HYDRA

Hydra: introduction (YOUTUBE)

Coelenterata (or Cnidaria) is the phylum of scoelomate and radially symmetrical lower invertebrates (Radiata). Coelenterate animals are represented by two morphologically different represented types of individuals, polyps and medusae.
(1) Polyps are sessile with a tubular body (e.g., Hydra), whereas medusae are free swimming with an umbrella or bell-shaped body (e.g., Aurelia, Metridium). Some coelenterates pass (e.g., Aurelia, Metridium). Some coelenterates pass through both stages in their life- cycle with an alternation of generations (e.g., Obelia).
Hydra belongs to the most primitive class Hydrozoa of phylum Coelenterata. It is simple in form and structure and serves as a good example for the study of coelenterate organization by beginners.

Hydra valgaris

There are several species of hydras. Following description applies in particular to H. vulgaris, the common Indian species, and in general to all the species of hydras.

Systematic Position

Hydra: Systematic Position

Phylum Coelenterata
Class Hydrozoa
Order Hydrozoid
Suborder Anthomedusae
Genus *Hydra*
Species *Hydra vulgaris*

Habits and Habitat

Hydra: habits and habitat (YOUTUBE)

Hydras are solitary, sessile, freshwater animals, cosmopolitan in distribution. They occur in lakes, ponds, streams and seasonal ditches, where weeds and other vegetation are commonly present. They are absent in water which is foul and too warm, but flourish well in cool, clear and relatively permanent and stagnant water.
They may be found attached to and hanging downwards from underside of solid objects in water such as leaves, sticks, stones, weeds, etc. When hungry, their body and tentacles are stretched to the maximum limit and swayed in water in order to capture any prey that comes in contact with them. When disturbed, the body at once contracts into a minute jelly-like knob which escapes detection by inexperienced observers. Removed from water, it collapses into a soft and shapeless mass.

Collection and Preservation

Hydra may be collected easily during early winter from shallow water of ponds, lakes and streams. As these animals live habitually clinging to aquatic vegetation, quantities of vegetation may be picked and put in jars filled with pond water.
In laboratory, hydras may be dislodged from vegetation by squirting them with a jet of water from a pipette. They are then transferred to a dish with a pipette or small aquarium net. When fully expanded, hydras may be fixed in Bouin's fixative for 30 minutes, given several washes in 30% alcohol, kept in 50% alcohol for 10-15 minutes, and finally preserved in 70% alcohol.

External Morphology
Hydra: structure - external (YOUTUBE)

1. Shape and size.
Hydra is a polyp-like or polypoid coelenterate with a tubular or cylindrical body. When fully extended, it becomes elongated and slender and never measures more than 1 cm. in length. When retracted, body becomes shortened and somewhat globular and measures only a few millimeters. Symmetry of body is typically radial, comprising an oral-aboral axis, with different parts arranged concentrically around it.
2.Colouration.
Most commonly occurring species H. vulgaris is colorless.H. gangetica, found in ponds along river ganges is white or pink in colour. Pelmatohydra oligactis, formerly known as H.fusca is brown in colour. Chlorohydra viridissima formally called H. viridis, is the green Hydra its bright green colour is not because if chlorophyll containing chloroplast, but due to presence of symbiotic zoochlorellae chlorella vulgaris a unicellular green alga, that lives in its gastrodarmal cells. The hydra derives oxygen from the photosynthetic activity of this alga while the latter receives its carbon dioxide supply from the metabolic activity if the former.
3.Pedal disc.
Proximal or aboral end of is body is closed, flattened and termed pedal dis or basal disc. This is used for temporary attachment to substratum. It consists of a glandular zone which secretes substances for attachment and also a gas bubble for floating.
4.Hypostome.
mouth and tentacles. Distal or free opposite end of body is produced into a conical clevation, the hypostome. It contains a circular aperture or mouth at its apex. Hypo-some bears, at its base, a circlet of 6 to 10 slender, contractile and tubular thread-like processes, called tentacles (L. tentare, to feel). these can be stretched to several millimeters, when the animal is hungry. Tentacles assist the animal in feeding and locomotion.
5.buds.

Body of Hydra in some individuals may bear proximally lateral buds in various stages of development. A well-developed bud possesses its own mouth, hypostome and tentacles. On detachment, it gives rise to a new individual.

