CHAPTER IX

PORIFERA AND COELENTERATA

Porifera, *e.g.*, sponges, and Coelenterata, *e.g.*, jelly fishes, are called *Diploblastic Animals*. By this is meant that the body consists of two differentiated cell layers called *ectoderm* and *endoderm*. All the Metazoa are *diploblastic* during their early development.

Formation of Ectoderm and Endoderm. The fertilized egg divides into 2, 4, 8, 16, etc., cells (Fig. 303), often forming a spherical clump of cells resembling Pandorina, a stage known as the *Morula* (Fig. 303). The cells continue to divide and a cavity forms within the cell mass, which, remaining spherical, consists of but one layer of cells, about a central *segmentation cavity*. It resembles the protozoan, Volvox. This stage is known as the *Blastula* (Fig. 305). Then in many Metazoa, cells at one point in the blastula divide more rapidly than the others and *invaginate* into the *segmentation cavity*. The ingrowing cells form a blind tube or sac within the outer cell layer. Thus a double sac is formed. This stage is known as the *Gastrula* (Fig. 305). The inner blind tube is the embryonic intestine, composed of *endoderm* cells. The function of this embryonic intestine, or *archenteron* as it is called, is in general *metabolic, i.e.*, it develops structures having to do with ingestion, secretion, digestion, etc. The outer layer of cells constitutes the *ectoderm*, which is concerned with the functions of *adjustment*. The entrance to the archenteron is the *blastopore*, and it serves as a mouth and an anus. The gastrulae of some Metazoa function as free-living organisms soon after gastrulation is completed. Such a gastrula has to provide its own food from without in order to complete its development. In other cases, this stage is passed through quickly, and energy for development is derived from material stored up within or adjacent to the cells, or from the mother.

PHYLUM — PORIFERA

The Porifera or sponges are *diploblastic Metazoa*, but their early development is unlike that of the other Metazoa. The early

embryo swims about but later settles down with the blastopore at the bottom. This closes and the body, being urn- or flask-shaped (Fig. 125), develops a *new* opening at the free or opposite end. The body wall develops complicated passageways (Fig. 126) or pores through which water enters the central cavity. Microorganisms are taken up by appropriate cells lining the passages and so the animal feeds. Water currents pass out through the opening or *osculum* at the free end. Sponges were formerly considered plants on account of their lack of motion and because of their vegetative habits. They differ in so many ways from the remaining Metazoa that they have been called Parazoa, or *alongside animals*. There are about 2500 species. A few may be regarded as simple individuals, while many, such as the common bath sponge, *Euspongia* (Fig. 127), are associations of units with a complicated common system of waterways. The bath sponge of commerce is merely the skeleton of what was once a living animal. Its skeleton is composed of spongin, a nitrogeneous compound similar in some ways to silk. In other sponges, the skeleton consists in part or wholly of silica as shown by *Euplectella* (Fig. 128), Venus Flower Basket, and *Hyalonema* (Fig. 129), the Glass-Rope Sponge. It is said that flint

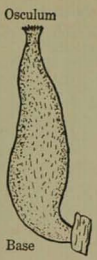

FIG. 125. — Grantia, a simple sponge.

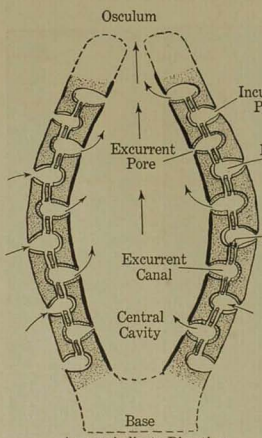

FIG. 126. — Plan of anatomy of a simple sponge.

rocks have been produced in part at least by marine sponges which abstracted silicon from seawater in forming skeletons. Porifera are regarded as an offshoot from the early Metazoa and not in the main line of evolution.

FIG. 127. — Euspongia. (Skeleton.)

PHYLUM — COELENTERATA

All the remaining Metazoa form a *diploblastic* embryo which is *gastrula-like* with *ectoderm* and *endoderm*, the latter forming an *archenteron*. The Coelenterates are the simplest of these. Although they have only two germ layers — ectoderm and endoderm — yet each of these is differentiated into a number of types of special cells. Some Coelenterates are free-swimming forms and some are sedentary, and some have a life history with an *alternation* of *generations* in which the *sedentary* stage is *asexual* while the *free-swimming* stage is *sexual*. The body exhibits *radial symmetry* — that is, one finds similar structures in any two vertical planes radiating from the central vertical axis.

