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HYDROZOA to JEREMY, EPISTLE OF

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"LET KNOWLEDGE GROW FROM MORE TO MORE AND THUS BE HUMAN LIFE ENRICHED."

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HYDROZOA to JEREMY, EPISTLE OF

HYDROZOA. The Hydrozoa (sometimes called Hydromedusae) are a class of animals, the vast majority of which are marine, and which belong to the still greater assemblage known as the Coelenterata (*q.v.*). The Hydrozoa include not only polyps, but also medusae or jellyfish (these terms are defined in the article COELENTERATA). They are, in fact, that group of Coelenterata in which neither the one nor the other of these two forms of body predominates, and in this respect they contrast strongly with the other main classes (Scyphozoa and Anthozoa). Moreover, both polyp and medusa have a simpler plan of structure than in the other classes. The polyp itself is frequently (though not always) small. Its mouth leads directly into the internal cavity of its body (coelenteron), without the intermediary of a definite throat or gullet of any kind, and the ectoderm and endoderm (*see* COELENTERATA) meet at the lips. The coelenteron is a simple cavity lined by endoderm; it is not subdivided by partitions into lesser cavities, nor does it contain definite organs of any kind. With these limitations the actual form of the polyp varies very greatly. The medusa presents infinite variety of form, but it too lacks a throat, and although its coelenteron sends out radiating canals which run from the central cavity through the solid tissues of the bell, it is otherwise simple in that it contains no definite organs. The medusae of Hydrozoa are, generally speaking, smaller and more slightly built creatures than the medusae belonging to the related class, Scyphozoa, although in certain cases they attain a larger size than the average, which is a matter of millimetres. The Hydrozoa are also characterized by the fact that the sex cells, when they ripen in the clusters known as *gonads*, typically lie in or under the ectoderm, although the site of their original formation may be in either ectoderm or endoderm. It is among the Hydrozoa above all other Coelenterata that the phenomenon, briefly characterized elsewhere (article COELENTERATA), and known as *polymorphism*, attains its height. The details of this condition are described in parts of the present article and a summary of the question is given after the section on Siphonophora.

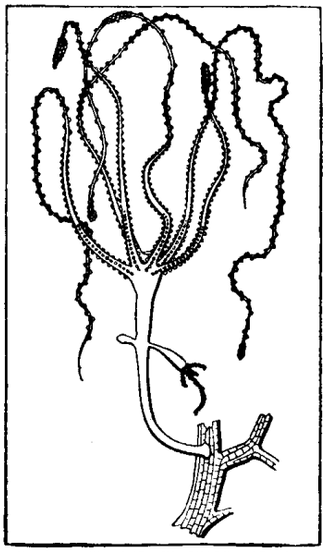
The infrequency of brackish or fresh-water forms among the Coelenterata makes their occurrence of interest. The ordinary marine Hydrozoa are either pelagic (swimming or floating organisms) or sedentary, according to their nature, and many of either kind exist. The brackish and fresh-water forms exhibit the same diversity, though few in number. One of the most interesting is a minute creature, *Protohydra*, the length of which is about 3 mm. This organism inhabits the surface layer of mud, rich in diatoms, which is to be found in the bottom of pools in certain tidal marshes; it also occurs in oyster beds and similar places. It is carnivorous, and reproduces freely by transverse fission. It possesses no tentacles, and is as simple in structure as any known Coelenterate.

The best known of the nonmarine Hydrozoa, however, are the genera *Limnocodium, Limnocnida, Cordylophora* and *Hydra*. Of *Hydra* more details are given below, and the chief interest of *Cordylophora* lies in the fact that it may flourish in water of different degrees of salinity as well as in fresh water; it is otherwise ordinary. *Limnocodium ryderi* possesses a feebly developed polyp generation (up to about 2 mm. long) which produces small colonies containing about 2–7 individual polyps without tentacles. These colonies can produce buds of two kinds; some become separated from the parent, form polyps and produce new colonies, others develop into medusae, and these are liberated and swim away. The species of *Limnocodium* (with which is now included *Microhydra*) are not very clearly recognized; but representatives of the genus occur in lakes, millstreams and similar places in the United States, Germany, China and Japan, and have appeared in water lily tanks at various botanic gardens, and in other tanks and aquaria. The genus *Limnocnida* contains medusae which have been found in several river systems in Africa and in some of the great lakes, as well as in India. The Hydrozoa comprise three large orders which from this point will be treated separately.

ORDER I. HYDROIDA

The Hydroida are, roughly, those Hydrozoa which possess a definite alternation of the polyp and the medusa in their life history, and in which one generation (the polyp) is sedentary and usually constructs a fixed colony, the other being free-swimming when fully developed. There are exceptions to this general statement, but they are not characteristic of the group as a whole. The variety of form and life history exhibited, however, is great. The common and well-known but quite untypical fresh-water genus *Hydra* (fig. 1),

is the only thoroughly successful freshwater Coelenterate. *Hydra,* of one species or another, occurs in ponds and ditches and similar situations in many parts of the world. It consists of small isolated polyps, each with a pillar-like body and a limited number of tentacles. The length of the body is a matter of millimetres, and the tentacles in some species may be longer when stretched out than the body, although both they and the body can contract into rounded knobs. The *Hydra* attaches itself to stems and water-weeds, or floats beneath the surface film. It catches prey, often of a large size compared with its own bulk, in the manner characteristic of the Coelenterata (this is described in the article COELENTERATA) by stinging and then swallowing it. From the body of the *Hydra* there grow out buds, each of which acquires tentacles of its own and ultimately becomes separated from the parent; but no medusae whatever are produced, this being quite exceptional among the Hydroida. There are usually developed separately, on different parts of the body, ovaries and testes which give rise to the sex-cells. Whether this represents a degenerate condition, and there was once a medusa-stage in the life-cycle, or whether it is a primitively simple condition, cannot be determined.



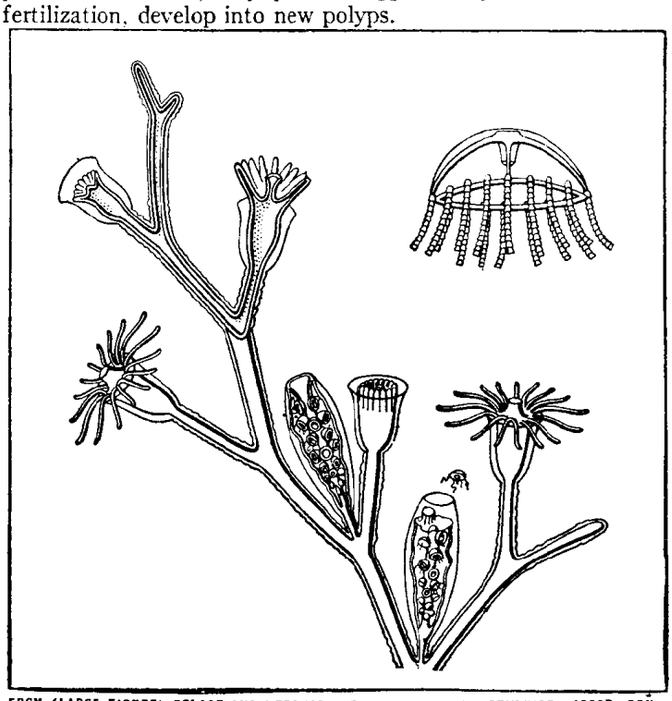
FROM DELAGE AND HEROUARD, "ZOOLOGIE CONCRÈTE" (REINWALD) (COPR. BONNAIRE)

FIG. 1.—FRESH-WATER POLYP (HYDRA), ENLARGED

The specimen is shown attached to a plant-stem. Its tentacles are well extended and it bears two buds on its side, one of which has acquired tentacles of its own

The few other simple genera which are known, such as *Protohydra,* may be related to *Hydra,* or may be primitive or degenerate forms of separate origin. With the above preliminary, the characteristics of the group as a whole, without reference to these special forms, may be considered.

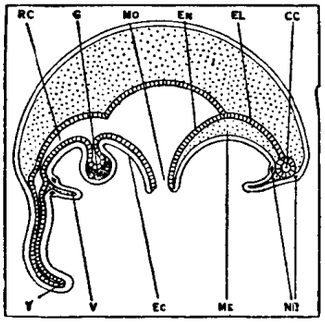
Structure.—The following is a description of the structure of a typical Hydroid, provided by the genus *Obelia* (fig. 2). *Obelia* begins its life, after the embryonic stages which succeed fertilization of the egg have transpired, as a single polyp, possessing a number of simple tentacles in a circlet around the base of its conical *peristome* or *manubrium.* The polyp sends out roots which attach it to the surface of a stone, the frond of a sea-weed, or other suitable support, and grows a stalk which raises it somewhat in the water. From this stem a bud arises from which, although it is at first a mere knob, a new polyp is gradually developed. This process of growth proceeds in a definite and regular manner, until a small tree-like colony, from less than an inch to several inches in height, is formed; the branches are definitely arranged, and all bear polyps. If one of the colonies be examined in detail, it will be found that each of the polyps possesses, outside its body, a little transparent cup of relatively stiff, horny material, into which it can withdraw when alarmed; and that not only are the polyps connected with each other by a stem composed of soft tissues, but the cups also are connected by a horny layer, outside the soft stem, which stiffens and supports the latter. The cups are known as *hydrothecae,* the soft stem as *coenosarc,* and the horny layer (including stem and cups) as the *perisarc.* The new polyps develop only from the tips of a branch of coenosarc, and not from one another; and in a well developed colony it will be seen that some additional branches have grown out, mostly in the lower part of the colony, each of them similar in structure to a developing polyp, and usually regarded as representing one. These branches (known as *blastostyles*) do not develop a mouth and tentacles; instead each produces a number of buds which gradually develop into small medusae, and which are known as *medusoid buds.* The blastostyle, like an ordinary polyp or *hydranth,* has a covering of perisarc known as a *gonotheca,* but this is at first imperforate. In due course it becomes open at the end, and the medusae separate off from the blastostyle and swim away into the sea, where, after a period of free life, they produce eggs and sperms which, after fertilization, develop into new polyps.



FROM (LARGE FIGURE) DELAGE AND HEROUARD "ZOOL. CONCRETE" (REINWALD) (COPR. BONNAIRE); (SMALL FIGURE) PARKER AND HASWELL, "TEXT BOOK OF ZOOLOGY" (MACMILLAN & CO.)

