorticlava humilis.* The diagnosis given above is compiled from Mr. Alder's description of it, supplemented by some observations of Hincks.

2. Vorticlava proteus, *Strethill Wright.*

Vorticlava proteus,—*Wright,* in Quart. Journ. Micr. Sci., vol. iii, n. s., p. 5, pl. v, figs. 1—6. *Hincks,* Brit. Hydr. Zooph., p. 133, pl. xxiii, fig. 2.

TROPHOSOME.—Hydrocaulus when extended cylindrical. Hydranths with five distal and nine proximal tentacles.

GONOSOME.—Not known.

Habitat.—Attached to stones in the sea.

Bathymetrical Distribution.—Coralline zone.

Locality.—The "Fluke Hole," Firth of Forth; Dr. Strethill Wright.

Under the name of *Vorticlava proteus,* Dr. Strethill Wright has described a hydroid which he regards as distinct from Alder's *Vorticlava humilis.* In Dr. Wright's description, however, which can hardly be regarded as a specific diagnosis, it is difficult to recognise any character which can be accepted as pointing to a specific distinction from *Vorticlava humilis*, for the great mutability of form which he assigns to his hydroid may equally belong to the latter, though no allusion is made to it in Mr. Alder's description. The slender cylindrical form of the stem when fully extended contrasts with the relatively thick tapering stem of *Vorticlava humilis*; and this, with our present knowledge of *Vorticlava proteus*, would seem to be the only reliable character for specific distinction. Under these circumstances it is with some hesitation that I retain the *Vorticlava proteus* as an established species. Dr. Wright gives a series of figures showing his hydroid in various states of contraction, and it would appear from these that the contractibility and consequent mutability of form is possessed no less by the hydrocaulus than by the hydranth. He informs us also that the hydroid "has the power of changing its place," a curious and important observation.

Wright has not been more fortunate in meeting with the gonosome of *Vorticlava proteus* than Alder has been in meeting with that of *Vorticlava humilis*.

HETEROSTEPHANUS, *Allman.*

Name.—From ἕτερος, dissimilar, and στέφανος, a wreath; in allusion to the dissimilarity of form between the two verticils of tentacles in the hydranth.

TROPHOSOME.—Hydrocaulus simple and solitary, destitute of perisarc. Hydranths with two verticils of tentacles, a proximal and a distal; the tentacles composing the proximal verticil filiform, those composing the distal verticil shorter and capitate.

GONOSOME.—Planoblasts borne on peduncles which arise between the two tentacular verticils (?). Umbrella in the form of a shallow bell, with one large marginal tentacle and three rudimental ones.

The genus *Heterostephanus* is constructed for the *Corymorpha annulicornis* of Sars, which is certainly not a *Corymorpha*, as, indeed, Sars himself suspects. It may possibly belong to the genus *Vorticlava*, as already suggested by Hincks; but, from our present knowledge of it, and the absence of all knowledge of the gonosome in *Vorticlava*, we should not yet be justified in associating the two forms in a common genus. I had originally assigned to this genus the name of *Heteractis* ('Ann. Nat. Hist.' for May, 1864), overlooking the fact that *Heteractis* had been already appropriated as a generic name by the botanist, but soon afterwards becoming aware of the inadmissibility of this name, I changed it to that of Heterostephanus.

*** Heterostephanus annulicornis, *Sars*, sp.

Corymorpha? annulicornis,—*Sars*, Forhandl. i vid. Selsk i Christiania, 1859; trans. in Wiegm. Arch., 1860, p. 311; trans. in Ann. Nat. Hist. for Nov., 1861.
Heteractis annulicornis,—*Allman*, in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—Hydrosome attaining a height of two thirds of an inch. Hydranth with the proximal tentacles twenty in number and "annulated;" the distal tentacles eight to ten, very short.

GONOSOME.—Peduncles of the gonophores very short.

Habitat.—On a muddy bottom in the sea.
Bathymetrical Distribution.—Coralline zone.
Locality.—Floroe, coast of Norway; Sars.

In referring the present species to the genus *Corymorpha*, Sars expresses a doubt as to the correctness of this association, but ventures no opinion as to an alternative. It is not easy to say what may be the character which Sars desires to express by the term "annulated," which he applies to the tentacles composing the distal verticil. He found the species on only one occasion, when he obtained two specimens at a depth of from thirty to forty fathoms.

ACHARADRIA, *Strethill Wright.*

TROPHOSOME.—Hydrocaulus simple or irregularly branched, with a well-developed perisarc. Hydranths with two verticils of tentacles, those composing the proximal verticil filiform, those composing the distal verticil shorter and capitate.

GONOSOME.—Unknown.

If a perisarc were developed in *Vorticlava* this genus would become *Acharadria*, so far at least as the trophosome is concerned, for we know nothing as yet of the gonosome. In *Acharadria*, moreover, the only described species is branched, while *Vorticlava* is simple.

The affinity of *Acharadria* to *Pennaria* and *Halocordyle* is too obvious to be overlooked.

Indeed, the hydranths of *Acharadria* and *Halocordyle* with their verticils of filiform and capitate tentacles present no difference of generic value, and in the absence of all knowledge of the gonosome in *Acharadria*, we can find nothing but the symmetrical ramification of *Halocordyle* to contrast with the simple or irregularly ramified hydrocaulus of *Acharadria* as grounds of generic distinction. The whole habit of *Acharadria*, however, is widely different from that of *Halocordyle*, and it is probable that if the gonosome of *Acharadria* were known, it would be found to differ no less than the trophosome does from that of *Halocordyle*. It is possible, however, that *Acharadria* is but the immature state of some already described form of pennaridan hydroids.

Acharadria larynx, *Strethill Wright.*

Woodcut, fig. 81.

Acharadria larynx,—*Strethill Wright*, in Micr. Journ., vol. iii, n. s., p. 50, pl. v, figs. 7, 8. *Hincks*, Brit. Hydr. Zooph., p. 131, pl. xxiii, fig. 3.

TROPHOSOME.—Hydrosome attaining a height of about a quarter of an inch; hydrocaulus "spirally twisted." Hydranths with from four to twelve tentacles in the proximal verticil, and from two to eight in the distal.

GONOSOME.—Unknown.

Colour.—Hydranths pale orange.
Habitat.—On stones in the sea.
Bathymetrical distribution.—Laminarian zone (?).
Locality.—Ilfracombe; Dr. S. Wright.

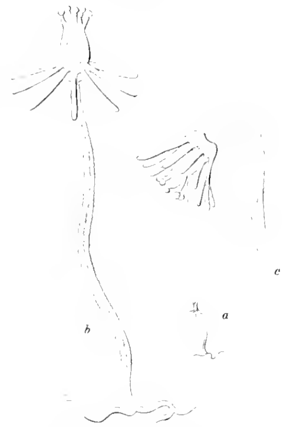
The little hydroid on which Dr. Wright founded his genus *Acharadria* was discovered by him on stones along with *Caryophyllia Smithii*, but from what part of the very wide bathymetrical range of the *Caryophyllia* his specimens were procured he does not tell us. He informs us that the *Acharadria* resembles *Tubularia larynx* in habit.

I am indebted to Mr. Rotch for an opportunity of examining a little solitary hydroid which had made its appearance in his aquarium, and which has afforded me the subject of the annexed woodcut (fig. 81). It corresponds in all characters of generic value with the *Acharadrium larynx* as described by Wright. From Wright's hydroid, however, it differs in its absolutely simple stem, and in the absence of the spiral twisting given as a character of *A. larynx*. The filiform tentacles were ten in number, and the capitate tentacles five. The former possessed considerable contractility, and might at one time be seen thrown forward (*c*) towards the mouth, and at another thrown back (*b*) so as to expose the whole of that part of the hydranth-body which lay above them. The very delicate transparent perisarc which invested the stem became, just below the hydranth, so thin as to be with difficulty detected; here the stem was irritable and contractile, and the hydranth would frequently be seen to incline from side to side, or would assume a nodding attitude, as represented in the right hand figure (*c*). The hydranth was of pale vermilion colour and the stem nearly colourless. No trace of a gonosome was present.

Though this little hydroid differs from *Acharadria larynx* in characters which may be deemed of specific value, I am not disposed to assign to it the rank of a distinct species. It has all the appearance of an immature form, and I regard it as the young state of *A. larynx*. Indeed the mature state of *Acharadria* has probably not yet been seen.

The aquarium in which it occurred was stocked by Mr. Rotch from the shores of the Channel Islands.

Fig. 81.



Acharadria larynx (young specimen).
a, Natural size; *b*, magnified; *c*, hydranth and distal extremity of stem; the hydranth has here assumed a drooping posture on its stem.

ACAULIS, *Stimpson*.

Name.—From α negative, and καυλός, a stalk, in allusion to the supposed absence of a hydrocaulus.

TROPHOSOME.—Hydrocaulus unknown. Hydranth sub-cylindrical; tentacles of the proximal set long, filiform, disposed in a single verticil near the proximal extremity of the hydranth; those of the distal set, short, capitate, scattered upon the body of the hydranth.

GONOSOME.—Gonophores sessile, scattered, springing from the body of the hydranth, between the proximal and distal sets of tentacles; form of medusa unknown.

Our ignorance of the form of the gonophore will not allow us to assign the genus *Acaulis* to any special family otherwise than provisionally, and it is only with such reservation that it is here placed in the *Pennaridæ*.[1]

[1] By an oversight *Acaulis* is placed under the family of *Corymorphidæ* in page 240.

In the above diagnosis I have confined myself to *one* of the forms described by Stimpson, as two different states of the same hydroid, and I have done so because I feel sure that Stimpson had two entirely different hydroids under examination when he believed that he had only two different phases of a single one.

After describing an animal with the characters given above, and which he found floating free in the open sea, Stimpson goes on to say:—"At a subsequent time I met with several of these animals, which presented a different appearance. The tentaculæ were larger, especially in the region of the mouth, at the now blunt extremity of the body, and the medusa-buds were in an advanced state of development, soon to become free-swimming individuals. The inferior appendages had disappeared, and the body was firmly attached by a broad base, and bore much resemblance to one of the ordinary *Corynidæ* deprived of its stalk. In strong contractions it assumed a shape resembling that of an hour-glass. The length of the animal in this latter stage was half an inch, the breadth two tenths. In the earlier stage the dimensions were one half these.

"It was dredged in the Laminarian zone, from five to fifteen fathoms, attached to various Rhodosperms, as *Ptilota*, *Chondrus*, and *Rhodymena*."

The animal thus described is a *Syncoryne*-like hydroid with undeveloped stem, and has assuredly nothing to do with the *Tubularia*-like free hydranth previously described. If I am correct in this supposition, the *Syncoryne*-like fixed hydroid presents us with a distinct generic form, characterised by its sessile hydranths with scattered capitate tentacula and phanerocodonic gonophores. It is not improbably identical with the genus *Halocharis* of Agassiz ('Contr. Nat. Hist.,' N. S., vol. iv, p. 239, pl. xx, fig. 10), a genus from which he afterwards withdrew the name of *Halocharis* in favour of M'Crady's name of *Corynites*. (See the description of *Corynites* given above.)

Stimpson found the animal for which he constituted his genus *Acaulis* in the condition of a free floating hydranth, and derived from this fact the leading character of the genus. I am strongly of opinion, however, that, with the similar condition attributed by M'Crady to *Nemopsis*, this free state is only accidental, and that the floating hydranth, with its gonophores, had been detached from a stalk in a way we know to be so common in *Tubularia*. I have therefore not included the freedom of the trophosome as a character in the diagnosis.

*** Acaulis primarius, *Stimpson*.

Acaulis primarius,—*Stimpson*, Marine Invertebrata of Grand Manan, pl. i, fig. 4, in Smithsonian Contributions, vol. vi, 1854. *Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 345. *Allman*, Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—Hydranth, with the tentacles of its proximal zone, eight in number; distal tentacles numerous, very small, commencing a little below the mouth, and thence scattered over about two thirds of the surface of the body.

GONOSOME.—GONOPHORES thickly scattered over the whole of the space which intervenes between the proximal and distal sets of tentacles.

Habitat.—Found floating in the open sea.
Locality.—Mouth of the Bay of Fundy, New Brunswick, W. Stimpson.

The floating hydranth found by Stimpson measured about half an inch from its summit to its base. As already said, it is highly probable that the *Acaulis primarius* is nothing more than the detached hydranth of a stalked form, whose hydrophyton has not yet been discovered.

CLADOCORYNIDÆ.

TROPHOSOME.—HYDRANTHS with both simple and ramified capitate tentacles.

GONOSOME.—Not known.

CLADOCORYNE, *W. D. Rotch.*

Name.—κλάδος, a branch, and κορύνη, a club; so named from the branched condition of the tentacles in the hydranth.

TROPHOSOME.—HYDROCAULUS developed, invested by a chitinous PERISARC, and rooted by a creeping filiform HYDRORHIZA. HYDRANTHS claviform, with a single verticil of simple capitate tentacles round the mouth, and several verticils of branching capitate tentacles on the rest of the body.

GONOSOME.—Not known.

The genus *Cladocoryne* is separated from all other known hydroid genera by the presence of ramified tentacles in the hydranths. This condition may be compared with that of *Cladonema*, in which the planoblast is distinguished by its ramified marginal tentacles.

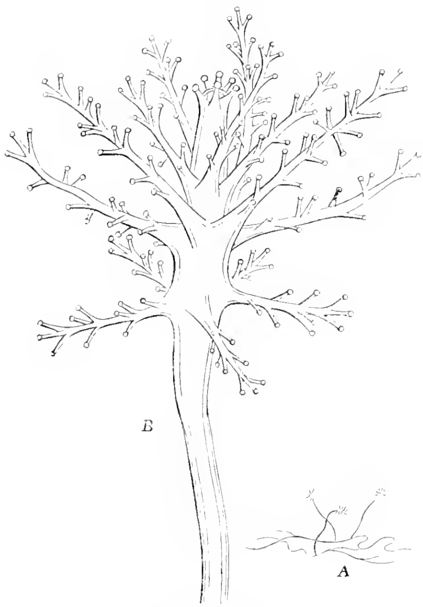
Cladocoryne floccosa, *Rotch.*

Woodcut, fig. 82.

Cladocoryne floccosa, *Rotch,* in Ann. Nat. Hist. for March, 1871.

TROPHOSOME.—Hydrocaulus attaining a height of about half an inch, slender, simple or sparingly branched; perisarc smooth, or slightly and irregularly annulated. Hydranths long, linear, slender, tentacles very long; the simple tentacles forming a verticil of four to eight immediately round the mouth, the branching tentacles forming three or four verticils round the body, with three or four tentacles in every verticil, each tentacle giving off numerous short capitate ramuli.

Fig. 82.



Cladocoryne floccosa.
A. A colony of the natural size.
B. Hydranth magnified.

GONOSOME.—Not known.

Colour.—Hydranth reddish-brown, with opaque white oral extremity, and with its proximal end merging into the light straw-colour of the perisarc.

Habitat.—On stones at low tides.

Bathymetrical Distribution.—Litoral zone.

Locality.—Herm, near Guernsey, Mr. W. D. Rotch.