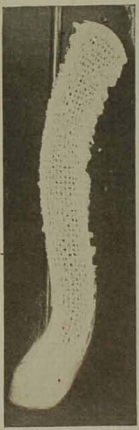

FIG. 128. — Skeleton of Euplectella, Venus Flower Basket.

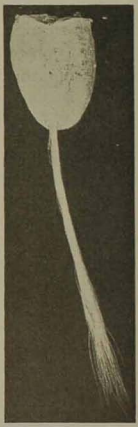

FIG. 129. — Skeleton of Hyalonema, Glass-Rope Sponge.

Type 1. Hydra. Morphology. Hydra (Fig. 130) is a common fresh-water genus. It is tubular in form, about 5 mm. in length and attached at the basal (foot or *aboral*) end. At the free or *oral* end is the mouth in the center of a small conical enlargement,

the *hypostome*, at the basal margin of which are the *tentacles*, below which is the cylindrical body. The mouth opens into the simple *enteric* or gut cavity. The body wall consists of two layers of cells, and hence Hydra, like all Coelenterates, is a *diploblastic* animal. The *endoderm* cells are somewhat larger than those of the *ectoderm*. Between the two layers is a thin and quite non-cellular substance called *mesogloea*, into which cells from the endoderm may migrate. In *Hydra viridis*, the endoderm cells contain small Chlorophyceae, which live there symbiotically. The structure of the tentacles is similar to that of the body, and each has a cavity continuous with that of the body. On the body wall near the tentacles, *testes* may be found and lower down, *ovaries*. Finally a slight swelling on the body may be the *bud* of a new Hydra; or a *young Hydra* which has developed from a bud may occur there. In spite of its apparent simplicity, Hydra exhibits a considerable degree of cell differentiation.

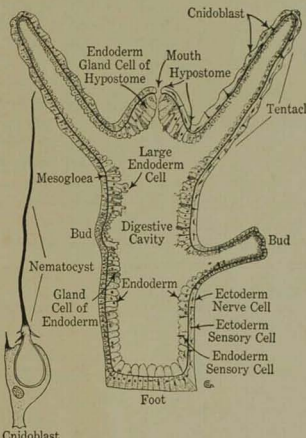

FIG. 130. — Morphology of Hydra. From Curtis and Guthrie: *Text Book of General Zoology* — copyright 1927, John Wiley & Sons, Inc. Reprinted by permission.

Structure of the Ectoderm (Fig. 131). Most of the ectodermal cells of Hydra are columnar in form, but the bases of many project into lateral processes attached to the mesogloea. The deeper processes are contractile so that the whole cell is *epithelio-muscular*. Epithelium is a tissue composed often of cubical or columnar-shaped cells forming a membrane. Between the *epithelio-muscular* cells are (1) *sensory cells*, spindle-shaped, with pointed tips and at the base provided with branching extensions running length-

wise of the body; (2) *nerve cells*, near the mesogloea, and having branching processes which with others form a *nerve net* over the entire body; (3) *neuro-sensory* cells, or nerve cells that have sensory fibers running to the surface, and finally, (4) *cnidoblasts* (Figs. 130 and 131). These last are special cells found chiefly in the tentacles. They have a cavity inclosing a *nematocyst*, a flask-shaped body with a long, pointed, thread-like process coiled up

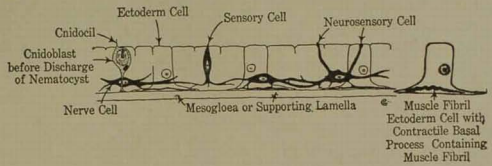

FIG. 131. — Hydra. Structure of ectoderm. From Curtis and Guthrie: *Text Book of General Zoology*, copyright 1927, John Wiley & Sons. Reprinted by permission.

inside. Extending from the free surface of the cnidoblast is a small, trigger-like process, the *cnidocil*. The testes and ovaries develop from ectoderm cells.