FIG. 2.—OBELIA (ENLARGED) SHOWING PART OF A COLONY OF THE POLYP GENERATION AND ALSO A MEDUSA. THE COLONY BEARS BOTH ORDINARY POLYPS AND BLASTOSTYLES, THE LATTER PRODUCING MEDUSOID BUDS

The structure of one of these fully developed medusae must now be considered in more detail (fig. 3). The body has the form of an umbrella, with a manubrium similar to that of a polyp hanging down inside it and bearing the mouth at its end. The manubrium is lined by endoderm, and contains a cavity, the main part of the coelenteron. The substance of the umbrella consists of mesogloea with ectoderm on both external surfaces; but the layer of mesogloea is penetrated by four narrow tubes or canals, lined by endoderm, which run out from the base of the manubrium like the four arms of a cross. Connecting these *radial canals* with each other is a flat sheet of endoderm like a web (*endoderm lamella*) and also a *circular canal* which runs round the edge of the umbrella close to the bases of the tentacles. The latter are solid, both in medusa and polyp. At the edge of the bell, on the inner side of the ring of tentacles, is a little circular shelf (the *velum*) which projects inwards and slightly narrows the opening of the bell. Round the margin of the bell, at the bases of certain of the tentacles, lie the sense organs, minute sacs, formed by the ectoderm, and each containing a calcareous particle (the *statolith*). They are known as *statocysts* (fig. 5), and are eight in number, two being definitely placed in each of the quadrants between the radial canals; they probably initiate and control the swimming-contractions of the bell. The sex-cells of the medusa ripen in the ectoderm of four gonads which occur on the course of the four canals, and which, when ripe, shed their products into the sea. The fertilized eggs develop into new polyps



FROM KUKENTHAL, "HANDBUCH DER ZOOLOGIE" (DE GRUYTER)

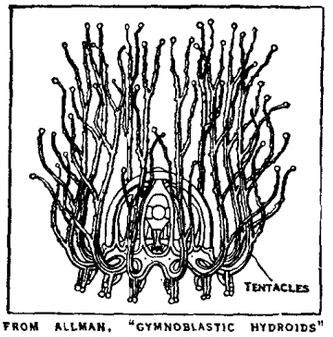
FIG. 3.—DIAGRAM OF A VERTICAL SECTION THROUGH A MEDUSA

EC, ectoderm; EN, endoderm; G, gonad; ME, mesogloea; MO, mouth; CC, circular canal; NR, Inner and outer nerve rings; RC, radial canal; T, tentacle; V, velum; EL, Endodermal Lamella

which initiate fresh colonies.

The story of *Obelia* is typical of the Hydroida, with modifications of one kind and another. In some cases the polyp-generation includes a single nutritive individual only, but usually it forms a colony. The form of the individual polyps and medusae, as also that of the colony, undergoes great modification however.

The polyps sometimes possess cups of perisarc as does *Obelia;* but often they are without these. Their tentacles are sometimes simple, sometimes knobbed at the tip or branched; sometimes arranged in one circlet, sometimes in two (one round the lip, one at the base of a conical manubrium), in other cases arranged irregularly over part or most of the surface of the polyp.

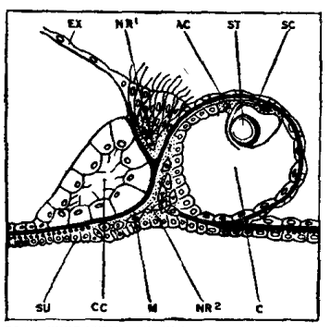


FROM ALLMAN, "GYMNOBLASTIC HYDROIDS" (COUNCIL OF THE RAY SOCIETY)

FIG. 4.—MEDUSA OF CLADONEMA (ENLARGED)

This is an example of a jellyfish with branched tentacles. The gonads here form swellings on the manubrium; and the medusa adheres to surfaces through knobs on the basal branches of its tentacles

The medusae vary even more than the polyps, both in shape and structure, and some idea of the diversity which occurs among them may be gained by reference to figs. 2–4 and 7–8. The shape of the bell may be shallow or almost flat, or on the other hand may be a high dome, and naturally varies with the movements of the animal. The number, arrangement and structure of the tentacles is widely various. The living medusae are some of the most beautiful of marine creatures. Their transparency, which is often touched with definite colour in given parts, and the regularity of their structure are responsible for this, and in some cases their movements also are extremely graceful. The sense organs vary from one kind of medusa to another. Statocysts are present in a number of cases, and these exhibit varying degrees of complexity of structure, with this in common to all of them—that the epithelium of the statolithic sac or pit (for the simplest of statocysts consist of an open pit) is derived from the ectoderm, and no endoderm takes part in its formation. Many medusae possess sense-organs of another nature, known as *ocelli,* and these are sensitive to light. In their simplest condition they consist of a clump of sensory cells mingled with pigment cells; but the more complicated ones possess a definite lens. These ocelli may be situated close to statocysts, but many medusae possess ocelli only, and others statocysts only. Another important variation in structure is, that in some medusae, as in *Obelia,* the gonads are situated on the radial canals; but in many others the sex-cells ripen instead on the manubrium.



FROM KUKENTHAL, "HANDBUCH DER ZOOLOGIE" (DE GRUYTER)

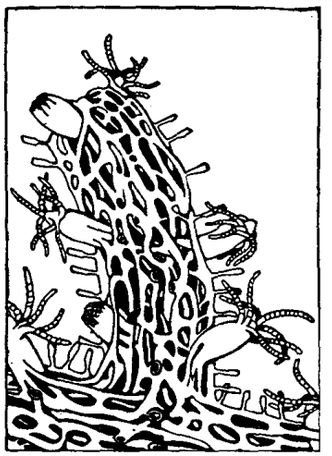
FIG. 5.—SECTION THROUGH A STATOCYST, MUCH ENLARGED

AC, sensory cell with sensory hair; C, statolithic sac; CC, circular canal; EX, ex-umbrella; M, mesogloea; NR¹, outer nerve ring; NR², inner nerve ring; SC, statolithic cell; ST, statolith; SU, sub-umbrella

Colonies.—The next consideration must be that of the kinds of colonies which Hydroids construct. These colonies are frequently small and relatively soft, the horny perisarc giving a considerable amount of support, but not constituting a really rigid skeleton. Many such colonies are an inch or less in height, although colonies several inches long are common. Only rarely does the colony become actually large, but in a few cases it achieves a size and solidity which give it rank with the reef-forming corals; in these cases the skeleton is massive and calcareous, and is in fact "coral."

Hydroid colonies are roughly speaking of two kinds—mat-like and tree-like structures. The mat-like forms consist of a network of rootlets, attached to a stone, sea-weed or other support, from the upper surface of which arise the polyps. The network is sometimes straggling, sometimes compact, and may form a continuous sheet. The tree-like forms are mostly delicate feathery structures, resembling rather the fronds of a finely divided sea-weed than any animal. The general aspect of some of them is shown in the accompanying Plate. The size of the whole colony, the exact way in which it branches, and the way in which one polyp after another is added upon a branch, affect the general appearance of the ultimate result. Sometimes the branches themselves are thick and are composed of a dense network of branching rootlets (*Clathrozoon,* fig. 6), the polyps projecting at the surface. This condition, which is achieved in a manner different from that which produces the average tree-like colony, leads on to the state of affairs found in the massive, limy colonies.

These massive forms deserve special mention. They have been considered in time past as a separate group of Hydrozoa, the *Hydrocorallina;* but it has become evident that they may be simply Hydroids with a more than usually solid skeleton, and that some of them are probably related to one series of Hydroid ancestors, others to a different series. A good example of these creatures is found in *Millepora.* This animal constructs a colony containing innumerable minute individual polyps, which are connected with each other by a continuous surface-sheet of ectoderm and by a network of ramifying tubular rootlets. The colony secretes a massive, limy skeleton which may become a foot or more in height, and which, though varying in form in different species, is often branched somewhat like the antlers of a stag, but in more compact fashion. The polyps inhabit little pits in the surface of the skeleton, and can retire into these completely when alarmed. The network of rootlets is lodged in a network of canals in the surface layers of the skeleton, the deeper parts consisting of coral only and containing no soft parts; this internal portion was secreted by the soft parts originally, but as growth proceeded and further skeleton was formed, these retired to the surface-layers. One can imagine that a similar state of affairs would be produced if a colony such as that of *Clathrozoon* were to secrete limy material into the meshes between its network of rootlets. *Millepora* is extraordinarily interesting in one respect. When the time comes for sexual medusae to be produced by the colony, these are not formed from buds as in *Obelia* and other Hydroids. Instead the sex-cells, which are migratory, move from the rootlets into one or other of the polyps. Each polyp so affected loses under their influence its characteristic structure, and becomes transformed by degrees into a medusa. The pit surrounding it enlarges and becomes closed in, so that it forms a cavity cut off from the outer world, and until the medusa is ready to escape it remains so; finally the cavity opens again and the medusa comes out. It is a weak swimmer and cannot feed; it swims a very little distance before shedding its ripe eggs or spermatozoa, the union of which gives rise to a polyp so that the life-cycle begins once more.



FROM KUKENTHAL, "HANDBUCH DER ZOOLOGIE" (DE GRUYTER)

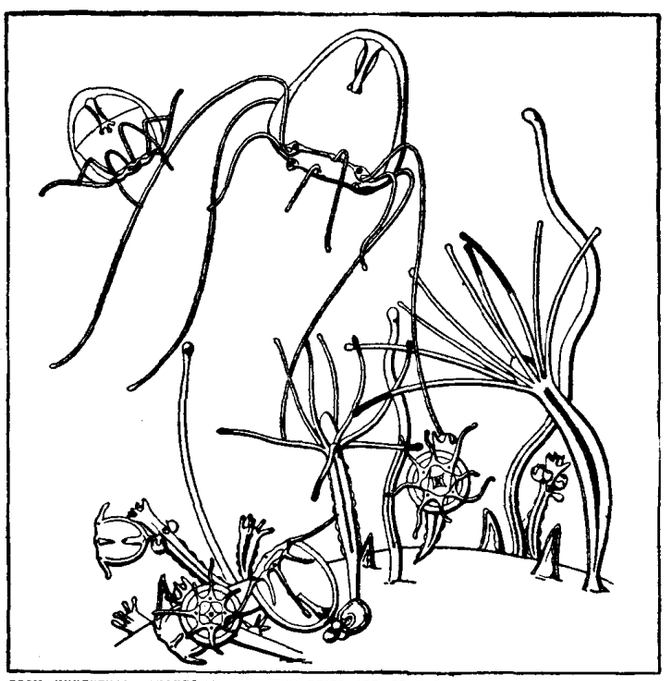
FIG. 6.—PART OF A COLONY OF CLATHROZOON

Diversities Exhibited by the Polyps and Medusae.—We may now pass on to some of the interesting diversities which the polyps and medusae exhibit. To begin with, in certain colonies, such as those of *Millepora* and *Hydractinia* (fig. 7), the hydranths are not all alike. Some of them (*gastrozooids*) possess mouths as well as tentacles, and inside these polyps digestion of food takes place. Other polyps on the contrary possess no mouths, but may have tentacles and are well provided with stinging capsules such as are described in the article COELENTERATA. These polyps themselves cannot feed, but they play a defensive part in the colony and assist the others in the capture and paralysing of food; they are known as *dactylozooids.* This is

a simple example of the phenomenon of polymorphism, which has been previously mentioned and which will be further discussed later. It is carried to greater lengths in *Hydractinia* than in *Millepora,* since in this case the colony produces also *blastostyles* similar in principle to those of *Obelia.* These may be regarded as modified polyps with a body but without mouth or tentacles, which produce sexual buds. Therefore a Hydractinia colony possesses four kinds of individuals—gastrozooids, dactylozooids, blastostyles and sexual buds.