For our knowledge of this beautiful little hydroid we are indebted to Mr. Rotch, who obtained it in the Channel Islands. Among the whole range of hydroid trophosomes there is not one more remarkable. It is absolutely unique in the ramified condition of the tentacles of the hydranth. Unfortunately no gonosome had been developed in any of the specimens collected, and we wait with much impatience for the discovery of this important element.

The accompanying woodcut has been made from a specimen in Mr. Rotch's aquarium.

MYRIOTHELIDÆ.

TROPHOSOME.—Hydranth solitary, attached; tentacles scattered, capitate. Hydrocaulus not developed.

GONOSOME.—Gonophores fixed sporosacs borne on special processes which spring from the body of the hydranth.

MYRIOTHELA, *Sars.*

Name.—From *μυρίος*, numberless, and *θηλή*, a nipple; in allusion to the great number of nipple-like tentacles in the hydranth.

Lucernaria,—*Fabricius.*
Candelabrum,—*De Blainville.*
Arum,—*Vigors.*
Spadix,—*Gosse.*

TROPHOSOME.—Hydranth claviform or sub-cylindrical, springing from a broad adherent hydrorhiza, which is invested with a perisarc; tentacles very small, papilliform.

GONOSOME.—Processes which support the sporosacs naked, springing from the hydranth at the proximal side of the tentacles.

I have never had the good fortune of meeting with an example of this remarkable genus. It was first accurately defined by Sars,[1] to whom we owe the name of *Myriothela*; but, as Mr. W. Stimpson has pointed out,[2] the first example of the genus was described by Fabricius,[3] whose *Lucernaria phrygia* is certainly a *Myriothela*, probably identical with the *Myriothela arctica* of Sars.

De Blainville, seeing that Fabricius's animal had no relation with *Lucernaria*, constituted for it, in 1834, his genus *Candelabrum*, and as this name has priority over *Myriothela*, it is accepted by Agassiz as the legitimate name of the genus.

[1] Sars, 'Beretning om en Zoologisk Reise i Loftoen,' 1850.

[2] See Agassiz, 'Cont. Nat. Hist. U. S.,' vol. iv, p. 341, note.

[3] 'Fauna Grœnlandica,' p. 343.

Though I followed Agassiz in this view myself,[1] more mature consideration has induced me to return to the name of *Myriothela*. De Blainville deserves no credit for seeing that the *Lucernaria phrygia* of Fabricius was not a *Lucernaria*. Any zoological contemporary of his would have done the same, and though by withdrawing this hydroid from the genus *Lucernaria* he has so far rectified the error of Fabricius, he has, nevertheless, totally misunderstood its relations. He asserts of it that it "certainement n'appartient pas au type des Actinozoaires," and he concludes his allusion to it by affirming its affinity to *Sipunculus*.[2] Indeed, Fabricius had a far more correct conception of the zoological position of his animal than De Blainville had, for besides giving a very good description of it, he expresses doubts as to its relations with *Lucernaria*, and plainly recognises its hydroid affinities.

Now Sars was well acquainted with the animal, for which he formed his genus *Myriothela*. He had a true conception of its relations, and gives a legitimate generic diagnosis of it, so that I have no hesitation in returning to the name of *Myriothela*, though the laws of priority, if rigidly enforced, might justify the suppression of Sars's name in favour of De Blainville's.

I can find no reason for regarding Fabricius's species as distinct from that of Sars, and as no reason can be urged against the use of the specific name given to it by the famous author of the 'Fauna Grœnlandica,' I believe that here the law of priority must prevail, and that Fabricius's name of *phrygia* must take the place of *Arctica* given by Sars.

From the observations of Mr. Cocks it would appear that the young of *Myriothela phrygia* escape from the gonophores under a form which has much resemblance to the young of *Tubularia*,[3] and Mr. Alder informed me that he had himself made a similar observation. It would thus appear that the young of *Myriothela* are not *planulæ* but *actinulæ*.

MYRIOTHELA PHRYGIA, *Fabricius*.

LUCERNARIA PHRYGIA,—*Fabricius*, Fauna Grœnlandica, p. 343.
CANDELABRUM PHRYGIUM,—*De Blainville*, Mem. d'Actinologie, p. 318. *Agassiz*, Cont., Nat. Hist. U. S., vol. iv, p. 341.
MYRIOTHELA ARCTICA,—*Sars*, Beretning om en Zoologisk Reise i Lofoten.
ARUM COCKSII,—*Vigors*, in Report of Royal Polytechnic Society of Cornwall, 1849. *Cocks*, in ditto, 1853, p. 34, pl. iii, figs. 7—12.
SPADIX PURPUREA,—*Gosse*, in Ann. Nat. Hist., vol. xii, 2nd ser., 1853, p. 126; and Man. of Marine Zoology, p. 19, fig. 25.
MYRIOTHELA PHRYGIA,—*Hincks*, Brit. Hydr. Zooph., p. 77, pl. xi, fig. 3.

TROPHOSOME.—HYDRANTH attaining a height of two inches when extended, and then nearly cylindrical in form; tentacles densely crowded.

[1] "Genera of Hydroida," 'Ann. Nat. Hist.' for May, 1864.
[2] De Blainville, 'Actinologie,' p. 318.
[3] W. P. Cocks, in 'Report of the Roy. Polytechnic Soc. of Cornwall,' 1853, p. 34, pl. iii, figs. 7—12; and in 'Ann. Nat. Hist.,' vol. xii, 1853, p. 365.

GONOSOME.—GONOPHORES spherical on alternately branched processes.

Habitat.—Attached to stones in the sea.

Bathymetrical Distribution.—Laminarian to deepwater zone.

Localities.—Coast of Greenland, Fabricius; coast of Norway, Sars; Falmouth, Mr. Cocks; coast of Devonshire, Mr. Gosse and Mr. Hincks; Grand Manan, Atlantic shores of North America, Mr. W. Stimpson.

If I am right in believing that all the examples of *Myriothela* hitherto found belong to a single species, the distribution of *Myriothela phrygia* in the North Atlantic is a wide one, for the species is found both upon the European and American shores.

Not having succeeded in obtaining a specimen of *Myriothela*, I am unable to record any observations of my own on this most interesting hydroid, and the account here given has been derived from the notices of other observers, more especially of Cocks, Alder, and Hincks. Hincks compares the processes which carry the gonophores to the blastostyles of *Hydractinia*. To this view, however, the origin of the processes from the body of the hydranth is opposed. Their form and situation, indeed, judging from the published and other figures which I have seen, would suggest rather a comparison with the gonophore peduncles of *Tubularia* and *Corymorpha*.

CLAVATELLIDÆ.

TROPHOSOME.—HYDRANTHS with simple verticillate capitate tentacles.

GONOSOME.—GONOPHORES in the form of ambulatory MEDUSÆ, with undeveloped umbrella and branching marginal tentacles.

CLAVATELLA, *Hincks.*

Name.—A diminutive noun, formed from *clava*, a club, in allusion to the form of the hydranth.

ELEUTHERIA,—*Krohn.*

TROPHOSOME.—HYDROCAULUS rudimental, springing from a creeping filiform HYDRORHIZA, the whole invested with a chitinous PERISARC. HYDRANTH elongated, with its tentacles in a single verticil, which surrounds the base of a conical hypostome.

GONOSOME.—GONOPHORES developed in clusters on branched peduncles from the body of the hydranth. Rudimental umbrella not fitted for natation. Manubrium short, conical, destitute of oral appendages; radiating canals six; marginal tentacles six, bifurcated, the outer branch of the bifurcation terminated by a capitulum of large thread-cells, the inner by a claviform enlargement, which carries a suctorial disc of attachment; an ocellus at the root of each tentacle, but no distinct marginal bulbs.

For the establishment of the genus *Clavatella* we are indebted to Hincks, who gave this name to a hydroid trophosome, which he discovered on the south coast of England. From this trophosome he observed the development of gonophores having a close resemblance to the free medusiform body which had previously been described by Quatrefages under the name of *Eleutheria dichotoma*, but which had not been traced to a trophosome. Its chief difference from *Eleutheria* consists in the fact that the inner branch of the marginal tentacle is terminated by an apparatus for suctorial attachment, while in *Eleutheria* it ends in a capitulum of thread-cells like that of the outer branch.

This difference, however, I regard as of generic value, so that notwithstanding the close resemblance between Quatrefages's *Eleutheria* and the gonophore of *Clavatella*, the two will scarcely admit of being associated in a common genus, however closely the trophosomes may ultimately be found to resemble one another. *Clavatella* and *Eleutheria* must, therefore, stand as two distinct genera, though the latter will not admit of complete definition until the discovery of its trophosome.[1]

CLAVATELLA PROLIFERA, *Hincks*.

Plate XVIII.

CLAVATELLA PROLIFERA,—*Hincks*, in Ann. Nat. Hist. for Feb., 1861, pls. vii and viii, Brit. Hydr. Zooph., p. 73, pl. xii, figs. 2, 2*a*. *Allman*. in Brit. Assoc Rep. for 1862, p. 100; and in Ann. Nat. Hist. for May, 1864.

ELEUTHERIA (Planoblast),—*Krohn*, in Wiegmann's Archiv, 1861, p. 157, trans. in Ann. Nat. Hist. for Jan., 1862. *Filippi*, in Mem. della Reale Academia d. Scienze di Torino, ser. ii, tome xxiii.

TROPHOSOME.—HYDROCAULUS consisting of very short cylindrical processes,

[1] *Eleutheria*, being as yet known only by its free planoblast is not included among the genera of the descriptive part of the present monograph.

springing at intervals from the creeping filaments of the HYDRORHIZA. HYDRANTHS very much elongated, cylindrical in extension, with a dilated base, where they spring from the summits of the rudimental hydrocaulus; when fully extended attaining a height of about half an inch; tentacles six to eight, with well-defined spherical capitula.

GONOSOME.—GONOPHORES in one or two clusters, each cluster containing two or three gonophores, which are borne on a very short, branched peduncle which springs from the dilated base of the hydranth. PLANOBLAST dome-shaped, with its margin continued into six short cylindrical tentacles, which divide, with their two branches of nearly equal length, a little to the distal side of their middle point.

Colour.—Hydranths white, tinged with a pale pink at the distal extremity. Medusæ with pale reddish-yellow endoderm appearing through the translucent colourless ectoderm; ocelli red.

Development of Gonosome.—Observed during the summer and autumn.

Habitat.—Attached to the sides of rock-pools.

Bathymetrical Distribution.—Litoral zone near its upper limit.

Localities.—Coast of Devonshire, Rev. T. Hincks and G. J. A.; coasts of Cornwall, Cork, and west of Scotland, G. J. A.; Gulf of Genoa (free planoblast), Prof. Trinchesi; Mediterranean sea (free planoblast), Krohn, Filippi (?).

Among the observations which have of late years so greatly advanced our knowledge of the HYDROIDA, one of the most important is that of Hincks, who, as already stated, found a hydroid trophosome giving origin to gonophore-buds, having an intimate affinity with the free hydroid organism described by Quatrefages, some years previously, under the name of *Eleutheria dichotoma*. This discovery renders it almost certain that Quatrefage's *Eleutheria* is also a planoblast, originating as a bud from some hydroid trophosome, a fact which the excellent description given by Quatrefages had already led more than one zoologist to suspect, but which, until Hincks's discovery, had received no further confirmation.

A free gonophore, apparently undistinguishable from that of Hincks's *Clavatella prolifera*, has also been well studied by Krohn, who obtained it in the neighbourhood of Nice; and by Filippi, who found what would seem to be the same organism in the marine aquariums of the Zoological Museum of Turin; while a nearly allied form, though apparently belonging to a different species, has been examined by Claparède, who discovered it on the coast of Normandy.[1] In none of these, however, any more than in the original *Eleutheria* of Quatrefages, have the observers seen the trophosome which has as yet been witnessed only by Hincks and by myself. For my first opportunity of examining this remarkable little hydroid I am indebted to Mr. Hincks, who directed me to the spot on the coast of Devonshire, where he originally discovered it. Since then I have found the *Clavatella* in other localities, and have been enabled to make both trophosome and gonosome the subject of a careful study. (See above, p. 212.)

[1] I am indebted to Professor Trinchesi, of the University of Genoa, for a drawing of the free planoblast of a *Clavatella*, which is probably identical with the British species.

One of the most striking features in the trophosome of *Clavatella prolifera* is the comparatively great development and the elongated form of the hydranth, which, just as in *Clava*, contrasts strongly with the rudimental and inconspicuous hydrocaulus. When extended its form is that of a cylinder, slightly dilated at its proximal end, where it springs from the summit of its supporting hydrocaulus, and at its distal end, where it carries its verticil of tentacles. When contracted its form varies, according to the degree of contraction, from that of an elongated cone to that of a flask.

The tentacles are usually seven or eight in number, springing in a single verticil from the dilated summit of the hydranth, and surrounding a short bluntly conical hypostome. When extended they slightly taper from their base towards their summit, where they terminate in a well-defined spherical capitulum, formed by an accumulation of large thread-cells in the thickened ectoderm.

The fully formed planoblast is very remarkable in the non-development of a free umbrella. It is thus destitute of an organ of natation; but, to compensate for this deficiency, the marginal tentacles are peculiarly developed and adapted to the function of creeping, so that the free gonophore of *Clavatella*, instead of being natatory, like other hydroid medusæ, is truly ambulatory. The generative elements are produced between the endoderm and ectoderm on the dorsal or proximal side of the medusa. In all the specimens I have examined the medusa had six marginal tentacles. The variation from this number noted by Filippi, who occasionally found seven, is probably abnormal. The planoblast may frequently be seen repeating itself by buds, which are developed in the interradial spaces of the margin.

Clavatella prolifera is a singularly beautiful little hydroid. It grows in small scattered groups, which the eye will easily detect in the shallow reservoirs of clear water left behind by the retiring tide, and whose gracefully bending hydranths, with their coronals of globe-tipped tentacles, and budding clusters of medusæ, render it one of the most attractive and interesting of all the smaller tenants of the rock-pool.

It appears to be confined to a zone just below the upper limit of the range of neap tides, and seems to prefer the smaller and shallower pools, more especially such as have their sides overgrown with an incrustation of nullipores.

CORYMORPHIDÆ.

TROPHOSOME.—HYDROCAULUS solitary, destitute of PERISARC. HYDRANTHS with a proximal and a distal set of filiform tentacles.

GONOSOME.—GONOPHORES in the form of medusiform PLANOBLASTS, with four radiating canals, and one or more simple marginal tentacles.

CORYMORPHA, *Sars* (in part).

Name.—From κορύνη, a club, and μορφή, form, in allusion to the form of the hydranth with its stem.

TROPHOSOME.—Hydrocaulus emitting towards its proximal extremity tubular fleshy processes; perisarc replaced by a delicate filmy pellicle. Hydranths flask-shaped, abruptly distinct from the hydrocaulus; proximal tentacles imperfectly contractile, larger than the distal, and arranged in a single verticil near the base of the hydranth, the distal tentacles very contractile, forming several closely approximate alternating verticils round the base of a conical hypostome.

GONOSOME.—Planoblasts borne on branched peduncles which spring from the body of the hydranth between the proximal and distal sets of tentacles, with a deep-belled umbrella, a well-developed simple-mouthed manubrium, and a single marginal tentacle; each of the radiating canals terminates at its junction with the circular canal in a bulbous expansion without distinct ocellus; one of these bulbs is larger than the other, and from this alone the solitary tentacle is developed.