Endoderm (Fig. 130). This layer consists of larger columnar cells with the muscular processes at their basal ends. These processes on the inside of the mesogloea are at *right angles* to the long axis of the body and therefore function as circular muscles. Around the mouth opening and at the basal end of the tentacles these muscular processes are well developed. Centrally the endoderm cells have processes which extend into the digestive canal. Some especially large endodermal cells are thought to be unicellular glands. There are also a few nerve cells and sensory cells in this layer.

Physiology. *Metabolism.* With body and tentacles extended, the green hydra waits for small organisms to come in contact with its tentacles. If the "feeding" is poor, it contracts and extends its body in another direction. It may even change its location. If a small organism hits the projecting trigger or cnidocil of a cnidoblast cell, a nematocyst is discharged. This penetrates the prey and also paralyzes it. Many nematocysts may be discharged. Then the tentacles bring the food to the mouth. "Hungry" Hydras voraciously ingest food. Small food particles may be taken into endoderm cells and digested in intracellular

food vacuoles as in Amoeba. However, most food is digested in the upper part of the gastric cavity. Endoderm cells secrete enzymes which are discharged to mix with the food in this cavity. Undigested fragments are egested through the mouth, sometimes *shot out*. With the mouth closed and body contracting, the digested food products come into contact with the endodermal lining of the enteric cavity and those of the tentacles. The food is absorbed, circulated slowly to all other cells and assimilated. Excretion occurs at the free surfaces of all exposed cells, probably chiefly from the external surface.

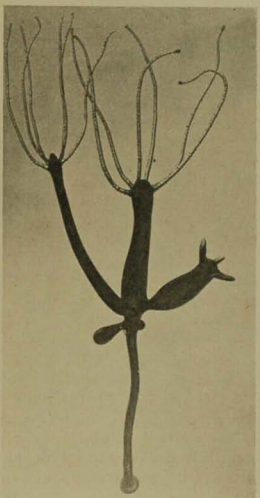

FIG. 132. — Hydra fusca with four buds in various stages of growth. (Photo of model in Am. Mus. Nat. History.)

Movement. The body and tentacles contract, becoming shorter and thicker or expand, becoming longer and thinner. The animal can bend its body and change its position from place to place. It can loosen its hold on the substratum and glide or hitch or somersault. Its behavior is a series of reflexes which are reactions carried on by reflex mechanisms. The latter have three parts: (*a*) a Receptor, *i.e.*, sensory part *excited* by the stimulus; (*b*) Adjustor, for *conducting* the impulse and (*c*) Effector or muscular part, the activity (or contraction) of which *produces the movement*. A review of the histology of the ectoderm indicates that Hydra is provided with such mechanisms. By these, adjustments are made to new conditions with which the animal is constantly confronted. For example, a single epithelio-muscular cell is a complete, though primitive, reflex machine in which the exposed portion of the cell is receptor, the middle part, adjustor,

and the contractile part, effector. Then again a stimulus may irritate certain sensory ectodermal cells. The physico-chemical change brought about in these cells is communicated to the ectodermal *nerve net*, which distributes the impulse to all contractile elements. Hydra is positively thigmotropic, soon attaching itself after being forcibly torn from its resting place. It is very sensitive to mechanical stimulation, for it contracts if the aquarium is even *slightly* jarred. It locates in positions *optimum* as to light, temperature, chemical and other environmental conditions. Small organisms on which Hydras feed may collect in well-lighted areas so that Hydras will gather in those same areas.

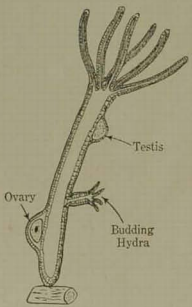

FIG. 133. — Hydra. Reproductive organs.

Reproduction. (*a*) *Budding.* This is asexual. A blind outgrowth (Fig. 130) of the body wall involving both endoderm and ectoderm takes place. Tentacles appear, a mouth is formed and after attaining a certain size the basal end of the young Hydra closes the connection with the parent body (Fig. 132) and later becomes detached.

(*b*) *Sexual Reproduction.* Both sex organs may form at the same time, or testis first and ovary later. They are formed from ectoderm (Fig. 133). The testis is a sac containing flagellated cells, the *spermatozoa*, which are discharged from the testis capsule into the water outside. From another ectodermal cell an ovary is developed. This consists of a thin capsule containing one *ovum*. When mature, the capsule of the testis splits open, permitting sperm to swim about so that they fertilize the eggs of other Hydras. Gamete formation occurs in the autumn, the embryo passes the winter within a cyst, and development is completed in the spring.