To turn to the medusae, we find here a most curious state of affairs. To begin with, medusae may arise from blastostyles or direct from ordinary polyps; and the blastostyles may arise from the root or stem of a colony or from a polyp itself. Moreover, a medusa may itself bud off others from its manubrium, or from its tentacle-bases or other parts. The most remarkable fact connected with the medusae, however, is that despite the fact that a medusa is obviously an advantageous development, in that it can swim away and spread the eggs and spermatozoa over an area vastly wider than they could otherwise reach, there is yet a strong tendency among the Hydroida toward a condition in which the medusa not only remains permanently attached to the colony whence it sprang, but also becomes much reduced and simplified in structure. A series of medusae can be traced, in which at one end there is found the fully formed free-swimming jellyfish, at the other end a degenerate sac-like structure, devoid of any medusa-like features, and resembling the gonad of an active medusa, such as that of *Obelia.* This degenerate formation, which remains attached to the colony, is known as a *sporosac,* and consists of a layer of ectoderm containing or covering the sex-cells, and surrounding an endodermal core. Between these two extremes all intermediate stages may be found.

It has been considered by some authors that the sporosacs represent, not a reduced but a primitive condition, and that the other stages are to be regarded as developments leading up to the fully formed medusa. This would seem reasonable from the

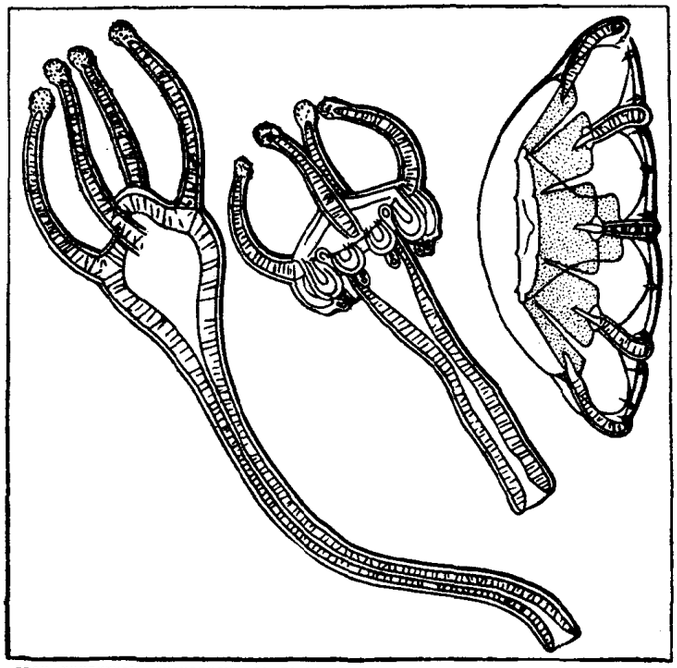


FROM KUKENTHAL, "HANDBUCH DER ZOOLOGIE" (DE GRUYTER)

FIG. 7.—PART OF A COLONY OF HYDRACTINIA (ENLARGED), SHOWING GASTROZOOIDS, DACTYLOZOOIDS, BLASTOSTYLES AND MEDUSOID BUDS, AS WELL AS FREE MEDUSAE

point of view that the roving medusa is an obvious gain to a fixed colony; but the facts of the case do not seem to support it. From the structure and mode of occurrence of the various grades of medusae, and from the fact that in the development of certain of the reduced forms, medusoid features appear for a time and are subsequently lost, it is judged that they are not primitive but degenerate. The precocious development of the sex-cells may be the factor which leads to the reduction of the medusae; the gain being increased fertility.

The Coelenterata are singularly free from parasitic members. Of the few that are known, one is particularly interesting. This is *Hydrichthys boycei,* a species referred to the Hydroida but which may be an unusual siphonophore. The colony is one of the mat-like kind, and the mat, instead of being affixed to a stone or weed,



FROM KUKENTHAL, "HANDBUCH DER ZOOLOGIE" (DE GRUYTER)

FIG. 8.—STAGES IN THE DEVELOPMENT OF A TRACHYLINE (MUCH ENLARGED)

The figures show the direct transformation of a polyp-like larva, with a long proboscis, into a medusa

is attached to the fins or body of a fish. The underside of it sends roots into the integuments of the fish, and under its growing edge are cells which are able to destroy the surface of the fish's skin and expose the vascular layer beneath. The polyps, which have no tentacles, bend down over the edge of the mat, apply their mouths to the wound made by the latter, and obtain blood from the vessels of the fish. Another parasite, better known than *Hydrichthys,* is *Polypodium;* this is parasitic at one stage of its life in the eggs of a sturgeon, which it destroys.

Classification.—The classification of the Hydroida is instructive, though as yet imperfect. The connection between medusae and polyps was at first not understood by naturalists, since it could not be deduced from observation of one of these types only, without a study of the whole life history. Even now there are polyps and medusae which have not yet been linked on to their corresponding alternative form. Consequently a double classification has grown up, dealing with the two sets independently, and the two systems can be correlated with each other so far as the inter-connections are known.

The polyps are divided into:—

1. Gymnoblastea. Here the polyps are not enclosed in cups of perisarc (hydrothecae), nor are the blastostyles enclosed in gonothecae.
2. Calyptoblastea. Here the polyps possess hydrothecae and the blastostyles gonothecae.

The medusae are classified as follows:—

1. Anthomedusae. Medusae in which there are no statocysts (though there are usually ocelli) and in which the gonads develop on the manubrium. These are the medusae belonging to the Gymnoblastic polyp-generation.
2. Leptomedusae. Medusae in which there are typically statocysts and sometimes ocelli, and in which the gonads are arranged on the radial canals. These medusae belong to the Calyptoblastic polyp-generation.

In the above scheme *Hydra* and its relatives would be considered Gymnoblasts by some authors, by others they would be placed in an independent group, the *Hydrida.*

ORDER II. TRACHYLINA

The Trachylina are an assemblage of Hydrozoa which differ sufficiently from any of the Hydroida or Siphonophora to warrant their inclusion in a separate group.

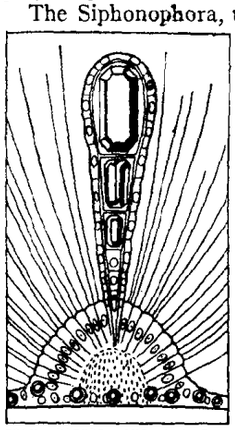
Among the Trachylina the medusa is the dominant form, and many reach a considerable size (*e.g.*, 10 x 3cm.). In accordance with this fact the Trachylina are mostly oceanic forms, pelagic throughout life; whilst the Hydroida are tethered, so far as their polyp-generation is concerned, to the bottom or to sea-weed, and include many characteristic shore-forms. The cleavage of the fertilized egg of the Trachylina typically produces a planula (*see* COELENTERATA), which develops into a more or less distinctly polyp-like larva; the latter is transformed directly into a medusa (fig. 8). In certain forms (Cuninidae) the polyp-larva is parasitic within medusae of its own or other kinds. In such cases it reproduces by budding, and both the parent and daughter polyps become transformed into medusae; or, the larva may form a stolon from which medusae are budded.

Beyond the facts thus outlined the Trachylina contribute little of general interest to the study of the Coelenterata, although their structure and life-histories are in themselves extremely interesting. For this reason they are dealt with very briefly here, and the only part of their structure calling for further mention is that of the sense organs. Ocelli (eye-spots) are rare amongst them, but all possess organs containing statoliths. These are of a different grade from those of the Hydroida, in that they exhibit the structure, not of ectodermal pits or sacs containing statoliths, but of small tentacles containing an endodermal core in which lie one or more statoliths, and covered by ectoderm. These modified tentacles are known as *tentaculocysts* (fig. 9), and they may, like tentacles, project freely at the surface, or may themselves become embedded in a pit or sac formed by the surrounding tissues.

ORDER III. SIPHONOPHORA

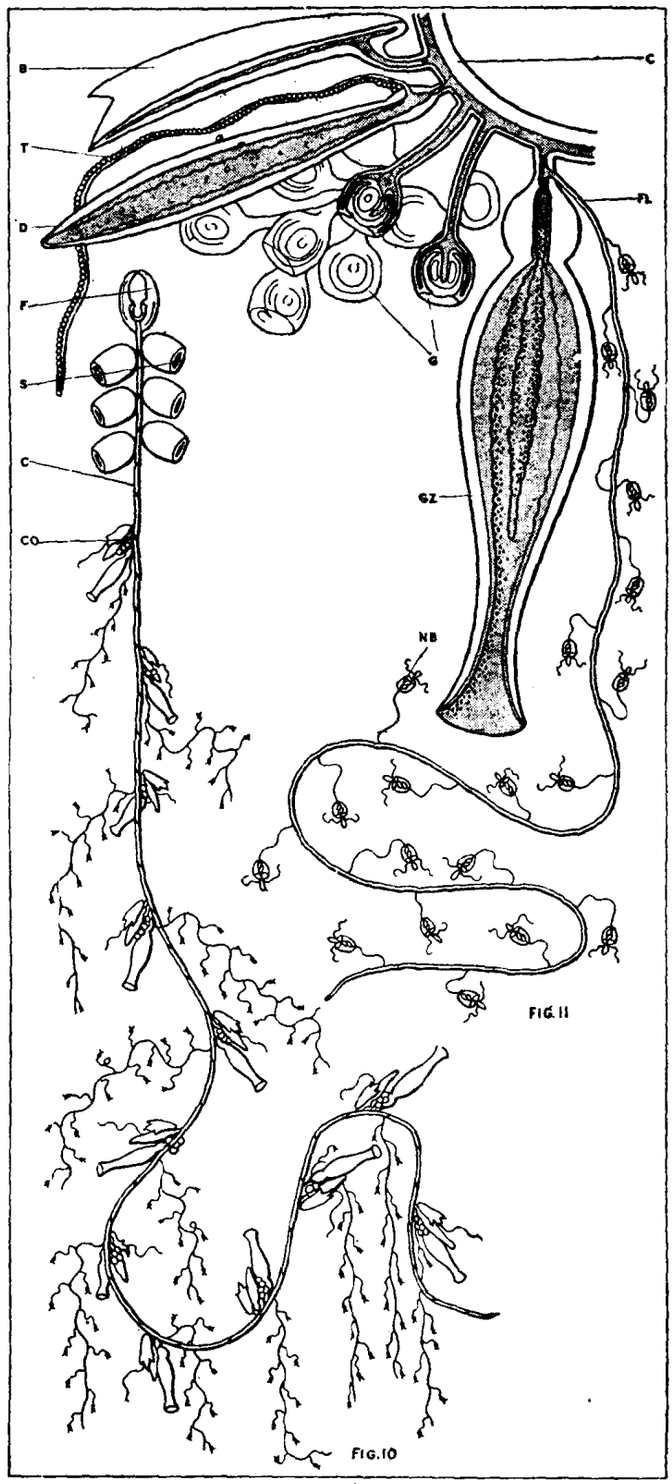
The Siphonophora constitute one of the most interesting groups of the animal kingdom, since they illustrate the lengths to which an organism may go in the direction of stringing together a number of different kinds of individuals in a single chain. In scientific terminology they exhibit at its height the phenomenon of polymorphism.