The genus *Corymorpha* was instituted by Sars for the *Corymorpha nutans*, a beautiful hydroid discovered by the celebrated Scandinavian zoologist on the coast of Norway. Since then several species have been admitted into the genus, but I believe that of these one only has any claim to be congenerically associated with the original *Corymorpha nutans*.

Among the characters which especially strike us in the planoblast of *Corymorpha* is the absence of symmetry, as shown in the development of only a single marginal tentacle. This must not be confounded with that deficiency of marginal appendages which in other planoblasts is merely the result of an immature condition. Here it is a permanent feature, having an important morphological significance, and undoubtedly entitled to a place among the essential characters of the genus.

CORYMORPHA NUTANS, *Sars.*

Plate XIX.

CORYMORPHA NUTANS,—*Sars,* Beskrivelser, 1835, p. 6, pl. i, fig. 3. *Forbes* and *Goodsir,* Ann. Nat. Hist., 1840, vol. v, p. 309. *Johnson,* British Zooph., 1847, p. 54, pl. vii. *Sars,* Forhandl. i Vid. Selsk. i Christiania, 1859; trans. in Wiegm. Archiv, 1860, p. 3341, and in Ann. Nat. Hist., 1861, p. 353. *Hodge,* in Trans. Tynesdale Naturalist's Field Club, vol. v, p. 80, pl. ii, figs. 1—9. *Allman,* in Ann. Nat. Hist. for May, 1864. *Hincks,* Brit. Hydr. Zooph., p. 127, pl. xxii, fig. 2.

TROPHOSOME.—HYDROCAULUS attaining a height of from two to three inches, and having in its thickest part a diameter of about two lines, sub-cylindrical, usually enlarging towards the base, and again contracting and tapering away to a blunt point at the proximal end, the proximal pointed end bent at nearly a right angle to the rest; behind the short papillary projections which are emitted from the stem near its proximal end are numerous very fine long capillary filaments; the whole stem marked with narrow longitudinal bands; the pellicle which takes the place of the perisarc very thin, filmy, and colourless, closely embracing the ectoderm in the greater part of its extent, but towards the proximal extremity separated from it by a considerable interval, and here forming a loose corrugated sac in which the pointed extremity of the stem is enveloped. HYDRANTHS with a proximal zone of about thirty-two long tentacles, and a distal one of about eighty, which are very much shorter and thinner than the proximal, and form a brush-like group, composed of six or seven closely approximated verticils.

GONOSOME.—Peduncles of GONOPHORES fifteen to twenty in number, springing in two alternating verticils from the body of the hydranth immediately within the proximal zone of tentacles, and carrying the gonophores in clusters at the extremities of their branches. GONOPHORES with the summit of the umbrella continued into a short conical projection; marginal tentacle rendered moniliform by clusters of thread-cells.

Colour.—Hydranth light red from the mouth to the proximal set of tentacles; stem very pale red. Peduncles of gonophores, manubrium, bulbous terminations of radiating canals, and nodules of marginal tentacle light red.

Development of Gonosome.—June to September.

Habitat.—On sandy sea bottoms.

Bathymetrical distribution.—Coralline zone.

Localities.—Coast of Norway, Sars; Orkney Islands, Forbes and Goodsir; Shetland Islands, G. J. A.; Firth of Forth, Mr. M'Fie and G. J. A.; Coast of Northumberland, Mr. Hodge; Coast of Cornwall, Mr. Alder and Mr. Peach; Isle of Man, Mr. Alder.

Corymorpha nutans is one of the most beautiful of the many beautiful acquisitions of the dredge. When the naturalist is fortunate enough to carry his dredge over the sandy ground inhabited by it, he will usually bring up numerous specimens, which may be all derived from so limited an area as to force upon him the conviction that the species is gregarious in its habit, though the trophosomes are never united so as to form composite colonies. The specimens on being brought to the surface are always found with sand adhering to their proximal end, which is constantly bent on the rest of the stem, and it is almost certain that while in their natural habitat they live with this end plunged into the sandy sea bottom.

When freed from the sand, thus adhering to the lower end of the stem, and transferred into a jar of sea water, the *Corymorpha* soon begins to fix itself to the bottom of the vessel, and at the termination of about twenty-four hours its base is seen to be surrounded by a delicate web, which closely adheres to the glass, and in a few days has spread itself over a surface of a square inch or more in extent.

Under the microscope this web is found to be composed of a multitude of fine tubular filaments, which are given off from the stem all round close to its lower end, and then by repeatedly crossing one another form an entangled web-like tissue. It is almost certain that similar filaments existed in the hydroid while yet undisturbed beneath the sea, where they must have served to fix it to its sandy bed, and that in the act of detaching it they had become torn off, to be speedily renewed on the specimen being again allowed to rest in the confinement of our jars.

There is no true perisarc, but the stem is invested by a delicate pellicle, so delicate, filmy, and colourless indeed, that it may easily be overlooked; and when the animal is removed from the water the stem, destitute of the support which the HYDROIDA usually receive from their firm perisarc, appears soft, flaccid, and gelatinous. Towards the proximal end of the stem, however, this pellicle becomes separated from the ectoderm by a considerable interval, and here constitutes a loose filmy sac, in which this portion of the stem is enveloped, and which allows the passage across it of the delicate filaments of adhesion already described.

By the naked eye the stem is seen to be traversed from one end to the other by narrow longitudinal bands. Under a low magnifying power these bands are seen to inosculate with one another here and there, while towards the base of the stem they become fewer and broader by coalescence. They indicate the canals which are excavated in the endoderm of the stem, and which thus show themselves through the more superficial tissues.

The peculiar short conical papillæ which are given off from the stem near its proximal end are arranged in regular longitudinal series, which follow the course of the longitudinal bands, the stem immediately over each band bearing two alternate rows.

The planoblasts when they become free are about $\frac{1}{25}$th of an inch in diameter. Their solitary tentacle constitutes one of their most striking features, and has acquired a great development even before the detachment of the medusa. It consists of a very extensile moniliform chord, and when extended presents the appearance of a cylindrical string with ten or twelve little spherules distributed upon it at equal distances. The last of these spherules exactly terminates the string, and is larger than the others. The medusa undoubtedly belongs to the form to which Edward Forbes had given the generic name of *Steenstrupia*. Of this relation between *Steenstrupia* and *Corymorpha* Forbes himself had a suspicion; indeed, he expresses a belief that his *Steenstrupia rubra* will turn out to be the free medusa of *Corymorpha nutans*.

A medusa, which I regard as the adult planoblast of *Corymorpha nutans*, was obtained in the open sea, near the spot from which the complete hydroid was dredged. It has been fully described above (p. 211), and from the account there given, it will be seen that the changes undergone by the medusa between the time of its liberation from the trophosome and its attainment of sexual maturity are of little importance. It is especially to be noted that the marginal tentacle always remains solitary.

When the animal is allowed to assume its natural position in an aquarium, with its proximal extremity rooted in the sandy bottom, the stem rises vertically from the point of attachment, while the hydranth usually droops gracefully from the opposite end, its long tentacles forming a beautiful coronal of curved rays round its base, and the short ones forming a dense brush-like cluster round its oral extremity. But there is no part of this beautiful hydroid which tends so forcibly to impress the observer as the gonophores. Nestling at the base of the great coronal of tentacles we may see them in every stage of development, from the nascent bud, in which no medusoid structure can yet be detected, to the fully-formed medusa ready to break away from its restraining stalk, some—as if the life of the hydroid was specially concentrated in these wonderful buds—palpitating in rapid systole and diastole, seemingly eager for their approaching freedom; while others, less restless, but no less actively engaged in ministering to the welfare of their existence, are casting their long tentacles into the water, marvellous fishing lines, loaded with deadly thread-cells, and sensitive to the slightest touch of the passing prey.

Corymorpha nutans has afforded to me one of the subjects of detailed hydroid study contained in the former part of this Monograph. (See above, p. 208.)

HALATRACTUS, *Allman*.

Name.—From ἅλς, the sea, and ἄτρακτος, a spindle; so called from the form of the hydrosome.

TROPHOSOME.—Hydrocaulus surrounded towards its proximal extremity with tubular fleshy processes. Hydranth abruptly distinct from the hydrocaulus; the proximal set of tentacles in a single verticil, and larger than the distal, which are scattered or subvertillate round the base of a conical hypostome.

GONOSOME.—Planoblasts sessile, springing from the body of the hydranth between the proximal and distal sets of tentacles; umbrella at the time of liberation bell-shaped, with one of the four radiating canals continued into a short club-shaped tentacle, while each of the others terminates at the margin of the umbrella in a bulb destitute of tentacle; manubrium long, with a simple mouth.

The genus *Halatractus* has been instituted for the *Corymorpha nana* of Alder, whose sessile gonophores at once distinguish it from the true Corymorphas, whose gonophores are always pedunculated. Alder, however, in his description of this hydroid, mentions another character, which, if established, would be one of great importance; for he tells us that while the gonophores are phanerocodonic in some individuals, they are adelocodonic in others, and he figures irregularly-lobed oval bodies as the adelocodonic form, suggesting at the same time that this condition may depend on a difference of sex.

The peculiarity thus indicated I cannot accept without the confirmation which the examination of a greater number of specimens may afford. The phenomenon of phanerocodonic and adelocodonic gonophores being borne by one and the same species of hydroid rests upon no valid evidence, though its occurrence has been maintained in more than one instance, and I am far more inclined to regard the unsymmetrical, irregularly-lobed bodies of Alder's *Corymorpha nana* in the light of misshapen monstrosities, occurring in an individual instance, than as a constant and normal phenomenon; and this view I am the more disposed to adopt as Alder's figures convey no idea of true sporosacs.

It is also a point for further investigation to determine whether the peculiar club-shaped form attributed by Alder to the solitary marginal tentacle of the planoblast is not the result of a contracted condition of this organ. Alder evidently thinks not.

Halatractus nanus, *Alder*.

Corymorpha nana,—*Alder*, Catal. Zooph. of Northumberland, Durham, p. 80, pl. vii, figs. 7 and 8; Suppl. Catal., p. 9, pl. xi. *Allman*, in Ann. Nat. Hist. for May, 1864. *Hincks*, Brit. Hydr. Zooph., p. 130, pl. xxii, fig. 3.

TROPHOSOME.—Hydrocaulus about one half an inch in height, marked by longitudinal opaque white bands, and tapering towards its proximal end, where it terminates in a blunt point, which is surrounded by a loose sheath of filmy perisarc. Hydranth with from fifteen to twenty tentacles in the proximal zone, and about sixteen or eighteen in the distal, where they are disposed in two imperfect rows.

GONOSOME.—Gonophores forming a verticil close to the proximal zone of tentacles; medusa with the summit of the umbrella rounded.

Habitat.—(?).
Bathymetrical distribution.—(?).
Locality.—Coast of Northumberland, Mr. Alder.

The remarkable little hydroid to which Alder assigns the name *Corymorpha nana*, is by far the smallest of the species which have been referred by authors to the genus *Corymorpha*. It was obtained from the refuse of the fishing boats on the Northumberland coast, but we know nothing of its habitat or of its bathymetrical distribution.

AMALTHÆA, *Oscar Schmidt.*

Name.—*Amaltheia*—a mythological name: the goat that suckled Jupiter.

TROPHOSOME.—Hydrocaulus emitting tubular processes near its proximal end; perisarc rudimental. Hydranth abruptly distinct from the hydrocaulus; the proximal tentacles larger than the distal, and disposed in a single verticil near the base of the hydranth, the distal tentacles scattered (or else multiverticillate?).

GONOSOME.—Planoblasts borne upon peduncles which spring from the body of the hydranth between the proximal and distal sets of tentacles, having a deep bell-shaped umbrella, and four equal marginal tentacles with bulbous bases.

The genus *Amalthæa* is closely allied to *Corymorpha*. It was instituted by Oscar Schmidt for a hydroid which he names *Amalthæa uvifera*, and which was obtained off the Island of Loppen, in Finland.

From *Corymorpha* it is distinguished by the form of its gonophore, the umbrella of which is provided with four equal marginal tentacles instead of the solitary tentacle of *Corymorpha*, a character which is certainly of generic imporance, though Sars, not recognising it as such, places Schmidt's hydroid in the genus *Corymorpha*.

Admitting the generic value of this character, two other species placed by Sars in *Corymorpha* must be removed to the genus *Amalthæa*, which will thus include three species, all distinguished from *Corymorpha* by the possession of four equal marginal tentacles in the medusa. These are the original *Amalthæa uvifera* of Schmidt, the *Amalthæa Sarsii*, and the *Amalthæa Januarii*.

*** 1. AMALTHÆA UVIFERA, *O. Schmidt.*

AMALTHÆA UVIFERA,—*Oscar Schmidt*, Hand-Atlas der Vergleich-Anatomie, 1854, p. 13, pl. ix, figs. 2 and 2*a*. *Allman*, in Ann. Nat. Hist. for May, 1864.

CORYMORPHA UVIFERA,—*Sars*, Forhandl. i Vid. Selsk i Christiania, 1859; trans. in Wiegmann's Archiv, 1860, p. 341; and in Ann. Nat. Hist. for Nov., 1861.

TROPHOSOME.—HYDROCAULUS scarcely exceeding an inch in height. HYDRANTH club-shaped.

GONOSOME.—GONOPHORE-peduncles much branched. MEDUSA with rounded summit and four very large marginal bulbs.

General colour of trophosome red.
Habitat.—Sandy sea bottoms.
Bathymetrical distribution.—Coralline zone.
Locality.—Off the Island of Loppen, Finland, O. Schmidt.

The only information we possess regarding this species is derived from Oscar Schmidt's figures, accompanied by a few explanatory words, in his 'Hand-Atlas der Vergleichenden Anatomie.' These figures, however, leave much to be desired, while their deficiency are in no respect supplied by the explanation, which, with a short note referring to the habitat of the species, is the only account we have of the hydroid for which Schmidt constituted his genus *Amalthæa*.

The medusa is figured without any marginal tentacles proceeding from the marginal bulbs, a condition which we must regard as indicating an immature state of the gonosome in the specimens from which the drawings were made.

It is from such materials that the above description has been compiled, a description which cannot be regarded as otherwise than deficient in many points which are essential for a satisfactory diagnosis.

*** 2. AMALTHÆA SARSII, *Steenstrup.*

CORYMORPHA NUTANS,—*Sars*, Reise i Lofoten og Finmarken nyt Magazin for Naturvidensk, 1850, vol. vi, p. 135.

CORYMORPHA SARSII,—*Steenstrup*, Meddel fra den Naturhist. Foren. i Kjobenh., 1854, p. 48. *Sars*, Forhandl. i Vid. Selsk. i Christiania, 1859; trans. in Wiegm. Archiv, 1860; and in Ann. Nat. Hist., Nov., 1861.

AMALTHÆA SARSII,—*Allman*, in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—HYDROCAULUS attaining a height of from two to three inches.

Hydranth with the tentacles of the proximal zone very long, thirty to forty in number, those of the distal zone very short and numerous.

GONOSOME.—Medusiferous peduncles divided at the apex. Medusa having an elongated bell-shaped form, with rounded summit.