Embryology. The fertilized cell divides and continues to divide, forming a *Morula* and later a hollow sphere of cells called the *Blastula*. Later ectoderm and endoderm cells are differentiated from the blastula and tentacles are formed. The embryo drops from the cyst, becomes attached at its basal end, the digestive cavity forms within the endoderm, and a mouth appears. Its *gastrula* character is evident.

Regeneration. If Amoebas are cut into pieces containing nuclear material, they will grow into mature Amoebas. Porifera possess this power. Hydra also exhibits remarkable powers of *regeneration*. This was first discovered by the Abbé Trembley in 1744. Pieces as small as $\frac{1}{8}$ mm. in length will grow into complete Hydras. Regeneration reminds one of vegetative reproduction in plants. Healing of wounds in the human body involves regeneration of injured cells and tissues.

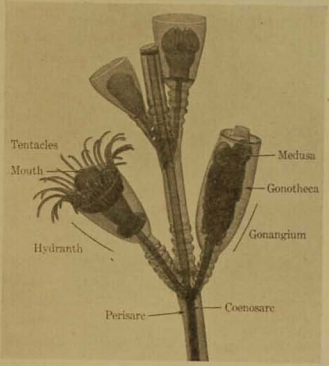

FIG. 134. — Part of an Obelia colony. Photo of model in the American Museum of Natural History.

Type 2. An Obelia Colony (Fig. 134) is a *colonial Coelenterate* which lives in seawater, where it is attached to submerged objects. A central stem-like part is present from which branches extend. Most of these branches end in hydra-like structures called *Hydranths*, the feeding members of the colony. All other branches end in reproductive individuals called *gonangia*. The soft parts of the colony are protected by a chitinous sheath called the *perisarc*. The soft part of the stem and branches forms the *coenosarc*. The gastric cavity of each Hydranth communicates with a duct in each branch and this with a similar duct in the main stem so that all the vegetative members of the colony are connected by a common gastro-vascular cavity. The coenosarc consists of two layers of cells: outer, ectoderm, and inner, endoderm. The mouth is in the center of a mound-like hypostome. Around the base of the hypostome are about thirty tentacles. The tentacles possess a great many nematocysts. The Obelia colony does not reproduce sexually. The gonangia arise as buds from certain branches. Each gonangium has a central axis, called the *blastostyle*, which produces

Medusae by *budding*. A sac-like covering over the whole structure is the *gonotheca*. The Medusae, when mature, become detached from the blastostyle and escape into the water, through the ruptured end of the gonangium. The jelly-like Medusae (Fig. 135) are very minute umbrella-shaped animals and are free-swimming. They bear sex organs. Some individuals produce sperm and others produce eggs. The fertilized egg undergoes cleavage into two, four, eight, sixteen-cell stages, etc., and a *blastula* and *gastrula* are formed. By further development, the *latter* becomes a new *colony*. Since the *colony* is composed of hydra-like members, all parts of one connected system, it is called a *hydroid colony*. Alternation of generations is present. The *hydroid colony* is the asexual generation and the Medusae constitute the *sexual generation*. Alternation of generations, which is so characteristic of plants, is exhibited by many Coelenterates and is present among other animal phyla.

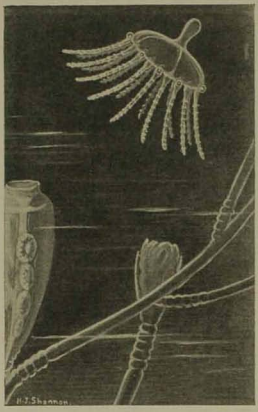

FIG. 135. — Free-swimming Medusa at upper right; gonangium at lower left. (Courtesy American Museum of Natural History.)