The Siphonophora, unlike the Hydroida, are essentially pelagic animals: they are exclusively marine, and most characteristic of warm seas. They one and all form colonies, but the colony is unattached and either floats or swims. It produces sexual medusae comparable to those of a hydroid, and these may or may not be set free from the colony; consequently there may be an alternation of generations, both pelagic, or the medusa-generation may never gain independent existence. There is however this difference from the state of affairs among the Hydroida, that a medusa which is set free as such is an exception, and that it has never the full structure of a Hydroid medusa, possessing no mouth or sense-organs. Most siphonophore medusae remain attached to the colony or to a segment of it, and many of them exhibit grades of reduction in structure. These are known as *gonophores*, but they are never as degenerate as a Hydroid sporosac. From the eggs produced by the medusae or gonophores a planula larva of a curious type develops, and this by budding produces a colony. The siphonophore contrasts with a trachyline in that it is here the colony, and not the sexual medusa, which is the dominant form; and in addition to this a new factor is introduced which is not found either in the Trachylina or in the Hydroida. This is the production by the colony not only of more than one kind of polyp (as in *Hydractinia*) but also of more than one kind of medusa. In addition to the sexual medusae corresponding to the sole medusa-form in the other groups, there are found here medusae of modified structure which neither feed nor produce gonads, but which act as swimming-bells for the whole colony; and other structures which are also probably modified medusae. Of these latter one is a medusa transformed into a gas-containing float.



FROM PARKER AND HASWELL, "TEXT-BOOK OF ZOOLOGY" (MACMILLAN & CO. LTD.)

FIG. 9.—ENLARGED VIEW OF A TENTACULOCYST
In the endodermal core of this organ statoliths are visible. The tentaculocyst is mounted on a prominence from which rise long sensory hairs



FROM DELAGE AND HEROUARD, "ZOOLOGIE CONCRÈTE" (REINWALD) (COPR. BONNAIRE)

FIG. 10.—THE STRUCTURE OF A STRING-LIKE SIPHONOPHORE COLONY.
FIG. 11.—TYPES OF INDIVIDUALS TO BE FOUND IN A TYPICAL SIPHONOPHORE CLUSTER

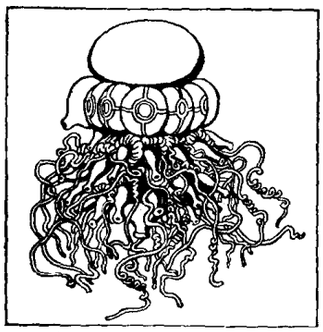
B, bract; C, coenosarc; CO, cormidium; D, dactylozooid; F, float; FL, tentacle of gastrozooid; G, bunch of gonophores; GZ, gastrozooid; NB, battery of sting cells; S, swimming-bell; T, tentacle of dactylozooid

Structure of Colonies.—It will be impossible to understand or to visualize the siphonophore organization, without first con-

sidering the structure of several typical colonies; these are so diverse in constitution that a general statement at the present stage would be unprofitable.

The first colony to be described will be that of *Halistemma* (figs. 10 and 11). At the upper end of this lies a small float, and depending from it a long thin string which is tubular and contractile. This is the *coenosarc* and corresponds to the stalk of an *Obelia*. Arranged on the string just below the float are a number of swimming-bells; each of these is a medusa attached to the coenosarc by a short stem arising from the outer side of its bell, and possessing radial canals and a velum but no manubrium or mouth. At intervals along the coenosarc are found little knots or clusters of individuals. These are not all alike, larger and smaller ones alternating regularly. Each cluster (*cormidium*) contains a certain number of individuals, but not the same selection in each case. The types of individuals comprised in the whole series are leaf-like protective structures, the *bracts*, together with digestive polyps (*gastrozooids*) each with a mouth and with a single tentacle which is attached to it at the base; other polyps (*dactylozooids*) with no mouths, each with a single tentacle at its base, which act as feelers and stingers; and lastly *blastostyles* upon which male and female gonophores are produced. The tentacles of the gastrozooids, which act as fishing-lines, are branched, the branches bearing terminal stinging-batteries; those of the dactylozooids are unbranched.

A type of colony similar in principle to that of *Halistemma* is formed by *Physophora*. Here we begin as before with a small float bearing a tubular string of coenosarc with swimming-bells. But below these bells, the rest of the coenosarc, instead of forming a long string, is short and compact, with the result that all the other individuals of the colony (which include dactylozooids, gastrozooids and blastostyles) are concentrated into a group with the dactylozooids forming a protective circlet round the outside. The same principle is further exemplified in a still more modified degree by *Stephalia* (fig. 12), in which the same essentials are present but the proportions and shapes of all the parts have changed. In this case the float is large and prominent and it opens to the exterior through a special spout-like structure (*aurophore*) at one side. The swimming-bells are restricted to a single circle below the float, instead of being strung out as in *Halistemma* and *Physophora*, and the coenosarc bearing the cormidia is neither the long string of the former nor the insignificant vesicle to which it is reduced in the latter, but is a bulky mass bearing in the middle of its lower surface a large terminal gastrozooid, and supporting the cormidia on its sides. This mass is penetrated by a number of tubes lined by endoderm, which run into each other and communicate with the digestive cavities of the gastrozooids.



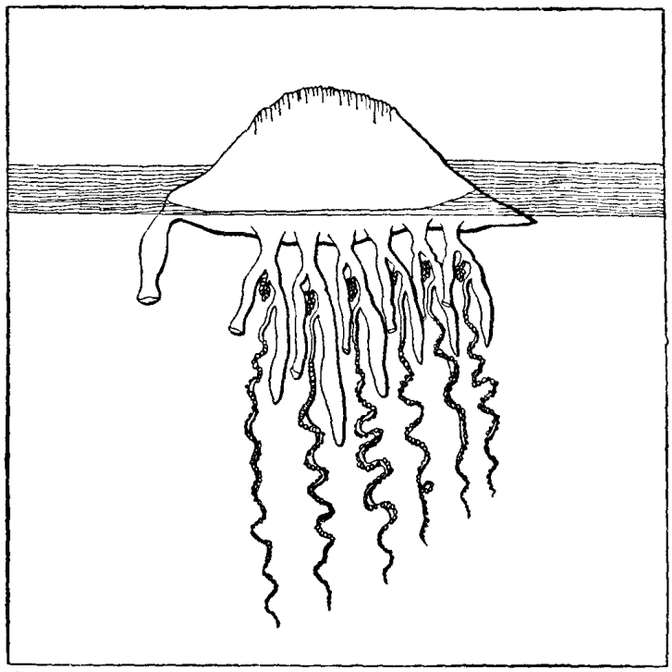
FROM E. RAY LANKESTER, "TREATISE ON ZOOLOGY," BY PERMISSION A. & C. BLACK

FIG. 12.—COLONY OF STEPHALIA

The swimming-bells are restricted to a single circle and not strung out as in *Halistemma* and *Physophora*

From *Stephalia* to *Physalia* (fig. 13) is a natural transition. Here there are no longer any swimming-bells, but there is a large crested float opening to the outside by a pore, and bearing a gastrozooid at one end. In a young *Physalia* the underside of the float bears directly half a dozen cormidia, each containing a gastrozooid without a tentacle, a dactylozooid with a long unbranched fishing-line, and a branching blastostyle bearing small dactylozooids upon it, and also male and female gonophores. As the colony increases in size new individuals are added somewhat irregularly upon the stalks of the old, and the simple early arrangement is lost. The colours of *Physalia* (blue, orange, etc.) are of great brilliance, and it is a well-known denizen of the Atlantic, Pacific and Indian Oceans, often occurring in fleets, and commonly known as "Portuguese Man-of-War." One of its fishing-lines reaches a greater length than all the others, attaining more than a yard; and the stinging powers of these lines are extremely powerful, producing serious conditions after contact with them even in man. The colony is not bound to float at the surface; it can deflate the float and sink, reforming the gas within it and so rising once more, within a quarter of an hour.

A colony quite unlike any so far described is formed by *Velella*. Here the whole organism has the aspect at first sight of a single flat medusa bearing a sail on its upper side and tentacles round its margin (fig. 14). On closer examination it is found, however, that the apparent tentacles are really a circle of long dactylozooids, and that the underside of the disc-like colony is covered by a number of curious blastostyles which, unlike an average blastostyle, possess mouths. In the centre of these is a single large gastrozooid, the only one which the colony possesses. The disc-like portion of the animal to which all these polyps are attached is complex in structure. It is thick and contains below the skin-layers of its upper side an internal horny float, below which is a mass of soft tissue, a concentrated coenosarc. The float is itself flattened in shape, is subdivided into chambers, bears a vertical extension in the centre stiffening the "sail," and is prolonged into the soft tissues as fine *air-tubes*. The coenosarc contains a ramifying system of endodermal tubules, in communication with the cavities of the various polyps, which is probably both absorptive and excretory in function. The coenosarc also contains a massive concentration of nematocysts, doubtless a nursery whence they migrate when sufficiently developed into the parts where they can function. Very similar to *Velella* but without a sail, is *Porpita*. In these creatures we have reached a stage in which the colony has become so compact and the parts so markedly subordinated to the whole that their interrelation resembles rather that of organs than that of independent beings; but free medusae are liberated by the colony.



FROM DELAGE AND HEROUARD, "ZOOLOGIE CONCRETE" (REINWALD) (COPR. BONNAIRE)

FIG. 13.—DIAGRAM OF A YOUNG COLONY OF PHYSALIA

From the crested float depend several cormidia. At the left end of the colony is a single large gastrozooid

Finally it may be mentioned that there are a number of siphonophore colonies which differ from any so far mentioned in that they possess swimming-bells but no float.