Habitat.—On a muddy sandy sea bottom.
Bathymetrical distribution.—Deeper parts of Coralline zone.
Locality.—Vestfjorden, near the Lofoden Islands, Sars.

The present species, which was discovered by Sars in 1849, has hitherto been found in only one locality, where, however, as Sars informs us, it is very abundant, and is often taken up with its long tentacles entangled in the meshes of the dredge.

It differs from *Amalthæa uvifera* by its greater size, by the longer proximal tentacles of its hydranth, and the more numerous distal ones, and by its shorter and more sparingly branched medusiferous peduncles.

*** 3. Amalthæa Januarii, *Steenstrup*.

Corymorpha Januarii,—*Steenstrup*, Vidensk. Meddel fra d. Naturh. Foren. i Kjöbenh., 1854, p. 46, *Sars*, Forhandl. i Vid. Selsk. i Christiania, 1859; trans. in Wiegm. Archiv, 1860; and in Ann. Nat. Hist., 1861.
Amalthæa Januarii,—*Allman*, in Ann. Nat. Hist., May, 1864.

TROPHOSOME.—Hydrocaulus attaining a height of six inches. Hydranths with the tentacles of the proximal zone very long, above eighty in number.

GONOSOME.—Peduncles of gonophores branched, about forty in number. Planoblast with the height of the umbrella about twice its width.

Colour.—Pale reddish.
Locality.—Rio Janeiro, Steenstrup.

The *Amalthæa Januarii* has been made known by Steenstrup, who described it from a single specimen obtained in the harbour of Rio Janeiro, and sent in spirits to the Zoological Museum of the University of Copenhagen. In the thickness of its stem, and in the size of its hydranth, it surpasses all known hydroids, even the great *Tubularia regalis* of the Spitzbergen seas, and the two hydroids with largest hydranths which have as yet come to the notice of the zoologist have thus been obtained, one from the icy ocean, the other from the regions within the Tropics.

The stem of *Amalthæa Januarii* measures six inches in height, and one third of an inch in thickness, while the hydranth is nearly two thirds of an inch in height, and one half of an inch in diameter, having the tentacles of its proximal circlet nearly two inches in length, and about eighty in number. The specimen appears to have been somewhat injured at the distal end of the hydranth, and only a few of the oral tentacles have been here preserved, so that nothing can be asserted as to the number and disposition of these.

The stem is marked by longitudinal deeper coloured bands, which are much more numerous than the corresponding bands of *Corymorpha nutans*. It terminates below in a blunt cone, and a little above this it presents a darker coloured zone, marked by longitudinal lines of small dark bodies, which would seem to represent the fleshy processes given off near the base of the stem in *Corymorpha*.

The gonophore peduncles are very numerous. They appear to be about forty, and are branched, and carry the gonophores on the extremities of the branches. The planoblasts are remarkable for the height of the bell in proportion to the width. The margin of the umbrella carries four nearly equal bulbs, but no tentacles appear to have been developed from these in the specimen, an indication, doubtless, of an immature state.

The specific name of this hydroid has been given to it by Steenstrup after the locality in which it was discovered.

MONOCAULIDÆ.

TROPHOSOME.—Hydrocaulus solitary, naked. Hydranths with a proximal and a distal set of filiform tentacles.

GONOSOME.—Gonophores in the form of fixed sporosacs.

MONOCAULUS, *Allman.*

Name.—From μόνος, solitary, and καυλός, a stalk, in allusion to the single zooid of which the trophosome consists.

TROPHOSOME.—Hydranth abruptly distinct from the hydrocaulus; proximal tentacles longer than the distal, and disposed in a single verticil near the base of the hydranth, the distal set scattered over a zone close to the summit of the hydranth.

GONOSOME.—SPOROSACS borne upon peduncles, which spring from the body of the hydranth between the proximal and distal sets of tentacles.

The genus *Monocaulus* is constituted for the *Corymorpha glacialis* of Sars, a form which, though its trophosome is that of a *Corymorpha*, is yet strongly distinguished from the true Corymorphas by its adeloconic gonophores.

The description given by Agassiz of his *Corymorpha pendula* renders it necessary to place this hydroid also in the genus *Monocaulus*.

⁂ 1. MONOCAULUS GLACIALIS, *Sars*.

CORYMORPHA GLACIALIS,—*Sars*, Forhandl. i Vid. Selsk. i Christiania, 1859; trans. in Wieg. Arch., 1860, p. 341; and in Ann. Nat. Hist., 1861, p. 353.
MONOCAULUS GLACIALIS,—*Allman*, in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—HYDROCAULUS attaining a height of four or five inches. Proximal tentacles of HYDRANTH very long, forty to fifty in number; distal tentacles very short and very numerous.

GONOSOME.—Peduncles of GONOPHORES thirty to thirty-five, but slightly branched. SPOROSACS oval, destitute of tentaculiform appendage.

Habitat.—On a soft clayey and stony sea bottom.
Bathymetrical distribution.—Deep sea, from 60 to 120 fathoms.
Locality.—The Varangerfjord, near Nadsoe, Sars.

The only account we possess of *Monocaulus glacialis* is Sars's short description, from which the above diagnosis has been compiled, and which is by no means so full as could be desired. Sars's specimens were obtained in small quantity at a depth of from 60 to 80 fathoms, and rather abundantly at a depth of from 80 to 120 fathoms. The only locality where it has as yet been found lies as far north as 70° N. lat. It thus possesses special interest, not only from the depth at which it lies, but from its very high northern latitude.

Prevailing *colour* a clear bright pink.

*** 2. Monocaulus pendulus, *Agassiz*.

Corymorpha pendula,—*Agassiz*, Cont. Nat. Hist. U.S., vol. iv, p. 276, pl. xxvi, figs. 7—17.
Monocaulus pendulus,—*Allman*, in Ann. Nat. Hist. for May, 1864.

TROPHOSOME.—Hydrocaulus attaining a height of four inches, and in its thickest part a diameter of one quarter of an inch, from which part it gradually tapers towards its proximal and distal ends, proximal end emitting filamentary hydrorhizal rootlets. Hydrocaulus marked by longitudinal bands. Hydranths pendulous.

GONOSOME.—Peduncles of gonophores branched. Sporosacs (male) with a thick tentaculiform process projecting from one side of the distal end, and with a band of greatly developed cells over each radiating canal.

Habitat.—On a sandy or muddy sea bottom.
Bathymetrical distribution.—Coralline zone ?
Localities.—Massachusetts Bay, Agassiz and Stimpson; Cape Cod, Agassiz.

The present species is one with regard to whose generic position we are by no means free from uncertainty. Agassiz gives us some beautiful figures of it, but the gonosome is hardly figured in sufficient detail. It would seem that radiating canals are visible in the gonophores; it appears pretty certain, however, both from the description and the figures, that the gonophores are as truly adelocodonic as those of *Tubularia.*

A short thick tentacle is described as being developed from one side of the distal end of the gonophore; and it is also stated that there exists "on the outer surface of the bell, over each radiating tube, a narrow longitudinal band of enormously developed cells." It is to be desired that we had more information regarding these bands than what is contained in the remark here quoted. The presence of a voluminous spermatic mass, enveloping the spadix and completely filling the cavity of the sporosac, shows that the male specimens—the only ones described—were mature when examined.

Mr. Alexander Agassiz, on the other hand, figures ('Proc. Boston Soc. Nat. Hist.,' 1862, and 'Illustrated Catal.,' p. 193) a medusa, which he regards as that of Professor Agassiz's *Corymorpha pendula.* It resembles that of a true *Corymorpha,* but besides the long solitary tentacle has others in process of development from the margin of the umbrella. Since, however, he states that it was taken in the open sea, and not directly observed to proceed from the trophosome to which he inferentially attributes it, we cannot consider Professor Agassiz's description of the gonophore in his *Corymorpha pendula* as superseded by the observation of his son.

The chitinous pellicle of *Monocaulus pendula* is described by Professor Agassiz as conspicuous over the proximal third of the hydrocaulus, though on the remaining two thirds it has either disappeared altogether, or exists only as a mere film. This condition appears to be pretty much the same as what we find in *Corymorpha*, where the thin pellicle which invests the stem becomes conspicuous near the proximal end by its separation from the ectoderm at this place. It is totally different from that of the firm perisarcal sheath of other hydroids, and cannot be regarded as invalidating the character of "naked" attributed to the genera of the *Corymorphidæ* and *Monocaulidæ*.

TUBULARIDÆ.

TROPHOSOME.—HYDROCAULUS developed, invested by a chitinous PERISARC. HYDRANTH with a proximal and a distal set of verticillate filiform tentacles.

GONOSOME.—GONOPHORES in the form of fixed SPOROSACS.

TUBULARIA, *Linnæus* (in part).

Name.—From *tubulus*, a diminutive noun formed from *tubus* a pipe, in allusion to the pipe-like stalks which support the hydranths.

TROPHOSOME.—HYDROPHYTON consisting of a simple or branched HYDROCAULUS and a filiform adherent HYDRORHIZA. HYDRANTHS flask-shaped, abruptly marked off from the supporting stalk; tentacles composing the proximal circlet larger than those composing the distal one; distal circlet surrounding the base of a conical hypostome.

GONOSOME.—SPOROSACS developed upon branched peduncles, so as to form racemiform clusters, which spring from the body of the hydranth between the distal and proximal circlets of tentacles. Embryonal development by ACTINULÆ.

The genus *Tubularia* of the older naturalists was an ill-assorted and heterogeneous group, and at the close of the last century it still included, along with the true *Tubulariæ*, not only other hydroid genera, but various *Actinozoa*, *Polyzoa*, and certain members of the sub-kingdom *Annulosa*. Even after it had been freed from its more glaring misassociations, it continued to be imperfectly defined; and it was reserved for Ehrenberg, in 1832, to make the first step towards a reform of the group as it then stood, though from overlooking certain characters of importance he failed to assign to it its natural limits as a well-defined zoological genus.[1]

[1] Ehrenberg, Corallenthière, Abhandl. der König. Ak. der Wesseus. zu Berlin, 1832.

Ehrenberg's reform consisted in a dismemberment of the genus *Tubularia* as then accepted into two groups, one of which included the simple and the other the branched forms. The former he retained under the old name of *Tubularia*, while for the latter he constituted a new genus under the name of *Eudendrium*.

Though Ehrenberg did not strike upon the true grounds of a philosophic revision when he selected as the fundamental character of his proposed groups the simple or branched condition of the hydrocaulus, neglecting the far more important characters found in the form of the hydranth, and the presence of two circlets of tentacles in *Tubularia*, while there is only a single one in *Eudendrium*, his establishment of the genus *Eudendrium* as distinct from *Tubularia*, nevertheless led the way to more accurate definitions of the two groups, and thus became a most important step in the systematic zoology of the Hydroida.

There is no one to whom we are so much indebted as to Agassiz for a knowledge of this beautiful genus. He has made some of the North American representatives of it the subject of laborious and conscientious study, and has illustrated his researches by the very finest hydroid iconography in existence. I am unable, however, to accept in all points the systematic dismemberment of the genus *Tubularia*, as proposed by the celebrated zoologist who has adopted America as his country.

The genus *Tubularia* of modern systematists has been broken up by Agassiz[1] into four separate genera, for one of which he retains the name of *Tubularia*, while for the three others he proposes respectively the designations of *Parypha*, *Thamnocnidia*, and *Ectopleura*. Agassiz gives no technical diagnosis of any of those genera, and it is by no means easy to discover the characters upon which he would chiefly rely as the grounds of his division; but from my own knowledge of the European species, which he separates from *Tubularia*, as well as from the very detailed descriptions and beautiful figures of the American species, which he now for the first time records, and refers to his new genera, I can find only in one of these forms, namely, the *Tubularia Dumortieri*, of Van Beneden, characters which would, in my opinion, justify the proposed dismemberment. For *Tubularia Dumortieri* Agassiz constitutes a new genus, under the name of *Ectopleura*, and relying on Van Beneden's account of this hydroid, I willingly follow Agassiz in regarding it as the representative of a separate genus; but the only common character of importance by which *Parypha* and *Thamnocnidia* are separated from *Tubularia*, would seem to be the non-development of distinct gastro-vascular canals in the sporosacs of the species referred by Agassiz to these genera, while they are present in the sporosacs of those species to which he would restrict the name of *Tubularia*.

Now, I cannot admit that the apparent absence of these canals, if unaccompanied by any other difference of importance, ought to be regarded as affording a character which would justify the construction of a separate generic group; for besides the practical objection that it is frequently very difficult to detect them even when present, it should be borne in mind that though they may exist in the younger sporosac, they may entirely disappear before the contents of the gonophore are discharged, a fact which Agassiz himself notices in the case of his *Tubularia Couthouyi*.

Again, between *Parypha* and *Thamnocnidia*, the only difference alleged is in the structure of the tentacula-like processes, which occur upon the distal end of the sporosac. I believe, how-

[1] 'Contr. Nat. Hist. U.S.,' vol. iv.

ever, that there is here no important difference. I have carefully compared the sporosacs of *Tubularia larynx* (= *T. coronata*, Abildg.), a species which Agassiz refers to his genus *Thamnocnidia* with that of *Tubularia mesembryanthemum*, mihi, a Mediterranean species which would certainly be referred by Agassiz to his genus *Parypha*, and the only difference of importance I can find between them is the conical form of the apical processes in *T. larynx* (see Plate XXIII, figs. 21, 22, 24) and their laterally compressed crest-shaped form in the female sporosacs of *T. mesembryanthemum* (see woodcut, figs. 83, 84, page 419). In both cases these processes contain a cavity, but the cavity is more conspicuous in the crest-shaped processes regarded by Agassiz as characteristic of his genus *Parypha* than in the conical processes which characterise his genus *Thamnocnidia*. Of the three new genera, then, which Agassiz has constituted for the reception of certain forms included by other systematists in the genus *Tubularia*, I can only admit the validity of one, and it is therefore to this one alone (*Ectopleura*) that I have assigned a generic rank in the present monograph.

I do not, however, wish to depreciate too much the value of the characters assumed by Agassiz as distinctive of the others; and I believe that these characters may be conveniently made the grounds of a subordinate grouping of the genus *Tubularia*. I shall, therefore, employ Agassiz's names for the designation of the subordinate groups or sub-genera thus constituted.

Among the characters which must be regarded as of value in determining the limits of the species included under the genus *Tubularia*, is one which has been hitherto unrecognised. It is afforded by a remarkable condition of the cœnosarc immediately below the summit of the stem, and shows itself in the presence of a collar-like expansion of this part, convex on its upper surface, which is always marked with rather deep, radiating flutings, and slightly concave on the lower. I believe that it is only the ectoderm which participates in the formation of this collar. It is entirely absent in *Tubularia indivisa*, but in *Tubularia larynx*, and all other species of this genus which I have had an opportunity of examining, it is present.

So far as we can determine from the data before us, species 1—4 in the following enumeration would be referred by Agassiz to *Tubularia*; 5—15 to *Thamnocnidia*; and 15—17 to *Parypha*.

† Sub-genus, TUBULARIA proper, *Agassiz*.

Sporosacs with conspicuous gastro-vascular canals.

1. TUBULARIA INDIVISA, *Linnæus*.

PLATE XX.