6. Gonads

Other structures, occasionally seen on the external surface temporarily are the gonads. Conical testes occur near the oral end, while rounded ovaries are situated near the aboral end of animal.

Internal Structure

Hydra: structure - internal (YOUTUBE)

Internal or histological structure of Hydra is best seen in its longitudinal and transverse sections.

[I] Gastrovascular cavity

Sections of Hydra show a central cavity or coelenteron (Gr., kilos, hollow + enteron, gut), functionally referred to as the gastrovascular cavity. It is surrounded by the body wall. Mouth leads into this cavity which also extends into tentacles as their lumen. There is no anus and no excretory pore.

[I] Body wall (Histology)

Hydra is a diploblastic animal, i.e., it is derived from two germ layers, the ectoderm and endoderm. These germ layers form two distinct cellular layers, outer epidermis and inner gastrodermis, respectively, of body wall and tentacles. Between these two layers is a thin, delicate, transparent and non-cellular mesogloea.

A. Epidermis

Outer cellular layer of body wall, or epidermis, is composed of small, more or less cuboidal cells. It is a protective, and sensory layer and is enveloped by a thin coating of cuticle. Various epidermal cells are of the following types:

1. Epithelio-muscle cells. Most of epidermis is formed by roughly conical or pear-shaped epithelio-muscle cells that serve both for epithelial covering and for muscular contraction.

Thus each cell has two functional parts: epithelial and muscular. Outer epithelial part extends up to body surface, while inner or basal muscular part is drawn out into two muscle processes along the longitudinal axis of body. Muscle processes contain a contractile fibril, the myoneme. Muscle processes of all cells are 'embedded in surface folds of mesogloea. Contraction of these processes shortens the body and tentacles. A pair of non-contractile supporting fibrils extend into epithelial part as well as muscle processes of cell. Electron microscopy has revealed the detailed structure of epithelio-muscle cells. In addition to the presence of usual intracellular organelles, like nucleus, Golgi bodies, mitochondria, endoplasmic reticulum, ribosomes, lysosomes and vacuoles, there are present some other organelles as well. The cell membrane, at the outer free surface, has a few outward projections or microvilli. At the periphery below this membrane, are present a few mucous

bodies. These secrete a finely granular material to form a thick, protective mucous layer on the cell surface. Basal part of the cell is produced into muscle processes, which run parallel to the long axis of animal body. These contain contractile myofilaments which constitute the myoneme.

2. Gland cells.

These are tall cells found chiefly on pedal disc and around mouth region. These secrete a mucus-like sticky material which serves for attachment, protection and entanglement of prey. Sometimes they secrete a gas bubble by which Hydra can rise to water surface or float.

3. Interstitial cells.

These occupy the interstices or spaces between narrow basal ends of epithelio-muscle cells, hence their name. They are small, rounded, undifferentiated cells, measuring about 5u in diameter. Each cell contains a clear cytoplasm and a relatively large nucleus with one nucleolus. Electron microscope also reveals smooth endoplasmic reticulum, scattered free ribosomes and a few small mitochondria. Interstitial cells are capable of developing into other kind of cells such as reproductive, granular, stinging, and buds etc., as required. they are thus totipotent or reserve cells. according to Brien (1955) over a period of 45 days, all the cells of hydra are replaced by interstitial cells. Thus, interstitial cells play an important role in regeneration, growth, budding, and sexual reproduction etc.

4. Cnidoblasts.

Many of the interstitial cells of epidermis become specialized to form stinging cells, called cnidoblasts (Gr., knide, nettle + blastos, germ). These are especially abundant on tentacles arranged in clusters or batteries. A cnidoblast is somewhat oval with a basal nucleus and contains the sac-like organoid, the nematocyst or stinging cell. It is in the form of a capsule enclosing coiled tube or thread. Nematocysts are characteristic of Cnidaria. These form organs of offence and defence of Hydra and also help in food-capture, locomotion and anchorage. Nematocysts have been described in detail elsewhere in this chapter.

5.Sensory cells.