We may now summarize the state of affairs in this very curious group of animals. In the course of the above descriptions mention has been made of a number of structures—gastrozooids, blastostyles, dactylozooids; swimming-bells, floats, bracts; and sexual medusae (fig. 11). It remains to comment on the status of these various entities. Continuing the view which is taken throughout the articles on Coelenterata in this Encyclopædia, most or all of these structures represent individuals, modifications

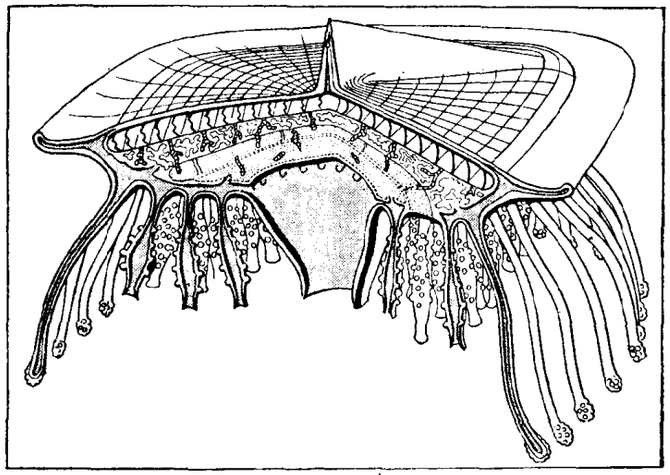
of either the polyp or the medusa form of body, or independently developed entities of equivalent standing. The gastrozooids and dactylozooids are varieties of polyp, the sexual medusae, the swimming-bells and probably the bracts are modifications of medusae. The float is sometimes regarded as the invaginated upper end of the stem of coenosarc and sometimes as a modification of a medusa. The status of the blastostyles is uncertain; they represent polyps in *Velella,* in other cases they are perhaps the present day substitute for bygone polyps.

It should be mentioned in conclusion that the Siphonophore is regarded by Moser not as a colony of individuals but as an individual animal with division of labour between organs and "on the way to alternation of generations and to colony-formation"; and that the medusae of *Velella* are regarded by this author as free-swimming gonophores leading up to true sexual medusae. The work of Moser has thrown considerable light on the morphology and the development of the Siphonophora and has made clearer than formerly the homologies of parts throughout the group, especially that of the float, which may fairly be regarded as equivalent to the apical adult bell of the forms with no float. This work also forms a valuable contribution to the question of evolution within the Siphonophora, but in the view of the present writer it hardly establishes the claim that a siphonophore is an individual animal (*see* also the following section on Polymorphism).

POLYMORPHISM

In the articles COELENTERATA and ANTHOZOA, and in the accounts of the groups of Hydrozoa already dealt with in the present article, references will be found to the phenomena known as *polymorphism* and *alternation of generations* (*metagenesis*). Since these phenomena are aspects of one and the same thing and are of general interest and importance, a summary of the subject is indicated. In the following remarks it is taken for granted that the articles above mentioned are familiar to the reader.

Firstly it must be made clear that alternation of generations as found in *Obelia* is simply an example of polymorphism, which may be defined as the ability of a single species of animal to exist



FROM DELAGE AND HEROUARD, "ZOOLOGIE CONCRÈTE" (REINWALD) (BONNAIRE)

FIG. 14.—DIAGRAM ILLUSTRATING THE STRUCTURE OF VELELLA

A sector of the disc-shaped coenosarc has been cut away so as to reveal the internal structure

under more than one form—in this instance as polyp and medusa. In a clear-cut case of alternation of generations one of these forms is sexual and *succeeds* the alternative non-sexual form, the two co-existing on a single colony only for the period during which the medusae are developing from buds. It may be noted that some writers no longer regard the polyp and medusa as alternate "generations," but the polyp as a persistent larva and the medusa as the adult. This view has its difficulties, however, and for purposes of the present argument the older terminology is retained. In any case the polyp phase is very persistent and has the general status of an adult organism.

The other type of polymorphism is that which is exhibited by such colonies as *Hydractinia* and in far higher degree by the Siphonophora, and in which there is not only the distinction of individuals into sexual and nonsexual forms, but the nonsexual polyps are themselves divided into kinds (gastrozooids, dactylozooids, etc.). This is exemplified even in *Obelia* by the distinction of the polyps into hydranths and blastostyles. In the Siphonophora there is the additional development that here there exist nonsexual as well as sexual medusae, and probably more than one kind of these (swimming bells, bracts and float).

In other words there exists: (*a*) a differentiation into sexual and nonsexual forms and (*b*) a division of labour between the nonsexual forms by virtue of which they become, for practical purposes, reduced to the condition of organs.

It must be noted, however, that the sexual forms tend to lose their independence; and the separate free-swimming generation so obvious in *Obelia* and similar forms becomes at the other end of the series a degenerate sporosac attached to the colony as permanently as any nonsexual individual. In fact it has become a sex-organ or gonad, and "alternation of generations" has been transformed into "division of labour."

Interesting divergences from the ordinary kinds of polymorphism typical of the Hydroida and Siphonophora are found among the Trachylina, Scyphozoa and in forms such as *Millepora.* In *Millepora* a polyp, be it a gastrozooid or a dactylozooid, becomes directly transformed under the influence of the immigrating sex cells into a medusa, instead of the medusa being formed from an independent bud. The polyp is a changeling. In the Trachylina the same process takes place, but in this case it is a pelagic or parasitic larval polyp which turns into a jellyfish, not an adult member of a colony. Among the Scyphozoa a unique condition exists; here the alternation of generations is very marked, and the medusa arises from the polyp direct; but in this case the polyp divides itself transversely into a series of superimposed saucer-like sections, which separate from it one by one, each becoming a medusa. A single polyp has therefore produced not one but several medusae. This is partly paralleled by a blastostyle; for if the latter be a polyp, it produces by *budding,* several medusae: but the scyphozoan polyp achieves the same end quite differently.

The Anthozoa are the least interesting of the Coelenterata from the point of view of polymorphism. They possess no medusoid form and among their polyps little polymorphic variation in form occurs. In certain colonial forms ordinary polyps and siphonozooids co-exist, and there is also a distinction in some colonies between an original axial polyp and those subsequently formed. In the coral *Fungia* part of the life cycle in some respects resembles the strobilization of the Scyphozoa.

Polymorphism is chiefly interesting as an example of the extraordinary ability of animals to produce an almost infinite number of variations upon a given theme. It has also been much employed as a subject for argument, however. The argument frequently adopted has been that a siphonophore or a compound Hydroid is a *colony* and that its parts represent, morphologically speaking, *individuals* connected by a common intermediate tissue, the coenosarc. This view may appear to be far-fetched when one contemplates a sporosac, which is in effect a gonad, since it involves the claim that this structure represents not an organ but an animal. It is also true that in some cases, such as those of meandrine corals, it is difficult to decide whether a polyp with a dozen mouths represents one polyp or twelve. But taking the whole story, as presented to us throughout the Coelenterate series, as a unity, the interpretation of the systems encountered as colonies of individuals appears to be the soundest working hypothesis. The alternative view, that everything which results from the development of a single egg is an individual animal, however much it may subdivide asexually, and that gastrozooids, bracts and the rest are nothing more than the organs of this animal, seems relatively satisfactory when applied to such a form as the adult *Velella.* But when one applies it to a free-swimming medusa it becomes reduced to an absurdity—is a jellyfish, an organism provided with mouth and stomach, canals, velum, tentacles and sense organs, simply a moving *organ* and not an animal at all? Further, one may meet on many shores hosts of sea anemones, none of which have developed from eggs—each is an independent organism, not

part of a colony, and each has been produced asexually by fission. Are these anemones then "organs"? To reduce the term "organ" to such a level is to remove its actual meaning. It is interesting to note that Moser combines the two theories by regarding the Coelenterata other than Siphonophora as colonies of individuals, but the Siphonophora themselves as relatively primitive organisms, individuals comprising organs and the forerunners of true colonies.

In this connection it should however be noted that in the above paragraphs the term "individual" has been used in a purely morphological sense—*i.e.*, the individuals of a Siphonophore represent morphological individuals which have suffered a loss of independence similar to that of the component cells of any multicellular animal, which latter may be regarded as having been derived originally from a colony of individual single-celled animals (protozoa). In a physiological sense on the other hand the Siphonophore colony is a unity and may be regarded as an individual system. The status of such a system in relation to the wide general question of individuality is discussed in INDIVIDUALITY.

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HYENA, the name applied to members of the family Hyaenidae, a group of Carnivora (*q.v.*) distinguished by the four toes on each foot, the comparative length of the forelegs, the non-retractile claws, and the enormous strength of the jaws and teeth, enabling them to crush hard bones. Three species are known; two belong to the genus *Hyaena,* while the other is *Crocuta.*

The striped hyena (*H. striata*) has the widest distribution, being found in India, Persia, Asia Minor, North and East Africa. About the size of a wolf, the animal is grayish-brown in colour, marked with indistinct longitudinal stripes of a darker hue. There is a mane along the neck and back. The animal is nocturnal in habits and has an unearthly cry, aptly compared to demoniac laughter. It feeds mainly on carrion, but occasionally carries off sheep, goats and dogs. It is a solitary and cowardly animal.

The brown hyena (*H. brunnea*) is South African, and about the size of the striped species. It is ashy brown in colour, with a lighter collar, chest and belly. The spotted form (*C. crocuta*) ranges from Abyssinia to the Cape, and is yellowish-brown, with darker spots. Both spotted and striped hyenas have been found fossilized in the Pliocene of Europe.

HYÈRES, a town in the department of the Var in S.E. France, 11 mi. by rail E. of Toulon. Pop. (1946) 23,654. The town of Hyères was founded in the 10th century, as a place of defense against pirates, and takes its name from the *aires* (*hierbo* in the Provençal dialect), or threshing-floors for corn, which then occupied its site. It passed from the possession of the viscounts of Marseille to Charles of Anjou, count of Provence. The château on the summit of the hill was dismantled by Henri IV, but the town resisted in 1707 an attack made by the duke of Savoy. Hyères is celebrated (as is also its fashionable suburb, Costebelle, nearer the seashore) as a winter health resort. The town is situated about 2½ mi. from the seashore on the sheltered southwestern slope of a steep hill (669 ft. of the Maurettes chain) but is exposed to the Mistral. To the southwest, across a narrow valley, is the suburb of Costebelle. The older portion of the town is surrounded, on the north and east, by remnants of its mediaeval walls, and has steep and dirty streets. The more modern quarter has broad boulevards and villas, with gardens, filled with semi-tropical plants. The parish church of St. Louis was built originally in the 13th century by Franciscan friars, and restored in the 19th century. The plain between the new town and the sea has large nurseries, an excellent *jardin d'acclimatation* and many market gardens, which supply Paris and London with early fruits and vegetables, especially artichokes and roses in winter.

HYGIEIA, in Greek mythology, the goddess of health. The eldest traces of her cult, so far as is known at present, are to be found at Titane in the territory of Sicyon, where she was worshipped together with Asclepius, to whom she appears completely assimilated, not an independent personality. Her cult was not introduced at Epidaurus until a late date, and therefore, when in 420 B.C. the worship of Asclepius was introduced at Athens coupled with that of Hygieia, it is not to be inferred that she accompanied him from Epidaurus, or that she is a Peloponnesian importation at all, but rather a new invention, an offshoot of the

VOTIVE RELIEF FOR AN AESCULAPIUM, OR TEMPLE OF AESCULAPIUS; GREEK SCHOOL, EARLY 4TH CENTURY, B.C.; ORIGINAL IN NATIONAL MUSEUM AT ATHENS

already existing worship of Athena Hygieia. At first no special relationship existed between Asclepius and Hygieia, but gradually she came to be regarded as his daughter, the place of his wife being already secured by Epione. Later Orphic hymns, however, and Herodas, iv, 1–9, make her the wife of Asclepius. The cult of Hygieia then spread concurrently with that of Asclepius, and was introduced at Rome from Epidaurus in 293, when she was gradually identified with Salus (*q.v.*). While in classical time Asclepius and Hygieia are simply the god and goddess of health, in the declining years of paganism they are protecting divinities.