Type 3. Gonionemus. The medusa stage of Obelia can be more easily understood by studying *Gonionemus* (Fig. 136), which is a larger form. This *jelly fish*, about a half inch in diameter, looks like a plano-convex mass of jelly. The convex surface is the *exumbrellar surface*, while underneath is the *subumbrellar surface*. Beneath the subumbrellar surface

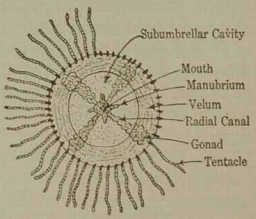

FIG. 136. — Gonionemus, viewed from subumbrellar surface.

is the subumbrellar cavity, bounded below by the *velum*, a flat, narrow, circular shelf with a large central opening (Fig. 137). When the body is relaxed, water fills the subumbrellar cavity through the opening in the velum. When the body contracts, it forces this water out through the velum opening, thus propelling the animal. Gonionemus swims by a series of such acts. Around the margin of the bell are a number of tentacles, and near the base of the tentacles are *statocysts*, organs of equilibrium. Hanging down in the subumbrellar cavity is a stalk-like process — the *manubrium*, with the *mouth* at its outer end. The mouth is the entrance to a canal which leads into the gastric cavity in the jelly-like substance between the exumbrellar and subumbrellar surface. Four radial canals extend at right angles from the gastric cavity out to the margin of the *Medusa*. The gastric cavity and the four radial canals are lined with endoderm. All superficial surfaces are covered with ectoderm. The mass of the animal is the jelly-like mesogloea. A fine circumferential canal runs around the peripheral margin of the animal and the radial canals connect with this. The general structural plan is similar to that of Hydra. The reproductive organs (*gonads*) are located on the under side of the radial canals. The sexes are separate (*dioecious*). Eggs and sperm are discharged into the water, where fertilization takes place. The hydroid stage is very much reduced, but it gives rise to other Gonionemus Medusae by asexual budding.

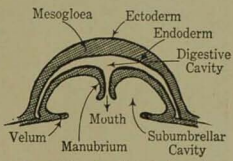

FIG. 137. — Sectional view of a Medusa.

In reviewing these types it is to be noted that in Hydra there is no medusa stage, the animal being able to reproduce by buds or by the sexual method directly; in Gonionemus, there is only a small hydroid stage, while some medusae have no hydroid stage. In the Coelenterates, therefore, we find different variations of alternation of generations so characteristic of an Obelia colony; but a comparison of Hydra, a Medusa and a Hydranth reveals underlying similarity in body structure although Hydra or the hydroid colony are adapted to a sessile existence and the Medusa to a freely moving life.

Classification

There are over 4000 species of Coelenterates, but all have a body plan essentially like that of a gastrula. The principal classes are:

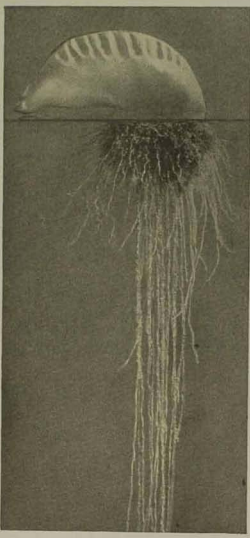

FIG. 138. — Physalia. Photo of model. Courtesy American Museum of Natural History.

Class I. Hydrozoa, to which Hydra, Obelia and Gonionemus and similar forms belong. *Physalia* (Fig. 138), the Portuguese Man-of-War, is a compound Hydrozoan. It has the appearance of a beautiful iridescent bladder or float, about six inches long. The prevailing color is blue, although other prismatic colors appear. Underneath the float are feeding, tactile, egg-producing and sperm-producing *individuals*. Still others have long tentacles which, when relaxed, trail down several feet in the water. When a small fish comes in contact with these, the batteries of nematocysts paralyze it, and tentacles, coiling about the fish, raise it up to the feeding polyps. Physalia is of great interest because of the organization into a colony of so many *types* of *individuals*. There is some degree of unity of organization, but not such unity as is shown by the higher animals which are organizations of different systems.

Class II. The Scyphozoa are large forms in which the medusa stage is prominent, while the hydroid or polyp stage is very much reduced. An example is *Aurelia* (Fig. 139), which is common along the North Atlantic coast. It is saucer-like in form and about 2 to 4 inches in diameter and free-swimming. *Cyanea arctica* grows

to a great size. Individuals one foot in diameter are common and specimens seven feet in diameter have been seen in northern waters. Some of the jellyfish produce nematocysts with so powerful a poison as to cause serious illness to the unfortunate swimmer who accidentally comes in contact with them.