ADIANTHI AUREI MINIMI FACIE PLANTA MARINA,—*Raii*, Syn. 31, 4. *Jussieu*, in Mem. Acad. Roy. des Sci., 1742, p. 296, tab. x.

TUBULAR CORALLINE, LIKE OATEN PIPE,—*Ellis*, in Phil. Trans. for 1754, p. 504, tab. xvii, fig. D.

CORALLINA TUBULARIA CALAMOS AVENACEOS REFERENS,—*Ellis*, Corall., p. 31, tab. xvi, fig. C.

TUBULARIA INDIVISA,—*Linnæus*, Syst., 1758. *Lamarck*, An. sans Vert., 1816, vol. ii, p. 110. *Lamouroux*, Cor. flex, 230. *Cuvier*, Regn. Anim., iii, 299. *Johnston*, Brit. Zooph., 1847, p. 48, pl. iii, figs. 1, 2. *Dalyell*, Rare and Remark. Anim., vol. i, p. 2, pls. i—iv. *Mummery*, in Trans. Mic. Soc., 1853. *Hincks*, Brit. Hydr. Zooph., pl. 115, pl. xx.

TUBULARIA CALAMARIS,—*Pallas*, Elenchus, p. 81. *Ehrenberg*, Corall. Roth. Mer. Abhandl. Berl. Acad., 1832, p. 295.

TROPHOSOME.—HYDROCAULUS consisting of a cluster of simple tubes, destitute of annulation, separate from one another above, but forming an entangled mass below, where the tubes become smaller in diameter, and more or less twisted together and adherent to one another; they vary in height in different specimens from about three to nine inches, and in the upper part of their course have a diameter of about one tenth of an inch; CŒNOSARC longitudinally striated, not forming a collar-like expansion below the hydranth. HYDRORHIZA consisting of branched, sinuous, inosculating tubes. HYDRANTHS with twenty to thirty proximal tentacles in a single verticil, and with about forty distal tentacles in two or three alternating verticils, which are so closely approximated as to form a single circlet.

GONOSOME.—GONOPHORES oviform in three or four pendulous racemes, which, when mature, surpass the body of the hydranth in length, the racemes of the male colony being somewhat longer than those of the female; the gonophores are destitute of tentaculiform tubercles, and have four radiating canals terminating in a circular canal, which surrounds a perforation near the distal end of the gonophores. ACTINULA with oral tentacles at the period of its liberation.

Colour.—Body of hydranth varying from a pale pink to a bright crimson or scarlet; hydrocaulus brown below, becoming light red or orange red towards the summit; spadix and peduncle of gonophore scarlet.

Development of Gonosome.—From April to October.

Habitat.—Attached to rocks, stones, shells, &c., in the sea.

Bathymetrical distribution.—Laminarian to deep-sea zone.

Localities.—English, Scottish, and Irish coasts abundant; Coast of Greenland, Mörch; Coasts of Scandinavia as far as the North Cape, Sars; and the coasts of Belgium and Northern France.

This magnificent hydroid—the type of the family of the *Tubularidæ*—besides offering features of great interest in the morphology and physiology of the HYDROIDA, has a special historical value, for it was it which in the hands of Bernard de Jussieu afforded the first proof we possess of the animality of the marine HYDROIDA.

During the early part of the last century the *Tubularia indivisa* had already by its large size and conspicuous hydranths forced itself on the attention of the marine naturalist. Its nature, however, was entirely misunderstood; no one doubted as to its being a genuine sea plant, and with this impression we find it described by the naturalists of that period under designations indicative of a belief in its vegetality, such as that of "Adianthi aurei minimi facie planta marina," under which it was recorded by Ray.

In 1741 De Jussieu obtained it during a visit to the coast of Normandy, when along with the actinozoal *Alcyonium*, and the polyzoal *Flustra* and *Cellepora*, he made it the subject of his famous memoir,[1] in which, opposing himself to the general belief of the day, he not only supports the views of Peysonel in favour of the animality of coral, but extends them to the plant-like *Hydroida* and *Polyzoa*. The figure of *Tubularia indivisa* which illustrates this memoir, though without the manipulative skill of modern engravers, is admirable; it is more exact than that subsequently given by Ellis, and though the gonosome is not represented in it, it has remained up to the present day unsurpassed in accuracy and expressiveness.

In the former part of the present monograph the structure of *Tubularia indivisa* has been fully described; it has been shown how the cœnosarc of the stems, instead of presenting the usual axial cavity, is excavated into numerous peripheral channels, first pointed out by Wright, with their walls all richly ciliated, and with the somatic fluid circulating through them in advancing and returning currents, and how the endodermal lining of the hydranth cavity is thrown into pendulous lobes and marked by deep intersecting sulci. It has been shown that the longitudinal fibrillæ, conspicuous in the tentacles, are formed by series of very much elongated, fusiform, nucleated cells, presenting thus the essential structure of the non-striated muscle of higher animals. The structure of the gonophores has also been fully detailed, with their four conspicuous, radiating canals, opening into a small circular canal which surrounds an orifice in the distal end of the gonophore, through which the contents of this body escape at the period of maturity. It has been further shown that the ova have their origin in differentiated masses of a granular plasma, which is developed as usual between the endoderm and ectoderm of the spadix, and which in its early condition consists of nucleated cells; and that these ova are developed into *actinulæ*, though no evident germinal vesicle nor any true process of segmentation has as yet been detected in them. And further, the remarkable phenomenon first noticed by Dalyell of the successive shedding and renovation of the hydranths has been described, and it has been shown that the new hydranth is produced by a metamorphosis of the distal end of the decapitated stem rather than by a true budding.[2]

Few more beautiful objects present themselves to the student of marine life than a well-developed specimen of *Tubularia indivisa*. From a complicated and intertwining mass of stems where the hydroid roots itself to some submarine rock or the surface of some old shell, it gradually becomes disentangled, and soon displays a group of flexile cylindrical stems, rising without a branch to the height of many inches, and each crowned by a scarlet or crimson hydranth, with its double coronal of tentacles. The longer tentacles now spread abroad like the petals of an expanded flower, now closed in over the summit, like the same flower in its bud, and now again thrown back in gentle curves round the summit of the supporting stalk, while the long pensile

[1] Bernard de Jussieu, in 'Mem. Acad. Roy. des Sci.,' 1742.

[2] The details of the morphological and physiological facts here referred to will be found in pages 69, 124, 131, 205, &c., and pl. xxiii.

clusters of berry like gonophores, which droop gracefully from among the tentacles, complete the attractions of this beautiful hydroid.

During the spring and summer months *Tubularia indivisa* is in its greatest perfection, though in some localities it may still be found in good condition until late in the autumn. It is during the season of its most active growth, and when the hydranths with their racemes of gonophores have attained their greatest size and perfection, that these may be seen to be perpetually cast off and renewed, the stem increasing in height with the formation of each successive hydranth. But towards the end of summer the renewal of the hydranths after the casting off of the old ones appears to cease, and we now usually find the upper parts of the perisarcal tubes empty, while their lower parts and the hydrorhiza are still filled with the living cœnosarc. In this state, I believe, they generally remain during the winter, ready on the return of spring to throw out new hydranths, and these hydranths, with their clusters of gonophores, undergo in their turn successive shedding and renovation, until the autumnal months once more put a check to the activity of their functions. Each successive renovation of the hydranth, and consequent elongation of the stem, is marked by a slightly elevated annular ridge on the surface of the perisarc.

Tubularia indivisa will continue to live for some time in the confinement of our aquaria, frequently throwing off and renewing its hydranths, and giving origin to hundreds of embryos, which during their actinula stage look like minute spiders creeping over the bottom of the tank or floating passively in the water. Many of these actinulæ will pass through subsequent phases of their development and attain their fixed condition, in which they may be seen rooted in multitudes to the sides of the vessel, a forest of diminutive *Tubulariæ*. They often, also, attach themselves to the stems of the parent colony, where they will continue to grow as long as these stems may afford them sufficient surface of support.

The species seems to range from the upper limit of the Laminarian zone to a depth of thirty fathoms, or even more. At extreme low-water spring tides it may frequently be seen growing luxuriantly in the rock pools or spreading over the rocks where these are still washed by the sea.

It is, perhaps, generally distributed over the European shores of the Atlantic. Some of the finest specimens have been obtained from estuaries where the influence of the fresh water has not yet wholly ceased to modify the saltness of the sea.

Under the name of *Tubularia gigantea*, Lamouroux (' Exposition Methodique,' tab. LXVIII, fig. 5) figures the dead stem of a large *Tubularia*, which he informs us attains a height of from 12 to 15 inches. He gives no description which might aid in its determination, but it is probably only a large form of *T. indivisa*.

*** 2. TUBULARIA COUTHOUII, *Agassiz*.

TUBULARIA COUTHOUYI,—*Agassiz*, in Contr. Nat. Hist. U. S., vol. iv, p. 226, pl. xxiii *a*, figs. 8, 9, pl. xxiv, pl. xxvi, figs. 1—6. *Alex. Agassiz*, in Illustr. Catal. N. A. Acalephæ, p. 196.

TROPHOSOME.—HYDROCAULUS varying in height from about three inches to six inches, and consisting of clusters of unbranched stems, which are about one twelfth of an inch in diameter, and spring from a HYDRORHIZA composed of "closely tangled knotty root-like tubes;" PERISARC "more or less ringed or jointed, sometimes very regularly at intervals of an eighth of an inch, or constricted once or twice, and then again smooth throughout." HYDRANTH with the tentacles of the distal set about fifty in number, gradually decreasing in length from before backwards, and disposed in three or four indistinctly defined closely approximated verticils; the hydranth is large, and, when fully expanded, measures from tip to tip of the proximal tentacles about an inch and a half.

GONOSOME.—GONOPHORES in dense pendulous racemes, which surpass the proximal tentacles in length, and are disposed one over the other, so as to form three or four superposed verticils; the gonophores are elongate-oval or piriform in the male, broadly oval or globular in the female; in both destitute of tentaculiform tubercles and with four radiating canals, which open into a small circular canal which surrounds a perforation near the distal end of the gonophore.[1] ACTINULA with oral tentacles at the period of its liberation.

Development of Gonosome.—From March to December.
Habitat.—Attached to submerged bodies in brackish water.
Locality.—Massachusetts Bay, Professor Agassiz.

This fine species is described and beautifully illustrated by Agassiz, from whose account of it I have obtained the characters embodied in the above diagnosis. It apparently comes near to the *Tubularia indivisa* of the European side of the Atlantic, differing from this species chiefly in its more or less annulated stem, the larger size of the hydranths, the more numerous racemes of gonophores, and the disposition of these in several superposed verticils.

Tubularia Couthouii has been studied by Agassiz, who has given us a very valuable chapter on its structure. He has described in its stem a large-celled imperforate axis, and a system of peripheral tubes, similar to those met with in *Tubularia indivisa*.

*** 3. TUBULARIA REGALIS, *Boeck*.

TUBULARIA REGALIS,—*Boeck*, in Forhand. Vidensk. Selsk Christiania, 1859, p. 115, tab. iii.

TROPHOSOME.—HYDROCAULUS simple, attaining a height of from six to seven inches, and with a thickness of about one eighth of an inch; CŒNOSARC exhibiting longitudinal vermilion bands, which are visible through the clear horny PERISARC.

[1] In some instances fine radiating canals were observed; plainly an abnormal irregularity.

HYDRANTH measuring across the proximal circlet of tentacles about two and a half inches; proximal tentacles twenty-eight in number.

GONOSOME.—GONOPHORES oval, destitute of tentaculiform tubercles, and disposed in simple pendulous[1] racemes, which alternate with the proximal tentacles, and are equal to them in length.

Locality.—Spitsbergen.

With the exception of *Amalthæa Januarii*, there is no known hydroid whose hydranths approach in size to those of the colossal *Tubularia* just described. For our knowledge of it we are indebted to a paper by Boeck, but further details are much to be desired. It approaches in many respects to *Tubularia indivisa*, and, like that species, presents the longitudinally striated condition of its stem, which indicates a channeled structure of the cœnosarc. We are not informed whether radiating canals exist in the walls of the gonophores. These, after the escape of the *Actinulæ*, present a wide orifice through which the spadix projects for a considerable distance. The *Actinula* appears to resemble very nearly that of *Tubularia indivisa*.

Tubularia regalis was obtained on the coast of Spitsbergen, and is thus the most northern hydroid whose trophosome has been yet discovered.

*** 4. TUBULARIA INSIGNIS, *Allman*.

TROPHOSOME.—HYDROCAULUS simple, attaining a height of seven inches (or more), gradually increasing in thickness from below upwards, until it attains a diameter of one eighth of an inch; CŒNOSARC longitudinally striated; PERISARC quite smooth. HYDRANTH borne on a collar; proximal tentacles about thirty, distal tentacles more than 200 in a dense brush, formed by numerous closely superimposed verticils; length of proximal tentacles about nine tenths of an inch; of distal about three tenths.

GONOSOME.—GONOPHORES barrel-shaped, with terminal aperture, destitute o tentaculiform tubercles, and with four obvious parietal canals; peduncles of gonophores in six or seven imbricated verticils, with about twenty in each verticil, not pendulous, each peduncle dividing near the summit sub-dichotomously into short ultimate pedicells.

Locality.—Dieppe, M. L. Rousseau.

The characters enumerated in the specific diagnosis just given are those of a tubularian, which far surpasses in size every British representative of the genus. A specimen consisting of a

[1] Boeck's figure represents them as erect, an attitude which their slenderness and length renders it impossible for them to assume.

single stem, with its hydranth and gonophores, exists in the Museum of the Jardin des Plantes.[1] This specimen, so far as I know, is unique, but it has been fortunately preserved in spirits, so that some of its most important characters are determinable. It is desirable, however, that we know more of this fine species than what can be satisfactorily made out from the preserved specimen, and we must still wait for an opportunity of inspecting other examples, more especially living ones. I have not been able to determine anything regarding its development, nor, indeed, even the sex of the specimen, for though this was with great liberality placed at my disposal, I did not feel justified in undertaking an examination which would have exposed to injury the only example as yet preserved of this remarkable hydroid.

The height of the hydranth in the specimen, from its base to its summit, is about half an inch, while the diameter of the basal portion is about three tenths of an inch. *Tubularia insignis* must, indeed, when in a living state, be a magnificent hydroid. Nothing, however, can be determined from the specimen regarding the colour of either hydranth or gonophores, the original colour of these parts having been entirely discharged by the action of the spirits; that of the perisarc, however, has probably remained unchanged. It is of a light brown in the distal parts of the stem, becoming darker towards the base. Where the transparency of the perisarc allows a view of the contained cœnosarc, numerous longitudinal parallel striæ may be seen, doubtless indicating the presence of a system of longitudinal cœnosarcal canals.

The gonosome has scarcely attained complete maturity, only two or three gonophores being sufficiently advanced, among the multitude of immature ones, to allow of even the approximate determination of their proper form.

The only known facts regarding the history of this unique specimen are found in a short appended note, which states that it was obtained at Dieppe, by M. L. Rousseau.

✝✝ Sub-genus THAMNOCNIDIA, *Agassiz*.

Sporosacs without evident gastrovascular canals, apical processes conical.

5. TUBULARIA LARYNX, *Ellis and Solander*.

Plate XXI.