See H. Lechat in Daremberg and Saglio's *Dictionnaire des antiquités,* and E. Thrämer in Roscher's *Lexikon der Mythologie.*

HYGIENE, the science of preserving health. The subject embraces all agencies affecting the physical and mental well-being of man, and requires acquaintance with physics, chemistry, geology, engineering, architecture, meteorology, epidemiology, bacteriology and statistics. On the personal side it involves consideration of food, water and other beverages; clothing; work, exercise and sleep; personal cleanliness, special habits, such as the use of tobacco, narcotics, etc.; and control of sexual and other passions. In its public aspect it deals with climate; soil; character, materials and arrangement of dwellings; heating and ventilation; removal of waste matters; medical knowledge on incidence and prevention of disease; and disposal of the dead.

These topics are treated in such articles as ADULTERATION; BACTERIOLOGY; CREMATION; DIET AND DIETETICS; FOOD PRESERVATION; HEATING AND VENTILATION; HOUSING; INDUSTRIAL MEDICINE; MATERNAL AND CHILD HEALTH; PSYCHIATRY; SEWER CONSTRUCTION; SOCIAL HYGIENE; VENTILATION; WATER; etc. *See* also PREVENTIVE MEDICINE; PUBLIC HEALTH.

HYGINUS (d. *c.* 140), eighth pope. It was during his pontificate (*c.* 137–140) that the gnostic heresies began to appear in Rome. See *Liber Pontificalis* ed. Duchesne.

HYGINUS (surnamed GROMATICUS, from *gruma,* a sur-

veyor's measuring rod), Latin writer on land surveying, flourished in the reign of Trajan (A.D. 98–117). Fragments of a work on legal boundaries attributed to him will be found in C. F. Lachmann, *Gromatici Veteres,* i (1848).

A treatise on Castrametation (*De Munitionibus Castrorum*), also attributed to him, is probably of later date, about the 3rd century A.D. (ed. W. Gemoll, 1879; A. von Domaszewski, 1887).

HYGINUS, GAIUS IULIUS, Latin author, a native of Spain (or Alexandria), was a pupil of the famous Cornelius Alexander Polyhistor and a freedman of Augustus, by whom he was made superintendent of the Palatine library (Suetonius, *De Grammaticis,* 20). His numerous works included topographical and biographical treatises, commentaries on Helvius Cinna and the poems of Virgil and disquisitions on agriculture and beekeeping. All these are lost.

Under the name of Hyginus there are extant: (1) *Fabularum Liber,* some 300 mythological legends and celestial genealogies, valuable for the use made by the author of the works of Greek tragedians now lost; (2) *De Astronomia,* usually called *Poetica Astronomica,* containing an elementary treatise on astronomy and the myths connected with the stars, chiefly based on Eratosthenes. Both are abridgments and both are by the same hand; but the style and the elementary mistakes (especially in the rendering of the Greek originals) are held to prove that they cannot have been the work of so distinguished a scholar as Hyginus. It is suggested that they are an abridgment (made in the latter half of the 2nd century) of the *Genealogiae* of Hyginus by an unknown grammarian, who added a complete treatise on mythology.

EDITIONS:—*Fabulae,* by M. Schmidt (1872); *De Astronomia,* by B. Bunte (1875); *see* also Bunte, *De C. Julii Hygin, Augusti Liberti, Vita et Scriptis* (1826).

HYGROMETER, an instrument for determining the humidity of the atmosphere (Gr. *ὑγρός,* wet, *μέτρον,* a measure). These instruments can be classed according to the method employed for detecting moisture, namely: (1) hair or strips of goldbeater's skin, making use of the principle that these organic substances will increase in length as the relative humidity is increased; (2) dew point apparatus, making use of cooling devices so as to cause the water vapour to condense from the air and measuring the temperature at which the condensation occurs; (3) chemical absorption, making use of chemical drying agents which extract the moisture from the air, and (a) the increased weight of the dryer noted, (b) the change in volume of the air at constant pressure being measured or (c) the change in pressure at constant volume being measured; (4) electrical, making use of the principle that changes in the electrical resistance of a chemically-treated coil of wire can be related to changes of relative humidity.

(B. G. H.)

HYKSOS or "SHEPHERD KINGS," the name of the earliest invaders of Egypt. Josephus (*c. Apion.* i, 14), who identifies the Hyksos with the Israelites, preserves an account of them from bk. ii of Manetho. According to it, in the days of King Timaeus, Egypt was invaded from the east by a destructive band who elected a king named Salatis. He made all Egypt tributary and established garrisons and fortresses in various parts of the country. His successors Beon, Apachnas, Apophis, Jannas and Asses reigned *c.* 199 years, and all aimed at extirpating the Egyptians. Their race was named Hyksos; *i.e.,* "shepherd kings," and some say they were Arabs (another explanation found by Josephus is "captive shepherds"). When their successors had held Egypt for 511 years, a rebellion began at Thebes. Misphragmuthosis confined the "Shepherds" in Avaris; and his son Thutmosis, failing to capture the stronghold, allowed them to depart; whereupon they established themselves, 240,000 in number, in Judea and built Jerusalem. In Manetho's list of kings, the six above named form the 15th dynasty and are called "six foreign Phoenician kings." The 16th dynasty is made up of 32 "Hellenic shepherd kings," the 17th is of "shepherds and Theban kings" (reigning simultaneously). The lists vary greatly in different versions, but the above seems the most reasonable selection of readings. For "Hellenic" *see* below. In 1847 E. de Rougé proved from a papyrus of the British museum that Apopi was one of the latest of the Hyksos kings, corresponding to Aphobis; he was king of the "pest" and suppressed the worship of the Egyptian gods in favour of his god Setekh or Seti. In 1850 a record of the capture of Hawari (Avaris) from the Hyksos by Ahmosi, founder of the 18th dynasty, was discovered by the same scholar. A large class of monuments was afterwards attributed to the Hyksos. Some statues, found in 1861 by Mariette at Tanis, had peculiar "un-Egyptian" features. One of these bore the name of Apopi engraved lightly on the shoulder, and on other grounds it was concluded that the features were those of the Hyksos. In 1893 Golenischeff produced an inferior example bearing its original name, which showed that it represented Amenemhe III. In consequence it is now generally believed that they all belong to the 12th dynasty. Meanwhile a headless statue of a king named Khyan, found at Bubastis, was attributed to the Hyksos, the soundest arguments being his foreign name and the boastful un-Egyptian epithet "beloved of his *ka.*" His name was afterwards recognized on a lion found in Baghdad. Flinders Petrie then pointed out a group of kings named on scarabs of peculiar type, which, including Khyan, he attributed to the period between the Old Kingdom and the New, while others were in favour of assigning them all to the Hyksos, whose appellation seemed to be recognizable in the title Hek-khos, "ruler of the barbarians," borne by Khyan.

HYLAS, in Greek legend, son of Theiodamas, king of the Dryopians in Thessaly, the favourite of Hercules and his companion on the Argonautic expedition. Having gone ashore at Kios in Mysia to fetch water, he was carried off by the nymphs of the spring in which he dipped his pitcher. Hercules sought him in vain; and ever afterwards, in memory of the threat of Hercules to ravage the land if Hylas were not found, the inhabitants of Kios every year on a stated day roamed the mountains, shouting aloud for Hylas (so Apollonius Rhodius I, 1207 et seq., and later authors). But, although the legend is first told in Alexandrian times, the "cry of Hylas" occurs long before as the "Mysian cry" in Aeschylus (*Persae,* 1054); and in Aristophanes (*Plutus,* 1127) "to cry Hylas" is used proverbially of seeking something in vain.

HYLOZOISM, in philosophy, a term applied to any system which explains all life, whether physical or mental, as ultimately derived from matter ("cosmic matter," *Weldstoff*) (Gr *ὕλη* matter, *ζωή,* life). Such a view of existence has been common throughout the history of thought and especially among physical scientists. Thus the Ionian school of philosophy, which began with Thales, sought for the beginning of all things in various material substances, water, air, fire (*see* IONIAN SCHOOL OF PHILOSOPHY). These substances were regarded as being in some sense alive and taking some active part in the development of being. This primitive hylozoism reappeared in modified forms in mediaeval and Renaissance thought, and in modern times the doctrine of materialistic monism is its representative.

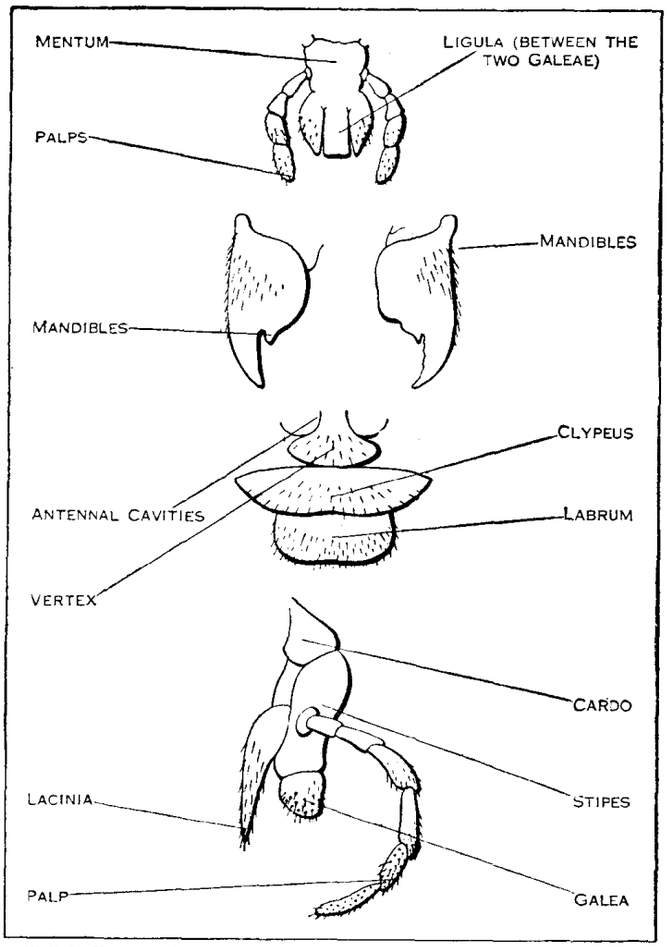
HYMANS, PAUL (1865–1941), Belgian statesman, was born at Ixelles, Brussels, on March 23, 1865. He became a barrister in 1885, and from 1898 to 1914 was professor of comparative parliamentary history at Brussels university. From 1900 he was deputy for Brussels and soon became the Liberal leader. After a mission to President Wilson in Aug. 1914 he was plenipotentiary in London, 1915–17, when he became head of the ministry of economic affairs. From 1918–20 and 1924–25 he was minister for foreign affairs. In Nov. 1918 he attended the Inter-Allied council at Versailles; he also represented Belgium at the peace conference in 1919 and on her behalf signed the peace treaty. In the same capacity he attended the conferences at San Remo, Boulogne, Brussels and Spa. He played a leading part in the settlement of the Ruhr question, the Dawes plan, the Security pact and the economic union of Luxembourg with Belgium. In Jan. 1920 he was appointed Belgian representative on the League of Nations and in the same year was made president of the first assembly at Geneva. He was again minister for foreign affairs, 1927–34 and 1934–35, and member of the council of ministers, 1935–36. A member of the Académie Royale de Belgique, Hymans continued *L'histoire parlementaire de la Belgique* (1875, etc.) and wrote *Frere-Orban* (1905, etc.), *Portraits, essais et discours*

(1914), and *Pages libérales* (1936).