Sensory cells occur scattered throughout epidermis among epithelio-muscle cells, especially on tentacles, hypostome and pedal disc. These are tall, narrow and columnar, thread-like cells, usually bearing a delicate hair-like process (apical cilium) at their outer free tips. Their basal or inner ends are connected by fine modulated processes with nerve cells. Sensory cells serve as undifferentiated receptors for sensitivity to touch, temperature, chemical stimuli and light, etc. They receive and transmit impulses. Electron microscope reveals that the apical hair-like process is in fact a cilium

arising from a notch at the apex of sensory cell. It contains the usual 9 peripheral and 2 central microfibers arising from a basal granule from which small rootlets extend into cytoplasm.

6.Nerve cells.

True nerve cells or ganglion cells occur for the first time in coelenterates.

They are derived from interstitial cells of epidermis. Nerve cells occur at the base of epithelio-muscle cells just above their muscle processes, forming a nerve net or nerve plexus.

Each nerve cell consists of a small cell-body containing nucleus, and gives off two to several nerve processes or neurites, which are not differentiated into dendrites and axons as found in higher animals. The neurites of adjacent nerve cells form synaptic contacts i.e., they lie very close together with microscopic gaps between them. Nerve cells, linked up with synaptic contacts, thus form an epidermal nerve net throughout the body of Hydra. The nerve net conducts impulses equally well in all directions due to restricted or no polarization.

Electron microscopy of nerve cells shows presence of usual cytoplasmic organelles. Nerve cells of the basal region of Hydra and devoid of microtubules and poor in ribosomes.

7.Germ cells.

During summer, interstitial cells in certain restricted regions of body repeatedly divide and proliferate like reproductive cells forming gonads, which later differentiate into either testes or ovaries.

B. Gastrodermis

Inner cell layer of body wall, called gastrodermis, lines the hollow and bag-like gastrovascular cavity. It constitutes nearly two-third of entire thickness of body wall. It is formed chiefly of large, typical columnar cells. This layer is mainly nutritive in function.

Following types of cells are included in it

1. Endothelio-muscle or nutritive-muscle cells. These are most numerous and conspicuous cells forming the bulk of gastrodermis. These resemble the epithelio-muscle cells of epidermis in all respects except that their basal contractile processes are single, much more delicate and oriented at right angles to the long axis of body next to mesoglea, thus forming a circular muscle layer. Each of these processes contain a muscle fiber or myoneme. Their contraction reduces the slameter of body and tentacles, which become harrower and longer. Contractile processes at tightly developed around tractile pro bases tentacles to form sphincters. free end of a nutritive-muscle cell, projecting to gastrovascular cavity, may bear long, spine like flagella, usually 2 in number, by means which the liquid food inside body-cavity is. hot in motion. Besides flagella, blunt pseudo-podia, like those of Amoeba, may also be put out from the free end to engulf particles of food. In a starving Hydra, protoplasm of nutritive cell remains much vacuolated. After a meal,

however, the cells become gorged with nutritive particles. Electron microscopic studies have shown that the free end of nutritive-muscle cell produces microvilli and more flagella that contain the usual 9 + 2 pattern of fibres. Apical cytoplasm includes, in large number, the milo-Dandria, glycogen granules, secretory granules and food vacuoles. Both smooth and rough endoplasmic reticulum, free ribosomes and lipid droplets are in abundance in cytoplasm. Nucleus lies centrally a basally and includes a single nucleolus. Small Golet apparatus lies close to the nucleus. At the base of cell occur circulars Oriented muscle containing myofilaments. pinocytic channels are also reported to run into cytoplasm from apical surface, which suggests occurrence of cell drinking phenomenon like that of Amoeba.

2. Endothelio-gland cells.

Endothelio-gland cells are smaller than nutritive-muscle cells and occurs interspersed among them. they lack muscle tails at their tapering basal ends but bear one or two flagella at their free ends. Endothelio gland cells are of two types.

Enzymatic gland cells secrete digestive enzymes into gastrovascular cavity for extracellular digestion. In the region of hypostome and mouth are found mucous gland cells, which secrete a slimy fluid serving as a lubricant and also for entangling and paralyzing the prey. Gland cells are absent in tentacles. Electron microscopy has revealed the presence of many Golgi bodies and large number of secretory granules, which are functionally divisible into mucus and enzyme-secreting types. Nucleus is basal, with or without nucleolus, and endoplasmic reticulum is rough-surfaced.