FUCUS DEALENSIS FISTULOSUS LARYNGÆ SIMILIS,—*Raii*, Syn., i, 39.

TUBULAR CORALLINE, WRINKLED LIKE THE WINDPIPE,—*Ellis*, in Phil. Trans. for 1754, vol. xlviii, p. 504, tab. xvii, fig. L.

CORALLINA TUBULARIA LARYNGI-SIMILIS,—*Ellis*, Coral., p. 30, pl. xvi, fig. *b*. *Bast.*, Opusc. Subsc., p. 28, tab. ii, figs. 3, 4, and tab. iii, figs. 2—4.

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[1] I must here express the obligations I am under to Prof. Milne-Edwards, and Prof. Lacaze du Thiers, for the opportunities they have afforded me of examining this and other specimens of the museum.

Tubularia muscoides,—*Pallas*, Elench., p. 82 (nec *Linnæus*, Gmel. Lin., 3832).
Tubularia larynx,—*Solander's Ellis*, p. 31. *Lamarck*, Anim. s. Vert., 1816, vol. ii. *Dalyell*, Rare and Rem. Anim., vol. i, p. 12, pl. v. *Johnston*, Brit. Zooph., second edit., p. 50, pl. iii, fig. 3, and pl. v, figs. 3, 4. *Alder*, Catal., p. 16.
Tubularia coronata,—*Abildgaard*, in Zool. Dan., pl. 141. *Van Beneden*, Tubulaires, p. 49, pl. i, figs. 7—19, and Faune lit. de Belg., p. 106, pl. iv. *Hincks*, Brit. Hydr. Zooph., p. 119, pl. xxi, fig. 2.
Eudendrium bryoides,—*Ehrenberg*, Corallenthière, Abhandl. Ak. Wissen. Berl., 1832, p. 296.
Eudendrium splendidum (?),—*Ehrenberg*, Corallenthiere, Abhandl. Ak. Wissen. Berl., p. 296.
Tubularia gracilis,—*Harvey*, in Proc. Zool. Soc. Lond., 1836, No. 11, p. 54. *Johnston*, Brit. Zooph., second edit., p. 52, pl. iv, figs. 3, 4, 5. *Alder*, Catal., p. 17.

TROPHOSOME.—Hydrocaulus consisting of numerous branching stems having a diameter of about $\frac{1}{30}$th of an inch, and rising from a creeping stolon to a height of from one inch and a half to two inches, or even more; stems presenting at intervals more or less distinctly marked transverse annulations; cœnosarc forming a collar-like expansion just below the hydranth. Hydranths about one fifth of an inch across the widest part of the body, with a circlet of from fourteen to twenty distal tentacles in two closely approximate alternate series, and with the proximal tentacles about twenty in number, and about two fifths of an inch in length.

GONOSOME.—Gonophores in pendulous clusters, forming in the male long simple racemes, which, when mature, surpass the proximal tentacles in length, while in the female the much shorter clusters do not equal these tentacles in length, and the peduncle is here branched, so as to form a sort of panicle or compound raceme. The gonophores are destitute of gastro-vascular canals, and are crowned with four conical tentaculiform tubercles, larger in the female than in the male; female gonophores somewhat more globular than the male, which are of an elongated oval form. Oral tentacles of Actinula not developed at the time of its liberation.

Colour.—Body of hydranths and peduncle and spadix of gonophores rose colour; perisarc straw colour.

Development of Gonosome.—Observed from April to October.

Habitat.—Attached to rocks, stones, old shells, other hydroids, &c.

Bathymetrical distribution.—From Laminarian to deep-sea zones.

Locality.—British, Scandinavian, and Belgian shores.

As long as naturalists confined themselves in their description of Hydroida to the dry perisarc, or when, without neglecting the soft parts, they still failed to see that certain differences in the gonosome depend merely on different degrees of maturity and on differences of sex, it was vain to expect correct specific diagnoses. The present species is exactly in this case; much confusion exists with regard to it, and it has been described under different names by different observers, a confusion which, I believe, results in great part from regarding the differences between the male and female colonies as indicative of two different species.

I have no doubt of the identity of our species with the *Tubularia* figured more than a hundred years ago by Ellis, under the appellation of "Corallina tubularia laryngi similis," and in his posthumous work, edited by Solander, described under the binomial designation of *Tubularia larynx*. Ellis's hydroid is referred by Pallas to *Tubularia muscoides* of the 'Fauna Suecica,' an identification which Linneus's short diagnosis, "T. culmis subdichotomis totis annuloso-rugosis," will hardly allow us to accept. Indeed, when we consider the very imperfect knowledge of the Hydroida at the time of the publication of the 'Fauna Suecica,' we must see that there is more reason to regard the *Tubularia muscoides* of that work as an annulated species of *Coryne* than there is to view it as a true *Tubularia*. The sufficiently characteristic figure of Ellis, however, though without any representation of the gonosome, and his short but accurate description, leave no doubt as to the hydroid the celebrated English observer had before him, and gives us a fixed and definite point in the determination of its synonymy.

I believe, also, that the *Tubularia coronata* of Abildgaard, figured in the 'Zoologica Danica,' is identical with Ellis's species, notwithstanding the unbranched condition and tortuous marking of the stems and the very short peduncles of the gonophores in the otherwise excellent figure of the Danish naturalist, while I have little doubt that it is this same species which is described by Mr. J. B. Harvey, in the 'Proceedings of the Zoological Society,' under the name of *Tubularia gracilis*.

Hincks maintains the specific distinctness of *Tubularia larynx* and *T. coronata*. I cannot see, however, in the characters contrasted sufficient grounds for distinction. The more important of them appear to me to be merely sexual differences.

If the criticism just offered of the synonyms of our species be accepted, we have no alternative but to adopt for this hydroid Ellis's specific name of *larynx*, as given in his posthumous work published under the care of Solander.

When *Tubularia larynx* is examined in its living state, obscure annular corrugations may usually be observed at short intervals on the stems; but it is in dried specimens that these corrugations become distinctly marked, and afford a character which, in the various descriptions of the species, has taken a prominent place, and has suggested the specific designation given to it by Ellis.

Under the name of *Tubularia coronata* the present species has been made the subject of some of Van Beneden's researches, published in his 'Faune Littorale de Belgique,' and in which his attention has been especially directed to the structure of the sporosac and the development of the Actenula.

I have obtained *Tubularia larynx* in abundance from the lines of the deep-sea fishing boats on the east coast of Scotland. It is also, however, an inhabitant of the Laminarian zone, and, like some other tubularian hydroids, it appears to delight in an admixture of fresh water with the sea, some of the finest specimens having been obtained from the lower reaches of estuaries. Though a much humbler species than *Tubularia indivisa*, it is yet one of the most charming of our British hydroids. When well developed it forms dense bushy tufts, which, with their rosy aster-like hydranths expanding from the summits of the branches, suggest, with a vividness unsurpassed by any other hydroid, some of the most familiar forms of the flower garden.[1]

6. Tubularia Bellis, *Allman*.

Plate XXII, figs. 5 and 6.

Tubularia Bellis,—*Allman*, in Ann. Nat. Hist. for Jan., 1863. *Hincks*, Brit. Hydr. Zooph., p. 122, pl. xxi, fig. 3.

TROPHOSOME.—Hydrocaulus consisting of short sparingly branched stems, which are mostly prostrate at the base, where they spring from the creeping stolon, and then becoming erect attain a height of three quarters of an inch or even one inch; perisarc towards the basal portion marked with wide but distinct annulations, which disappear towards the distal extremity of the stem. Hydranths supported on an annular collar-like dilatation of the cœnosarc, and with the breadth of its base exceeding its entire height; about twenty tentacles in the proximal circlet, and fifteen or twenty in the distal; diameter of proximal circlet when extended about five lines.

GONOSOME.—Clusters of gonophores short, erect, with four or five gonophores usually in the cluster, the gonophores, both male and female, crowned with four conspicuous conical tubercles.

Colour.—Hydranth scarlet; cœnosarc reddish-orange, becoming deeper in tint towards the base; spadix scarlet.

Development of Gonosome.—July and August.

Habitat.—Attached to the sides of rock pools.

Bathymetrical distribution.—Laminarian zone.

Locality.—Shetland Isles.

Tubularia Bellis is an exquisite little hydroid. It occurs in considerable abundance round the shores of the "Outer Skerries" and some of the other small rocky and more exposed islands of Shetland, where it grows in shallow rock pools, exposed only at extreme low-water spring tides, amid luxuriant meadows of Laminaria, and where the bright colour of its hydranths render it a conspicuous and beautiful object beneath the pure transparent water of the rock pool.

1 In the collection of the Jardin des Plantes is a dried specimen, labelled in Lamarck's writing, "*Tubularia larynx*." It is a sparingly branched, irregularly rugose, strong and somewhat coarse form. It is impossible, however, to determine it from the dried perisarc, but it is apparently very different from the true *Tubularia larynx*.

7. Tubularia attenuata, *Allman.*

Plate XXII, figs. 1 and 2.

Tubularia attenuata,—*Allman,* in Ann. Nat. Hist. for July, 1864. *Hincks,* Brit. Hydr. Zooph., p. 122.

TROPHOSOME.—Hydrocaulus attaining a height of three or four inches, slender, obscurely corrugated, very irregularly branched, with the branches given off at a wide angle. Hydranth supported on an annular expansion of the cœnosarc, and with the tentacles of the proximal circlet about three times as long as those of the distal one.

GONOSOME.—Gonophores (male)[1] borne on short erect branched peduncles, with usually five to eight in a cluster, and with four conical tentaculiform processes, which equal in length nearly half that of the mature gonophore.

Colour.—Body of hydranth deep vermilion between the two tentacular verticils, paler in the enlarged base; cœnosarc pale pink, with light straw-coloured perisarc; spadix vermilion.

Development of Gonosome.—June.

Habitat.—Attached to old shells and stones in the sea.

Bathymetrical distribution.—Deeper parts of Coralline zone.

Localities.—Shetland Islands and Firth of Forth, G. J. A.

Tubularia attenuata is a deep-water species. I have dredged it from about fifteen fathoms in the Firth of Forth, and from about fifty fathoms in the seas round the Shetland Islands. It has a diffuse and somewhat straggling habit. Its nearest congener would appear to be the *Tubularia simplex* of Alder, from which, however, it differs by its branched hydrocaulus, and apparently, also, by the greater length of its distal tentacles.

[1] I have had no opportunity of examining female specimens.

8. Tubularia simplex, *Alder*.

Tubularia simplex,—*Alder*, Catal. Suppl., pl. viii, figs. 3, 4. *Hincks*, Brit. Hydr. Zooph., p. 121, pl. xxii, fig. 1.
Tubularia Dumortieri,—*Johnston*, Brit. Zooph., second edit., p. 50. *Alder*, in Trans., Tynes. Club, vol. iii, p. 106.

TROPHOSOME.—Hydrocaulus attaining a height of from two to two and a half inches, slender, unbranched, smooth, generally a little bent or geniculated at intervals, and tapering towards the base, usually solitary. Hydranths slender, distal circlet of tentacles bi-serial, shorter and less numerous than in *Tubularia indivisa*, the proximal with about twenty or twenty-four moderately long tentacles.

GONOSOME.—Not observed.

Colour.—Hydranth rose colour; cœnosarc orange or scarlet, with the perisarc horn colour.
Habitat.—On shells, &c., in the sea.
Bathymetrical distribution.—Deep sea zone.
Locality.—Coast of Northumberland, Mr. Alder.

I have never met with this species, which is, doubtless, nearly allied to *Tubularia attenuata*, and, like it, is a deep-water species. Its unbranched hydrocaulus, however, and the angular flexures of its stem, will afford characters by which it may be distinguished.

Mr. Alder, who at first referred this species to the *Tubularia Dumortieri* of Van Beneden, subsequently recognised its distinctness, and described it as a new species.

9. Tubularia humilis, *Allman*.

Plate XXII, figs. 3 and 4.

Tubularia humilis,—*Allman*, in Ann. Nat. Hist. for July, 1864. *Hincks*, Brit. Hydr. Zooph., p. 123.

TROPHOSOME.—Hydrocaulus attaining a height of about an inch, sparingly branched; perisarc delicate, with nearly obsolete transverse corrugations. Hydranth supported on an annular expansion of the cœnosarc; greatest breadth of the basal portion exceeded by the entire height; about twenty proximal and fifteen distal tentacles; diameter of proximal circlet from tip to tip of the tentacles, when extended in full-sized specimens, about two lines.

GONOSOME.—Gonophores (male)[1] borne on very short branching peduncles forming erect clusters, with usually about three gonophores in each cluster; summit of gonophore with four rather large conical tentaculiform tubercles.

Colour.—Hydranth scarlet, cœnosarc reddish yellow, perisarc light straw colour, spadix scarlet.

Development of Gonosome.—Autumn.

Habitat.—On exposed rocks in the sea.

Bathymetrical distribution.—Laminarian zone.

Locality.—Kinsale Harbour, Ireland, G. J. A.

I obtained *Tubularia humilis* during the autumn attached to rocks close to the level of low-water spring tides near the mouth of Kinsale Harbour. It is a very elegant little hydroid, resembling *Tubularia Bellis* in its mode of growth and in the shortness of its gonophore clusters, but is at once distinguished from this species by the absence of distinct annulation, and by the smaller size and less appressed form of its hydranths.

*** 10. Tubularia calamaris, *Van Beneden.*

Tubularia calamaris,—*Van Beneden,* Recherches sur l'Embryogénie des Tubulaires, p. 44 (exclusive of synonymes), pl. i, figs. 1—6; Recherches sur la Faune littorale de Belgique, p. 111 (exclusive of synonymes).

Thamnocnidia calamaris,—*Agassiz,* Contr. Nat. Hist. U. S., vol. iv, p. 342.

TROPHOSOME.—Hydrocaulus attaining a height of about two inches, simple and straight towards the summit, tortuous and irregularly ramified at the base, with the tubes here united to one another, so as to form a cluster; perisarc annulated at the base. Hydranths with about thirty tentacles in the proximal circlet, and about twenty in the distal.

GONOSOME.—Gonophores borne on short erect peduncles; summit crowned with four well-developed conical processes; walls of gonophore with longitudinal contractile rib-like bands.

[1] All the specimens examined were male.

Colour.—Hydranth and cœnosarc red; in some specimens nearly or quite colourless.
Habitat.—Attached to submerged bodies of various kinds.
Bathymetrical Distribution.—Laminarian to deep-sea zones?
Locality.—Coast of Belgium, Van Beneden.

The *Tubularia calamaris* of Van Beneden is a species with regard to which there is much confusion. The Belgian naturalist assumes it to be identical with the *Tubularia calamaris* of Pallas, and the synonymes attached to his description are selected in accordance with this view.

Van Beneden's species, however, is altogether different from Pallas's *Tubularia calamaris*, which is the same as the true *Tubularia indivisa* of Linnæus. From this species it is at once distinguished by its much smaller size, branched hydrocaulus, and short erect clusters of gonophores—supposing this condition to be that of mature individuals—as well as by the occurrence of tentaculiform appendages, and of meridional bands on the gonophores.

It approaches more nearly to the *Tubularia larynx*, but from this again it is separated by the short, erect clusters of gonophores, and by the peculiar contractile, meridional bands of the gonophore.