HYMEN or HYMENAEUS, originally the refrain of the song sung at marriages among the Greeks. As usual, the name gradually produced the idea of an actual person whose adventures gave rise to the custom of this song. He occurs often in association with Linus and Ialemus, who represent similar personifications, and is generally called a son of Apollo and a muse. As the son of Dionysus and Aphrodite, he was regarded as a god of fruitfulness. In Attic legend he was a beautiful youth who, being in love with a girl, followed her in a procession to Eleusis, disguised as a woman, and saved the whole band from pirates. As reward he obtained the girl in marriage, and his happy married life caused him ever afterwards to be invoked in marriage songs (Servius on Virgil, *Aen.* i. 651).

See J. A. Hild in Daremberg and Saglio's *Dictionnaire des antiquités.*

HYMENOPTERA, the term used in zoological classification for that order of insects comprising ants, bees, wasps, and their allies the sawflies, gall wasps and ichneumon flies. These insects all exhibit the following characters: (1) The presence of two pairs of stiff membranous wings often with the venation reduced



FROM MARLATT, "ENTOMOLOGICAL BULLETIN," U.S. DEPT. OF AGRIC.

FIG. 1.—HYMENOPTERA: MOUTH PARTS OF SAWFLY (PACHYNEMATUS)
These are used principally for feeding, but in the bee the ligula is modified for sucking nectar

or almost absent: the hind wings are smaller than the fore pair and are interlocked with them by tiny hooklets. (2) The mouth parts have biting jaws, but the labium is usually modified into a kind of tongue for lapping or sucking. (3) The abdomen is generally constricted at the base to form a waist and its first segment forms a part of the thorax: an ovipositor is present and used for sawing, piercing or stinging. (4) Metamorphosis is complete and the larvae are either caterpillars or more often vermiform: the pupae may be in cocoons; their appendages are free.

Hymenoptera form one of the largest and most highly developed orders of insects and are of great interest, not only on account of the perfection of their structure but also with regard to the remarkable development of their instincts. In the latter respect they stand at the head of all invertebrate animals and their behaviour has been the subject of studies by many famous naturalists. About 80,000 species were known by 1945, but many thousands more still awaited discovery, and even in the British Isles it is only the ants, bees and wasps that have been adequately collected

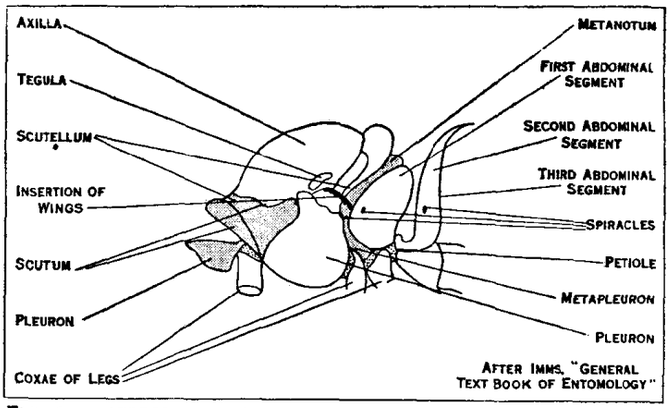
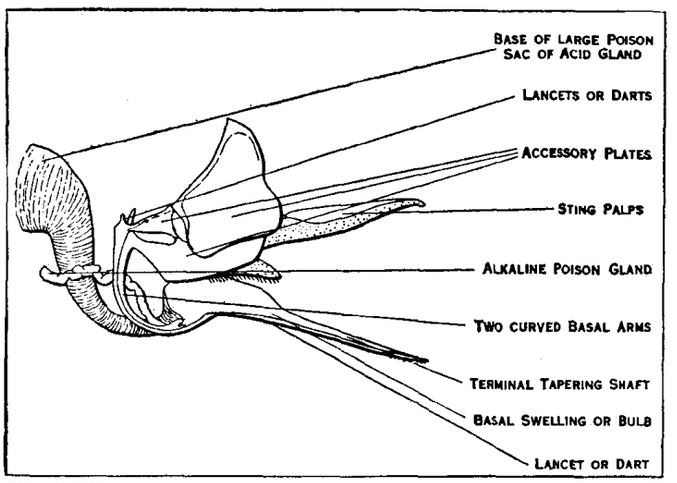


FIG. 2.—LATERAL VIEW OF THE THORAX AND BASE OF ABDOMEN OF HONEYBEE
The thorax is chiefly characterized by its fusion with the first segment of the abdomen. The parts of the pre- and metathorax are shaded; mesothorax and abdomen are plain

and studied. Although the vast number of species are solitary like other insects, individuals of some species have acquired the habit of living together in great societies as is the case in ants and certain bees and wasps: their social life and behaviour is fully discussed in the article SOCIAL INSECTS. Hymenoptera are also remarkable for the highly evolved condition parasitism has reached in the order: tens of thousands of species betray this habit, and although they confer immense benefit to man as agents destroying other forms of insect life, they have been little collected, and in many parts of the world are very slightly known.

General Structure.—Hymenoptera have acute vision; the compound eyes are consequently large and there are usually three ocelli or simple eyes. The antennae are sometimes dimorphic in



FROM SNODGRASS, "ANATOMY OF THE HONEY BEE," U.S. DEPT. OF AGRIC.

FIG. 3.—SEMI-DIAGRAMMATIC VIEW OF LEFT SIDE OF STING OF WORKER HONEYBEE

the two sexes and in the bees and wasps they are generally composed of 13 joints in the males and 12 joints in the females. The mouth parts exhibit their simplest form in sawflies (fig. 1) where they depart but little from the generalized biting type. In most other Hymenoptera the mandibles are used for what may be termed industrial purposes more than for feeding, and the ligula is modified into an organ for lapping or sucking nectar. In the higher types of bees this organ is elongated into a kind of tongue which, in some cases, exceeds in length that of the entire insect. In these instances the labial palpi and maxillae are also correspondingly lengthened and form, with the ligula, a definite proboscis

(fig. 1). The thorax (fig. 2) is chiefly characterized by the fusion of its last segment with the *propodeum* or first segment of the abdomen. In the sawflies this union is not complete, but in all other Hymenoptera it is a pronounced feature and the second abdominal segment (or first apparent segment) is constricted to form a waist or *petiole*. The wings have departed very widely from the primitive type of venation and almost every transition can be found from the well developed condition seen in sawflies to some of the parasitic forms where there is only a single vein to the fore wings or even no vein at all. At the bases of the fore wings are small scalelike plates or *tegulae,* which afford important characters used in classification. Most members of the order fly with the wings of a side interlocked by a row of hooklets. In the female the abdomen bears an elaborate ovipositor, typically composed of three pairs of valves. The first pair arises from the eighth segment and forms the lancets, while the other pairs arise from the ninth segment and form the lancet sheath and the so-called sting palps respectively (fig. 3). In addition to functioning as an egg-laying instrument the ovipositor is used in sawflies for sawing niches in plants into which the eggs are lodged: in ichneumon flies and their allies it is often employed in stabbing their insect hosts preparatory to laying their eggs within the bodies of the latter: in bees, wasps and some ants it is used for stinging, a habit which is found in no other insects.

Classification.—Hymenoptera are grouped into two main suborders and these, along with their chief subdivisions, are enumerated below.

SUBORDER I. CHALASTOGASTRA

Abdomen with no definite basal constriction or waist: trochanters 2-jointed. Larvae generally caterpillars with a variable number of legs.

Superfamily Tenthredinoidea. Included in this division are all the more primitive members of the order: they do not exhibit the specialized habits and instincts of the Clistogastra and their larvae are almost exclusively plant feeders. The best known family is the Tenthredinidae or sawflies (*q.v.*) which are distinguished by two large spines or spurs to each fore tibia. Their larvae are caterpillars which feed upon the leaves of plants, and those of a number of species are injurious to cultivated plants and forest trees. The ovipositor is usually elaborately toothed,

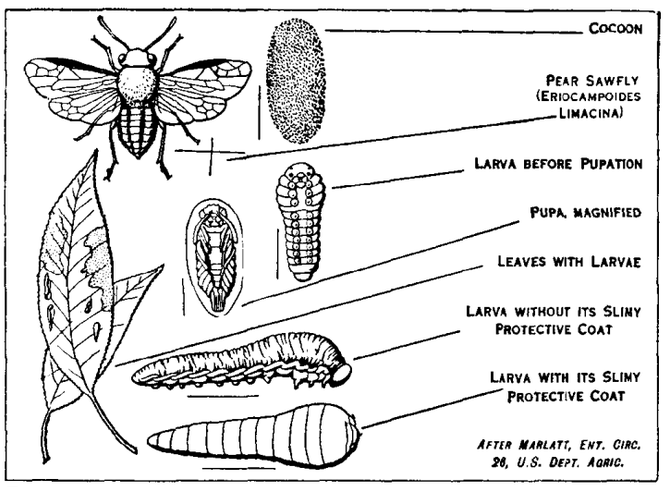


FIG. 4.—LIFE HISTORY OF PEAR SAWFLY (ERIOCAMPOIDES LIMACINA)
The larvae are plant feeders, those feeding openly on leaves being caterpillars, often with six or more pairs of feet

and is used for sawing notches to enable the eggs to be laid in plant tissues. The Cephidae or stem sawflies are a small group whose larvae feed in the stems of various plants, while those of the Siricidae or wood wasps bore into the wood of trees.

SUBORDER II. CLISTOGASTRA

Abdomen with a basal constriction or waist: trochanters 1- or 2-jointed. Larvae embryonic or vermiform without legs.

The great group is divisible into the *Parasitica* which generally have 2-jointed trochanters and the *Aculeata* or stinging forms in which the trochanters are single-jointed. The *Parasitica* include the following superfamilies.