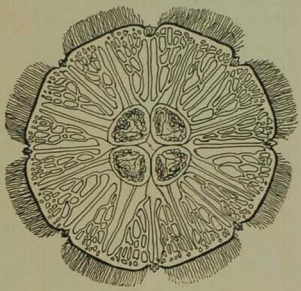

Fig. 139. — Aurelia. Courtesy U. S. Bureau of Fisheries.

Class III. The Actinozoa consist of the sea-anemones and true corals. The prominent stage may be regarded as a *specialized* hydra-like form. *Metridium* (Fig. 140), a sea-anemone, is found along our coast. It is a tubular, sedentary animal about 2 inches long, and attached to rocks or wharf pilings. The free end is crowned by many tentacles. In the center of the free end is the slit-like mouth. *Astrangea* (Fig. 141) is a coral found along the North Atlantic coast. It is a *colony* of individuals each of which resembles, in general, a sea-anemone. At the base of each individual is a substratum of calcium carbonate, coral, which is secreted by the animal. The colony spreads by budding. It reproduces sexually also.

Fig. 140. — Metridium.

Coral polyps build coral reefs and atolls. Colonies of corals are extended by budding. A great variety of form of the compound corals (Figs. 142 and 143) is effected by different methods of budding. There are two kinds of coral reefs. The shore or fringe reef is formed on the sea bottom near the land. There is no direct channel from the outer edge of the reef to the shore, although there are many pools and small channels in which

a great variety of marine animals live. A barrier reef is separated from the shore by a wide channel. The Great Barrier Reef (Fig. 144) of Australia is over a thousand miles long with a channel between thirty and sixty miles wide, and from 50 to 175 feet deep.

FIG. 141. — Astrangea, star coral. Courtesy American Museum of Natural History.

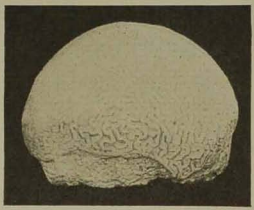

FIG. 142. — Brain coral, Diplora.

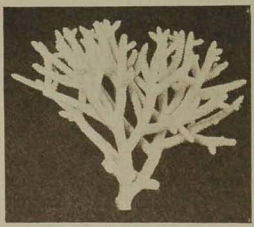

FIG. 143. — Stag Horn Coral, Madrepora.

An *atoll* is an island in the form of a ring with a lagoon inside. The waters of the lagoon are thus protected. The atoll is formed, according to Darwin, by coral colonies at the apex of some subsiding volcanic cone. Growth continues until a comparatively narrow ring of reef extends above the low-water mark.

Coral reefs have existed for untold ages. In the ancient Cambrian Period, the rocks show clear-cut evidence of their presence at that time. Corals have played an important part in the formation of limestone.

Summary: Coelenterata are Metazoa in which the body plan appears to be similar to that of the gastrula stage in the embryology of higher Metazoa. Their body consists of two layers of cells, an outer ectoderm and inner endoderm. The endoderm forms the digestive canal and the opening to it serves both as a mouth and an anus. The body is *radially* symmetrical, and between the ectoderm and endoderm is the jelly-like mesogloea which may contain cells that have migrated into it. Stinging cells

are characteristic of the group. Metagenesis or Alternation of Generations is present in many types. The more ancient type is thought to be the hydroid or polyp stage, while the free-swimming Medusa is a more specialized development. Both Polyps and Medusae reveal their similarity to Gastrulae. The appearance of ectodermal and endodermal structures has meant the

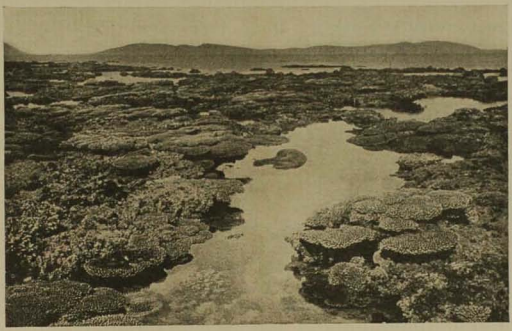

FIG. 144. — Great Barrier Reef, Australia. Courtesy American Museum of Natural History.

appearance of physiological division of labor, *i.e.*, functions of adjustment being carried out by ectoderm cells and those of metabolism, such as digestion, by endoderm cells. Special reproductive organs, male *and* female, are present.

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