It is to be regretted that we do not know more of these contractile bands than what we learn from Van Beneden's figure and the descriptive paragraph which refers to it. According to Van Beneden the bands are five in number, equidistant, and running in meridional lines along the sides of the gonophore; their normal number, however, is probably only four. When contracted they give a lobed outline to the gonophore.

There can be little doubt that two or more species have been confounded in Van Beneden's description of his *Tubularia calamaris*. It is at all events certain that—led astray, apparently, by an incorrect identification—he refers to it observations which various naturalists have made regarding the true *Tubularia indivisa*.

Professor Van Beneden states that his *Tubularia calamaris* is very abundant on the Belgian coasts. I have never met with any Tubularian referable to it on the British or other coasts which I have explored.

⁂ 11. Tubularia polycarpa, *Allman*.

TROPHOSOME.—Hydrocaulus attaining the height of about an inch and a half, and a thickness of about half a line, unbranched, or sparingly branched near the base, each stem crowned by a fluted collar for the support of the hydranth, and having its perisarc marked here and there by a few indistinct annulations; hydrorhiza consisting of an entangled plexus of thin tubes. Hydranth measuring about half an inch from tip to tip of the basal tentacles, which are about twenty-four in number.

GONOSOME.—GONOPHORES oval, in about twenty-four dense clusters, alternately longer and shorter.

Colour.—Body of hydranth carmine.
Habitat.—Found covering the bottom of a ship in the harbour of Coquimbo.
Locality.—Coquimbo, South America.

The above diagnosis has been drawn up from a specimen preserved in spirit, and sent to me by Dr. J. E. Gray, who received it from the coast of Coquimbo. Though a true *Tubularia* it is quite distinct from our European species, as well as from those of the North American coast. One of its most striking features is the great abundance of its clusters of gonophores, which are more numerous than in any other species with which I am acquainted.

In size it resembles the *Tubularia larynx* of our own shores, and like it has its stems terminated immediately below the hydranths by the peculiar fluted collar, which is found in this and other species. From *Tubularia larynx*, however, it is easily distinguished by its simple stems, and by the profusion of its gonophore clusters.

The common peduncles of the gonophore clusters are destitute of gonophores for a considerable distance from the root, and these naked flexile stems must have given a pendulous attitude to the clusters during life, though this attitude is not very obvious in the contracted state of the preserved specimens.

*** 12. TUBULARIA SPECTABILIS, *Agassiz.*

THAMNOCNIDIA SPECTABILIS,—*Agassiz*, Contr. Nat. Hist. U.S., vol. iv, p. 271, pl. xxii, figs. 1—20. *A. Agassiz*, Illustr. Catal. N. A. Acal., p. 195.

"The description already given of the head with its proboscis, the tentacles and the bunches of medusoids [sporosacs], the stems and their mode of branching, and the horny sheath of *Parypha* [*Tubularia*] *crocea*, apply equally to this hydroid, with the following exceptions:—The horny sheath is quite uniform and smooth as far as it covers the stem above its base, and is a very little narrower below than above, but the entangled mass of the base is perhaps more dense than in *Parypha*."

The *gonophores* have "three or four solid, short, unshapely tentacles" [apical processes]. In other respects the structure of the gonophore "is almost identical with that of *Parypha crocea*, even to the absence of radiating and circular chymiferous vessels."—*Agassiz.*

Development of Gonosome.—Summer and autumn.
Habitat.—On floating timber in brackish water.—*Agassiz.*
Locality.—Massachusetts Bay.—*Agassiz.*

Though Agassiz raises the present species to the rank of a separate genus under the name of *Thamnocnidia*, he gives no precise diagnosis of it either generic or specific, and I have been obliged to content myself with simply quoting his remarks as above. The beautiful figures, however, which accompany these remarks will greatly aid in identification.

The new genus *Thamnocnidia*, which Agassiz forms for the present species, appears to be based on the form of the tentacula-like processes of the gonophore, and the apparent absence of those parietal canals which in the gonophores of *Tubularia indivisa* represent the gastrovascular canals of the more developed medusa—characters which I do not regard as sufficient to justify a generic separation.

To his genus *Thamnocnidia* Agassiz also refers the *Tubularia larynx* of the European shores and the *Tubularia* (*Thamnocnidia*) *tenella*, Agassiz, a new species of the Atlantic shores of North America.

*** 13. Tubularia tenella, *Agassiz*.

Thamnocnidia tenella,—*Agassiz*, Cont. Nat. Hist. U. S., vol. iv, p. 275, pl. xxii, figs. 21—30. *Alex. Agassiz*, Illus. Catal. N. A. Acal., p. 195.

"Although this species agrees so closely in nearly all its details with *Thamnocnidia* (*Tubularia*) *spectabilis*, it has a very different habitat; it is never found with its congener in brackish water, but always in the open ocean, among rocky pools. It is a very delicate, graceful animal, and much the smallest of our Tubularians, having about half the size of *Thamnocnidia spectabilis* or *Parypha crocea*. It branches very irregularly, loosely, and openly, with a stem of uniform thickness throughout, about as large as a common sewing needle, or, to be more exact, one fiftieth of an inch in diameter. The medusoids have been observed in January, July, August, and December."—Agassiz.

Habitat.—Rocky pools in the open ocean.
Locality.—Massachusetts Bay, Agassiz.

The above is the only account Agassiz has given us of this species, which he refers to his genus *Thamnocnidia*. His remarks do not contain sufficient detail to admit of the construction of a technical diagnosis, and I have, therefore, as in the preceding species, been obliged to content myself by simply quoting his words, and referring to the beautiful figures by which the external characters of the species and certain structural details are represented.

*** 14. Tubularia pacifica, *Allman.*

Under the name of *Thamnocnidia tubularoides*, a species of *Tubularia* is also recorded by Mr. A. Agassiz, but without sufficient detail for a technical diagnosis. The following paragraph contains all he says of it:

"This species grows in clusters, which, at first sight, would readily be mistaken for a species of true *Tubularia*, on account of the great diameter of the stem and the large size of the head. The structure of the proboscis, however, shows plainly that it is a genuine *Thamnocnidia*, which can at once be distinguished from its Eastern congeners by the stoutness of the stem and size of the head, surrounded by as many as thirty and even forty tentacles, in large specimens. Found growing profusely on the bottom of the coal barges which bring coal from Benicia to the Pacific Mail Steamship Company's steamers at San Francisco." (A. Agassiz's 'Illustr. Catal. N. A. Acælephæ,' p. 196.)

For reasons already mentioned I regard *Thamnocnidia* as identical with *Tubularia*; and as the specific name of *tubularoides* can scarcely be retained with the generic name of *Tubularia*, I have here ventured to substitute for it that of *pacifica*.

The species possesses an interest as being a Pacific representative of the Atlantic forms of *Tubularia*. In the description just quoted from Mr. A. Agassiz allusion is made to "the structure of the proboscis, as proving the species to be "a genuine *Thamnocnidia*." I do not know to what peculiarity this statement refers. In the hydranths of such European species as Prof. Agassiz would refer to his genus *Thamnocnidia*, there are certainly no characters which would justify a separation from *Tubularia*.

††† Sub-genus Parypha, *Agassiz.*

Sporosacs without evident gastro-vascular canals; apical processes in female sporosac laterally compressed.

*** 15. Tubularia crocea, *Agassiz.*

Parypha crocea,—*Agassiz*, in Contr. Nat. Hist. U. S., vol. iv, p. 249, pl. xxiii. *A. Agassiz*, in Illustr. Catal. N. A. Acal., p. 195.

TROPHOSOME.—Hydrocaulus consisting of bunches of stems, which are "at the base very much contorted, irregularly branched, and densely intertwined," each stem ascending singly from this entangled mass to a height of from two and a half to three and a half inches; perisarc "wavy or slightly nodose, or faintly ringed at irregular distances." Hydranths with each tentacular circlet consisting of about twenty-four tentacles, disposed in a single verticil.

GONOSOME.—GONOPHORES in ten or twelve pendulous racemes, which are disposed in two or three rows one over the other, and which surpass in length the proximal tentacles of the hydranth; female gonophores with from six to ten laterally compressed crest-shaped, hollow tentaculiform processes; male gonophores destitute of processes; radiating and circular canals absent.

Colour.—Perisarc light yellow; generative mass deep yellow, on both male and female gonophores.

Development of Gonosome.—Summer and autumn.

Habitat.—In brackish water, attached to floating timber, &c.

Locality.—Boston Harbour, Prof. Agassiz.

The present species is referred by Agassiz to one of those separate genera into which he has broken up the genus *Tubularia* of the European zoologists. He here substitutes for *Tubularia* his new genus *Parypha*, but, in consequence of the want of a definite diagnosis in his description of the hydroid, it is by no means easy to perceive the exact characters which he would select as those entitling it to the rank of a separate genus. He appears, however, to find them in the absence of gastro-vascular canals, by which the sporosacs of the present species are distinguished from the sporosacs of those species which, along with the European *Tubularia indivisa*, he would still retain in the old genus *Tubularia;* and in a peculiarity of the tentacula-like processes with which the female sporosac is crowned, and which he believes sufficient to separate the present species from those which he would place, along with the European *Tubularia larynx*, in his new genus *Thamnocnidia*.

Tubularia crocea has not yet been found on the European side of the Atlantic. It is described by Agassiz as growing in great luxuriance on floating timbers in Boston Harbour, where the sea water, even at high tides, contains a large admixture of fresh water from the river. It affords the subject of one of the beautiful plates in the 'Contributions to the Natural History of the United States.'

*** 16. TUBULARIA CRISTATA, *M'Crady*.

TUBULARIA CRISTATA,—*M'Crady*, in Proc. Elliott Soc. of Nat. Hist., vol. i, p. 156.
PARYPHA CRISTATA,—*Agassiz*, Contr. Nat. Hist. U. S., vol. iv, p. 342.

TROPHOSOME.—HYDROCAULUS attaining a height of from two inches to nearly three inches.[1] HYDRANTHS slender, the basal portion "not much exceeding in diameter the width of the portion above it;" twenty or more tentacles in the proximal

[1] M'Crady does not state whether his *Tubularia cristata* is a simple or a branched form.

verticil, the distal circlet composed of at least two series, and containing eighteen or more tentacles.

GONOSOME.—Gonophores with "eight rows of thread-cells, which run up the outer surface like meridian lines," and with from four to eight laterally compressed tentaculiform processes which surround a very distinct orifice at the distal end.[1]

Colour.—Hydranths rose colour, cœnosarc varying from yellow through reddish-yellow into rose colour.

Development of Gonosome.—From March to September.

Habitat.—On rocks exposed to the ocean, near low-water mark.

Bathymetrical distribution—Laminarian zone.

Locality.—Sulivan's Island, South Carolina, M'Crady.

Though no figure of *Tubularia cristata* is given, and though some points of value in a specific diagnosis—such as the simple or branched condition of the hydrocaulus, the erect or pendulous condition of the gonophore clusters, and the presence or absence of gastro-vascular canals—have been left unnoticed in M'Crady's description, there is yet sufficient detail to show that the species is a well-marked one.

The peculiar bands of thread-cells, which extend in meridional lines along the outer surface of the gonophore, present a striking character, and call to mind what would seem to be a similar feature in the gonophore of Van Beneden's *Tubularia Dumortieri*, for which Agassiz constitutes, as I believe wisely, a new genus, under the name of *Ectopleura*.

The orifice in the summit of the gonophore of *Tubularia cristata* is occasionally so large as to allow of the extremity of the manubrium being protruded through it, a fact also noticed by Agassiz in his *Tubularia* (*Parypha*) *crocea*.

The *Tubularia cristata* is also one of those species for which Agassiz constitutes his genus *Parypha*.

*** 17. Tubularia mesembryanthemum, *Allman*.

TROPHOSOME.—Hydrocaulus consisting of a cluster of simple slender stems, destitute of annulation, springing from a plexus of filiform tubes, and attaining a height of about four inches; cœnosarc forming a collar below the hydranth; stem not longitudinally striated. Hydranths with from twenty to twenty-four tentacles in the

[1] It is possible that these processes are confined to one sex, though no statement to that effect is made in M'Crady's description of the species.

proximal series, and with about twenty-four in the distal, where they are disposed in two closely approximate alternating verticils, forming a single circlet.

GONOSOME.—Gonophores in short, erect, dense clusters; destitute of gastro-vascular canals; female with eight compressed, crest-like, apical processes, which are replaced in the male by four small rounded tubercles. ACTINULA destitute of oral tentacles at the period of its liberation.

Fig. 84.

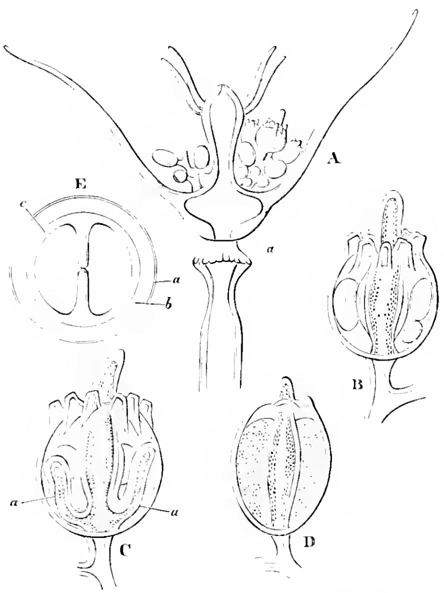

Fig. 83.

Tubularia Mesembryanthemum.

Fig. 83.—A portion of a colony, natural size.

Fig. 84.—Magnified details. A. Hydranth with gonophore-clusters; *a*, collar.

B. Female sporosac; the spadix projects through the apical orifice, and detached masses of the generative plasma are seen lying free in the cavity of the sporosac.

C. Female sporosac, showing two tubular processes, *a*, *a*, sent off from the base of the spadix.

D. Male sporosac, the spadix projecting through its apical orifice.

E. Transverse section of the stem. *a*, perisarc; *b*, ectoderm; *c*, endoderm, sending off two opposite vertical laminæ, which unite in the axis and divide the cavity of the stem into two similar longitudinal chambers.

Colour.—Body of hydranth and spadix of gonophore pale vermilion; perisarc straw-colour.

Development of Gonosome.—March.

Habitat.—Attached to submerged rocks.

Bathymetrical Distribution.—Zone of the *Cystoseira*.

Locality.—Gulf of Spezia, G. I. A.

Tubularia mesembryanthemum has the simple habit of *T. indivisa*, but with more slender stems. It is a very beautiful species, with large delicately coloured hydranths. The processes which crown the female sporosacs (Woodcut, fig. 84, B, C) are laterally compressed, and possess the form which Agassiz regards as characteristic of his genus *Parypha*. They surround a well-marked orifice in the summit of the sporosac, and the spadix may usually be seen protruding through this in the mature sporosac, a condition which it appears is also common in the American species which Agassiz would refer to *Parypha*.

The male sporosac (D), instead of possessing the eight flattened processes of the female, has four small round tubercles, bearing a close resemblance to the apical processes of *Tubularia larynx*, &c. There is here, also, a well-marked orifice, through which, as in the female, the summit of the spadix may often be seen to be protruded.