The Ichneumonoidea have the pronotum extending back to the tegulae, the antennae are not elbowed and the fore wings have a

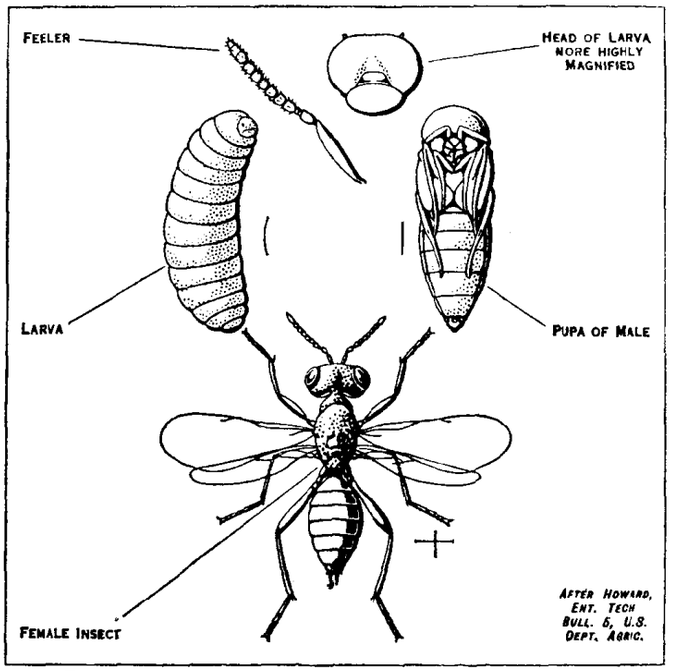


FIG. 5.—LIFE HISTORY OF CHALCID (DIBRACHYS CAVUS)
The suborder Clistogastra is chiefly characterized by the narrowly constricted waist of the adult and by the legless condition of the larvae

dark mark or stigma (fig. 7). The larvae of all members of this group are parasites preying upon some stage in the life cycle of other insects or spiders and are consequently of great economic importance. (*See* ICHNEUMON FLY.)

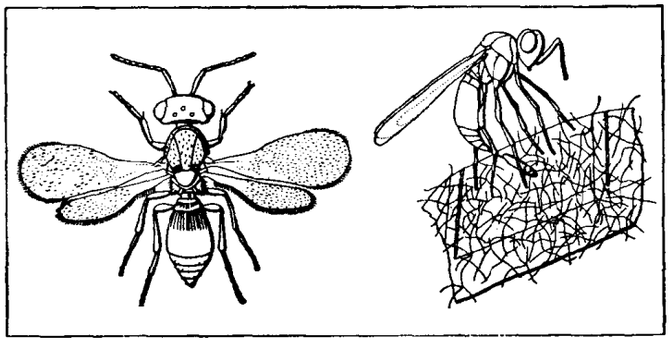
The Cynipoidea include the gall wasps or gallflies which differ from the ichneumons in the absence of a stigma to the fore wings and in the usually single-jointed trochanters, unlike most other Parasitica. In the family Cynipidae many of the species lay their eggs in various plant tissues which react in such a way that galls are produced wherein their development is completed. These galls are of characteristic form for each species, the oak apple and bedeguar of the rose being familiar examples. Other members of the family are inquilines, living within the galls and bearing a close resemblance to the true makers of the latter. The Figitidae are parasites, usually attacking fly larvae and aphides.

The Chalcidoidea or chalcid wasps (fig. 5) are very small insects with elbowed antennae and with the pronotum not extending back to the tegulae. The group includes more than 16 families, most of the members of which are either parasites of the eggs, larvae or pupae of other insects, or are hyperparasites. A small number are plant feeders living in seeds, in figs, or forming galls on cereals and grasses. The fig insects are very numerous; certain of these are important agents in the pollination of the flowers, and have been introduced for economic purposes into lands where they were absent. The parasitic forms are of great practical value, in that they destroy vast numbers of injurious insects: certain of these exhibit the phenomenon of polyembryony, which is dealt with in the article INSECTS. Chalcids often exhibit beautiful metallic coloration, and can be recognized by the wing veins being reduced to a single stem.

The Serphoidea resemble the Aculeates in that the ovipositor issues from the apex of the abdomen, but the trochanters are usually 2-jointed. This character, together with the fact that the pronotum reaches back to the tegulae, separates them from the chalcids (fig. 5). They are all very small or minute insects with greatly reduced venation, and many are wingless. They live as parasites of other insects, or of spiders, and frequently in the eggs, which they destroy in large numbers. The largest of the

eight chief families are the Platygastridae which mainly parasitize gall midges, their larvae often living in the brain or stomach of their hosts. Like the chalcids, the Serphoidea are beneficial.

The succeeding superfamilies form the series Aculeata or stinging Hymenoptera and in these the ovipositor issues from the apex



FROM SYLVESTRI, "PLATYGASTER DRYOMIAE" IN "BOLLETTINO DEL LABORATORIO DI ZOOLOGIA" (SCUOLA SUPERIORE D'AGRICOLTURA IN PORTICI)

FIG. 6.—A FEMALE PROCTOTRYPID (PLATYGASTER DRYOMIAE)
On the right the female is seen in the act of oviposition in an egg (O), of a gall midge, on a leaf

of the abdomen, whereas in the Parasitica it issues some distance in front of the extremity.

The Formicoidea or ants form a very natural assemblage which are easily recognized by the greatly constricted "waist" and by the petiole being marked by one or two nodes: the pronotum extends backward, but the tegulae are wanting and the antennae are elbowed. The females are differentiated into winged "queens" and wingless workers of varied forms; each species of ant leads a complex social life which presents many phases of surpassing interest. (*See* ANT and SOCIAL INSECTS.)

The Sphecoidea or digging wasps (fig. 8) are marked off from the Vespoidea by the fact that the pronotum forms a collar and does not reach back to the tegulae. For the most part they are to be regarded as beneficial insects from the fact that they are predators seizing other insects, which they carry off to their cells as food for their larvae. All are solitary insects which construct cells for their brood either below ground or in dry wood or stems. There are 12 families, the largest being the Sphecidae.

The Vespoidea include a large number of other digging wasps together with the social wasps. The pronotum generally reaches back to the tegulae but there are exceptions. Among the solitary species, some Mutillidae are parasites in bumblebees' nests and their females are wingless. The Pompilidae provision their cells with spiders: they are often large insects with slender bodies and elongate hind legs. The Scoliidae are robust, hairy wasps which often deposit their eggs in chafer larvae and chiefly inhabit warm countries. The Chrysididae or ruby-tailed wasps are beautiful metallic green or green and blue or ruby insects, which lay their eggs in the nests of bees and wasps where their larvae either prey upon those of their hosts or devour their food. In this family only three or four abdominal segments are visible, the remainder forming a retractile tube containing the ovipositor. The true wasps have their wings folded lengthwise in repose and the fore legs are of normal build—not specialized for digging as in the fossorial groups. The Vespidae or social wasps have "queens" and "workers" as in ants, but both forms are winged, while the Eumenidae or solitary true wasps have no such differentiation into castes. (For the habits of these two families *see* WASP and SOCIAL INSECTS.)

The Apoidea include the solitary and social bees which agree with the Sphecoidea in the pronotum not extending back to the tegulae but differ from them in having the hind tarsi dilated, while the hairs of the head and thorax are feathery or plumose. The glossa or tongue is well developed and often exceedingly long and the food consists of nectar and pollen. The larvae are fed upon a similar diet, except that the nectar is regurgitated as honey before being served to them. These substances are stored in the cells and the latter are never provisioned with animal food. Most bees are solitary in habit, but those of the families Bombidae, Meliponidae and Apidae are social insects resembling ants and wasps in the occurrence of a worker caste. (*See* BEE and SOCIAL INSECTS.)

Reproduction and Development.—One of the most interesting facts with regard to reproduction in Hymenoptera is the wide occurrence of parthenogenesis which obtains among members of all the great groups. The best known instance is in the honeybee, in which the unfertilized eggs produce males (drones): in the gall wasps or Cynipidae both sexes may be produced from unfertilized eggs and the generations which arise in this way alternate with those produced by the usual sexual method. In other of the gall wasps males are unknown: parthenogenesis is also very frequent in sawflies and chalcid wasps.

The larvae of the Chalastogastra are plant feeders: those which feed openly on leaves are caterpillars, often with six or more pairs of abdominal feet (fig. 4), but in the stem and wood borers these appendages are absent and the thoracic limbs are reduced to mere tubercles. Among the Clistogastra the larvae are usually hatched in immediate contact with an abundance of food: they are in consequence degenerate creatures devoid of limbs and of almost all traces of organs of special sense (fig. 5). In the parasitic groups hypermetamorphosis (*see* INSECTS) is very frequent, the larvae being hatched in forms very different from that assumed in the final instar. In a few cases the eggs are laid away from the hosts and the larvae upon hatching are active creatures of the type termed a planidium. The planidium seeks out its host, and having found it, assumes the legless maggot-like form common to all Clistogastra. Some of the parasitic species live externally on their hosts and feed by piercing the integument with their mouth parts, but the largest number are endoparasites. In the latter case the female parent drives her ovipositor into the host and lays one or more eggs wherever the larvae will find abundant food. Many of the minute Chalcidoidea and Serphoidea complete their development within the eggs of other insects: others parasitize the larvae or pupae or, more rarely, adult insects, and death of the host finally supervenes. The digging or fossorial wasps feed their brood with captured insects, which are stored away in cells along with a single egg: the wasp larva, upon hatching, thus finds its life's food supply immediately at hand. The true wasps feed their brood with animal food including many insects, from time to time, very much as a bird does her fledglings, while bees entirely resort to honey and pollen. Thus, we find throughout the order a degree of care for the offspring, not attained in other insects, which has led to the development of social life in certain groups. When fully fed most Hymenoptera pupate in cocoons formed of silk secreted for this purpose; and among the ichneumon flies and their allies, these cocoons are often elaborate and beautiful objects.

Geographical Distribution.—Hymenoptera are found in all except the most inhospitable regions of the globe, but the order, as a whole, has not penetrated to such remote parts as have the Apterygota and Coleoptera. Bees, for example, are dependent upon the existence of flowering plants and are not found outside their range: some, such as the giant *Xylocopa* or carpenter bees are mainly tropical or subtropical, while bumblebees are essentially creatures of temperate climates and are generally confined to the mountains in the tropics; they are absent from almost the whole of Africa, the plains of India and none are indigenous to Australia or New Zealand. The honeybee (*Apis mellifica*) has been introduced into most countries of the world, and some of the injurious sawflies enjoy a very wide distribution, mainly through the agency of commerce. Among the chalcid wasps the family Agaonidae, or fig insects, occurs wherever trees of the fig kind flourish, but are not found outside that limit: certain other chalcids (Eucharidae) are mainly tropical and are confined to where their particular ant hosts flourish. Perhaps the most interesting fact concerning the distribution of Hymenoptera is the great paucity of forms found in New Zealand, where they are represented by little more than 300 species, as compared with more than 6,000 found in Australia.

Geological Distribution.—The first members of the order to appear in geological history are wood wasps of the genus *Pseudosirex* from the Upper Jurassic of Bavaria. Certain parasitic Hymenoptera appeared soon afterward and some very highly specialized types occur in the Cretaceous of Canada. In Baltic