A remarkable fact noticed in the present species is the tendency of the spadix in the female gonophore to throw out from its base lobes which contain a continuation of its cavity, and which not unfrequently become so elongated as to assume the appearance of radiating canals (C, *a*, *a*). They were observed to vary in number from one to three, but were not invariably present. I never met with them in the male.

When a transverse section (F) of the stem is carefully made, its cavity is found to consist of two great longitudinal chambers separated from one another by a partition formed by two plate-like processes of the endoderm, which project from two diametrically opposite longitudinal lines until they meet in the axis. The walls of these chambers are clothed with vibratile cilia, so minute as to be with difficulty detected, and in this respect contrasting strongly with the long conspicuous cilia which clothe the canals in the stem of *Tubularia indivisa*.

In making sections of the living stem, distinct evidence was afforded of the irritability of the endoderm, which might often be seen immediately after the act of section to encroach upon the cavity of the stem at the inner edge of the surface of section to such an extent as nearly to shut it in. After a time, however, this encroachment of the endoderm recedes and fully exposes the double cavity of the stem.

Tubularia mesembryanthemum was obtained in considerable abundance in the more sheltered parts of the Gulf of Spezia, where it occurred growing upon rocks at a little distance below the lowest tide level.

PROVISIONAL SPECIES.

TUBULARIA ASPERA, *Allman*.

Under the provisional name of *Tubularia aspera*, I would indicate a hydroid whose dried stems are among the collection in the Jardin des Plantes. The soft parts have entirely disappeared, so that nothing can be seen either of the hydranths or of the gonosome, and a satisfactory determination is accordingly impossible.

The stems form dense tufts, contorted and entangled below, and then, becoming free, attain a height of about three inches, and a thickness of about $\frac{1}{20}$th of an inch. They are mostly simple, but occasionally give off a branch. The perisarc is of a papyraceous consistence, but its most characteristic feature is the presence upon the larger stems of slightly elevated annular ridges which follow one another at short and rather irregular intervals. They are very distinct under a low magnifying power, and give rise to a sensation of roughness when the dry stem is drawn through the fingers. They appear to indicate successive periods of growth, similar to what takes place in *Tubularia indivisa*, after each casting of the hydranth, where, however, the indications of periodic growth are neither so numerous within the same space nor so distinct as in the present species.

A note appended to the specimen informs us that it was brought from Coquimbo by M. Gaudechaud.

HYBOCODONIDÆ.

TROPHOSOME.—Hydrocaulus developed, invested by a chitinous perisarc. Hydranths with a proximal and a distal set of filiform tentacles.

GONOSOME.—Gonophores medusiform planoblasts.

HYBOCODON, *Agassiz.*

Name.—From ὕβος, hump-backed, and κώδων, a bell, in allusion to the unsymmetrical form of the planoblast.

TROPHOSOME.—Hydrophyton consisting of a simple (or branched?) hydrocaulus, rooted by a filiform hydrorhiza. Hydranths flask-shaped, abruptly distinct from the supporting hydrocaulus; the proximal set of tentacles long, and forming a single verticil, the distal set short, and arranged in two distinctly separated verticils.

GONOSOME.—Planoblasts springing from the body of the hydranth, between the proximal and distal sets of tentacles. Medusa at the time of liberation with a deep-belled umbrella, simple-mouthed manubrium, four radiating canals, and with only one marginal tentacle, which is prolonged from the distal extremity of one of the canals, and is furnished with a bulbous base destitute of distinct ocellus.

The genus *Hybocodon* was established by Agassiz for a large and beautiful tubularian from

Massachusetts Bay. It is a strongly marked genus, while its well-developed medusæ, each with its single tentacle and unsymmetrical bell-margin, indicate a decided approach to *Corymorpha*.

Hybocodon prolifer, *Agassiz*.

Hybocodon prolifer,—*Agassiz*, Contr. Nat. Hist. U. S., vol. iv, p. 243, pl. xxiii*a*, figs. 10, 11, and pl. xxv. *A. Agassiz*, Illustr. Catal. N. A. Acal., p. 193.

TROPHOSOME.—Hydrocaulus consisting of solitary or sparingly aggregated stems, which attain a height of about two inches, the stems gradually enlarging from the base, until just below the hydranth they attain a thickness of one sixteenth of an inch; perisarc destitute of annulations, except towards the summit of the stem, where it becomes dilated and furnished with annular constrictions; cœnosarc with longitudinal orange-red striæ. Hydranth with its two distal verticils composed each of about sixteen tentacles, the more distal of the two consisting of tentacles which are about half the length of those forming the other.

GONOSOME.—Umbrella of medusa with five orange-red granular bands, which extend upon its outer surface from the codonostome to within a short distance of the apex, two of these bands lying one on each side of that radiating canal which corresponds to the solitary tentacle, the others lying one over each of the three remaining radiating canals; bulbous base of the marginal tentacle large and proliferous; tentacle smooth for some distance from the base, and then to its extremity covered with annular groups of thread-cells.

Colour.—Deep orange-red.
Development of gonosome.—January.
Habitat.—In pools of purest sea water at low-water mark.
Bathymetrical distribution.—Laminarian zone.
Locality.—Massachusetts Bay, Agassiz.

Hybocodon prolifer, the only representative yet discovered of its genus, forms the subject of one of the beautiful plates in Agassiz's 'Contributions to the Natural History of the United States.' One of its most striking features is found in the constant tendency of its medusæ to multiply themselves by the formation of buds which are developed from the marginal termination of one of the radiating canals, that, namely, which is continued into the solitary tentacle. The buds are produced in clusters from this point, and when each attains a certain stage of maturity, it gives rise in the same way, and from the corresponding point of its radiating canal to a similar brood of medusa-buds.

Agassiz has shown that the general orange colour of the stem is produced by longitudinal bands of pigment cells upon the inner wall of the cœnosarcal cavity. He has further shown that this wall forms ridges which project into the cavity of the stem, but that the cavity itself, unlike that of *Tubularia indivisa,* is single and continuous, while its walls, except on the bands of pigment cells, are clothed with vibratile cilia.

ECTOPLEURA, *Agassiz.*

Name.—From ἐκτὸς, on the outer side, and πλευρὰ, a rib, in allusion to the prominent longitudinal ribs of the planoblast.

TUBULARIA,—*Van Beneden.*

TROPHOSOME.—HYDROCAULUS filiform, rooted. HYDRANTHS flask-shaped, abruptly marked off from the supporting stalk; tentacles of the proximal set longer than those of the distal.

GONOSOME.—PLANOBLASTS on branched peduncles, which are borne on the body of the hydranth between the proximal and distal verticils of tentacles. MEDUSA at the time of liberation with a nearly spherical umbrella and simple-mouthed manubrium; four radiating canals and four marginal tentacles; no distinct ocelli; umbrella furnished with eight prominent longitudinal ribs, formed of linear series of thread-cells.

To his genus *Ectopleura,* Agassiz, as has been already said, refers the *Tubularia Dumortieri* of Van Beneden. In thus separating Van Beneden's *Tubularian* from the true *Tubulariæ,* Agassiz seems to me to be fully justified, the phanerocodonic condition of the gonophore affording in itself an important generic character. I cannot, however, so easily assent to the correctness of associating with it in the same genus the *Sarsia pulchella* of Forbes, the *Sarsia turricula* of M'Crady, and the *Sarsia nodosa* of Busch.[1] These hydroid medusæ are very different from the medusa of Van Beneden's *Tubularia Dumortieri,* while one of them, *Sarsia turricula,* has been traced by M'Crady, if not with absolute certainty, at least with high probability, to a coryniform trophosome.[2]

It is possible that the medusa named *Ectopleura ocracea* by Mr. A. Agassiz,[3] has been rightly referred to this genus; but as we know nothing of its trophosome, its generic determination cannot be regarded as otherwise than provisional.

[1] See Agassiz in 'Cont. Nat. Hist. U. S.,' vol. iv, p. 343.

[2] M'Crady, in 'Gynophth. of Charleston Harbour.'

[3] 'Illustr. Catal.,' p. 191, fig. 320.

Ectopleura Dumortieri, *Van Bened.*

Tubularia Dumortieri,—*Van Beneden,* Recherches sur l'Embryogenie des Tubulaires, p. 50, pl. ii; Rech. sur Faune litt. de Belgique, p. 111.
Ectopleura Dumortieri,—*Agassiz,* Cont. Nat. Hist. U. S., vol. iv, p. 343. *Allman,* in Ann. Nat. Hist. for May, 1864. *Hincks,* Brit. Hydr. Zooph., p. 124, pl. xxi, fig. 4.

TROPHOSOME.—Hydrocaulus attaining a height of about one inch, isolated, slender, simple or slightly ramified; perisarc with annular constrictions. Hydranths comparatively large.

GONOSOME.—Gonophores on short, erect, slightly branched peduncles.

Habitat.—Attached to Flustras, the carapaces of crabs, &c.
Locality.—Coast of Ostend, Van Beneden; Isle of Man, Mr. Hincks.

I have never met with an example of the present genus, and have obtained the generic and specific characters here given from M. van Beneden's description of his *Tubularia Dumortieri,* the only species of the genus yet discovered, at least with its trophosome. The Belgian zoologist informs us that this hydroid is very abundant on the coast of Ostend, where it occurs on Flustras and Halodactylas, and on the backs of crabs, in the form of isolated stems, never forming tufted masses such as we meet with in many other Tubularians.

HYDROLARIDÆ.

TROPHOSOME.—Hydrocaulus undeveloped. Hydranths with but two tentacles, which are filiform and spring from one side of the base of the hypostome; mouth with two lip-like lobes.

GONOSOME.—Gonophores medusiform planoblasts, with six simple radiating canals and simple marginal tentacles.

In the enumeration of genera on page 241 the family to which *Lar* has been provisionally referred is named "Laridæ." This name, however, cannot be retained, being already in use for a well-known family of birds. It is difficult to form another in accordance with the principles which have regulated the nomenclature of the present monograph. The nearest approach to uniformity will, perhaps, be attained by the use of the name HYDROLARIDÆ, which I have accordingly adopted.

LAR, *Gosse.*

Name.—From *Lar*, a household god, in allusion to the mode in which the only known species is associated with *Sabellæ*.

TROPHOSOME.—HYDRORHIZA a creeping filiform stolon covered with a PERISARC. HYDRANTHS fusiform; hypostome separated by a constriction from the body; oral lobes in the form of two opposable plates.

GONOSOME.—PLANOBLASTS borne on BLASTOSTYLES which spring from the hydrorhiza and terminate distally in a globular cluster of thread-cells. MEDUSA at time of liberation with a sub-globular umbrella; manubrium moderately large, destitute of oral tentacles; marginal tentacles six, with bulbous bases destitute of ocelli.

The trophosome of this remarkable genus was described some years ago by Mr. Gosse. Nothing, however, of its gonosome was known until Mr. Hincks had the good fortune to obtain it on the northern coast of Devonshire. To him, therefore, we are indebted for rendering us acquainted with the missing element, which was needed for a complete diagnosis of the genus, and which can alone remove it from the domain of provisional genera, to which it would otherwise have to be relegated.

LAR SABELLARUM, *Gosse.*

LAR SABELLARUM (trophosome),—*Gosse*, in Trans. Linn. Soc., vol. xxii, 1857, p. 113, pl. xx.
(Trophosome and gonosome), *Hincks*, in litteris, July 5th, 1872.

TROPHOSOME.—HYDRANTHS attaining a height of about $\frac{1}{10}$th of an inch, scattered at short intervals on the creeping hydrorhiza; hypostome with a patch of imbedded thread-cells near its summit; tentacles smooth, and when extended about as long as the body of the hydranth.

GONOSOME.—BLASTOSTYLES cylindrical, slender. PLANOBLASTS springing from a point a little above the middle of the blastostyle in a sub-verticillate cluster of three or four; manubrium about half as long as the vertical diameter of the umbrella-cavity, with a constriction just above its oral extremity; margin of umbrella with a minute tubercle at the middle point between every two tentacles.

Development of Gonosome.—July.
Habitat.—Attached to the tubes of *Sabellæ* round the orifice.
Bathymetrical distribution.—Coralline zone.
Locality.—North coast of Devonshire, Mr. Gosse and Mr. Hincks.

Under the name of *Lar sabellarum* Mr. Gosse described a certain enigmatical organism which made its appearance in his aquarium, growing round the orifice of the tube of one of the sea-worms (*Sabella*). He tells us that from a creeping network of filaments which extended round the mouth of the *Sabella* tube there sprang numerous irregularly fusiform bodies, each terminating distally in a head-like lobe, immediately below which were two long tentacles. The terminal lobe is described as capable of opening itself out by the separation of two broad flattened lips, which then diverge from one another in the manner of "the leaves of a half-opened book."

The zooids of the colony are described as singularly energetic in their motions, and Mr. Gosse gives a graphic account of the various forms and attitudes assumed by them. He informs us that "about twenty bodies having a most ludicrously close resemblance to the human figure, and as closely imitating certain human motions, were standing erect around the mouth of the tube, when the *Sabella* had retired into its interior, and were incessantly tossing about their arms in the most energetic manner. . . . . The head-lobe moved to and fro freely on the neck; the body swayed from side to side, but still more vigorously backward and forward, frequently bending into an arch in either direction, while the long arms were widely expanded, tossed wildly upward and then waved downward as if to imitate the actions of the most tumultuous human passion."

A characteristic figure, in which these various attitudes are represented, accompanies the description.

This description by Mr. Gosse contained, up to the present time, all that we knew of the singular organism which formed the subject of it; and though we had no information regarding its gonosome, it was yet evident that *Lar sabellarum* was the trophosome of a hydroid which, however anomalous, had (as Mr. Gosse himself recognised) its nearest immediate relations with the *Gymnoblastea*.

Just, however, as the last sheet of the present work was on the point of going to press, I received a letter from Mr. Hincks informing me that he had just dredged up a colony of *Lar sabellarum* with its gonosome on the coast of North Devon. Mr. Hincks did not fail to profit by the opportunity thus afforded of making a careful study of the animal, and it is from his description, accompanied by a beautiful drawing, that I have here been enabled to supplement in important details Mr. Gosse's account of one of the most singular and distinct of the HYDROIDA.

The fact of the radiating canals in the planoblast being six in number constitutes an unusual though by no means unprecedented condition of the gastro-vascular system. The small tubercle which is interposed between every two tentacles on the umbrella-margin, and which Mr. Hincks informs me contains minute bodies like thread-cells, is probably the origin of what in the adult medusa would become an interradial marginal tentacle. Mr. Hincks has further observed that the gonophore is naked, no ectotheca being present at any period of its development, a condition in which it resembles *Clavatella* and some other hydroids with undeveloped or naked hydrocaulus.

It is, however, in the trophosome that the most striking characters are to be met with. The singularly unsymmetrical form of the hydranth, with its tentacles reduced to two, and thrown altogether to one side, and the two lip-like lobes with which the mouth is provided, are characters so unique as to necessitate the separation of *Lar* from all other known hydroid families. So far as I can judge from the description and figure, the mouth is also situated laterally on the hypostome, being, along with its two lips, directed towards the same side as that which carries the tentacles.

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TO THE

FAMILIES GENERA AND SPECIES OF GYMNOBLASTIC HYDROIDS DESCRIBED IN THIS MONOGRAPH.

The Names printed in Italics are Synonyms. Those between quotation commas are the names of provisional or doubtful species.

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