3.Interstitial cells.

A few interstitial cells occur between the bases of endothelio-nutritive-muscle cells. These are totipotent as they may transform into other types of cells whenever the need arises.

4.Sensory cells.

Large sensory cells are also found in gastrodermis. They are supposed to be stimulated by the entry of prey into gastro-vascular cavity.

5.Nerve cells.

These are similar to those of the epidermis but occur in far fewer numbers.
They form a separate (gastrodermal) nerve net on mesogloea.
Nematocysts are absent in gastrodermis.

c. Mesogloea

Mesogloea (Gr., Mesos, middle + glea, glue) of Hydra is a non-cellular thin layer, sandwiched between epidermis and. gastrodermis, which secrete it. It consists of proteinaceous matrix devoid

of cellular elements. It serves for attachment of cellular layers, thus serving as the supporting lamella or elastic framework of body.
This layer is thickest in pedal disc and gradually thins towards the tentacular ends. This arrangement is meant to enable the pedal region to withstand mechanical strain and to give flexibility to tentacles.

Nematocysts

One of the most characteristic structures of all coelenterates are the stinging nematocysts.
These cells, called are not cells but cell organelles found in specialized cells called cnidocytes or cnidoblasts (Gr., knide, nettle + blast, germ). These develop only from modified interstitial cells of epidermis and are not found in gastrodermis. When fully developed, cnido. blasis migrate to tentacles through mesoglea by means of amoeboid movement. Projecting in between the epithelio-muscle cells, or lying inside the bodies of these cells (host cells), the cnidoblasts act as organs for offence and defence. They also serve for locomotion, food capture and anchorage.

1. Structure of a cnidoblast. A cnidoblast is an oval or rounded cell with a conspicuous basal nucleus lying on one side. The interior of cnidoblast is filled by a peculiar oval or pyriform sac or bladder, the stinging capsule or nematocyst (Gr., nema, thread + kystis, bladder). Nematocyst consists of a tiny bulb or capsule, 5 u to 50м in length, and composed of a material similar to chitin. It is filled with a poisonous fluid, or hypnotoxin, which is chemically a mixture of proteins and phenols. The narrowed outer end of capsule is invaginated into a long, hollow and tubular filament or thread tube, coiled like a watch-spring inside the sac itself. The base of thread tube is swollen to form the butt or shaft. Inside the butt are three large spines, called barbs or stylets, and three spiral rows of minute spines, called barbules or spines. The butt is covered externally by a little lid-like structure, the operculum. Outer end of cnidoblast projects freely beyond the epidermal surface, as a tiny, pointed and hair-like process, the cnidocil. (Gr., knide, nettle + cilium, hair) or trigger. Groups of supporting rods surround the cnidocil. Cytoplasm of cnidoblast may contain contractile muscle fibrils. In some, a restraining thread, called lasso, is attached to the base of cnidoblast. It prevents the nematocyst from being thrown out of it. Nematocyst described above is of penetrant type. Electron microscopic studies have shown the presence of endoplasmic reticulum, free ribosomes, basally located Golgi bodies, mitochondria and multivesicular bodies in cytoplasm. A bundle of small myofilaments (probably lasso) extends from nematocyst capsule up to the basal part of cell. Cnidocil is composed of a central cord surrounded by large rods. The core is structurally like a cilium as it contains fibres in 9 + 2 pattern, Fine microtubules are attaches to, the base of capsule which is double-walled.

2. Occurrence of nematocysts. Nematocysts occur scattered, mostly singly, throughout the epidermis of body but remain absent on basal disc. They are especially abundant in the oral region

and on tentacles where they form "nematocyst batteries". A battery consists of one or two large central nematocysts, surrounded by
10-12 smaller ones, all enclosed within a single large epithelio-muscle cell. Cnidoblasts are never formed in tentacles where they literally migrate from their seat of origin in the epidermis of body, or they may enter body cavity, whence they are passively transported in large quantities to the tentacles where they encyst in clusters to become batteries. None seems to encyst in gastrovascular cavity.

3. Mechanism of discharge. Explosion or discharge of nematocyst takes place when cnidocil is stimulated by food, prey or enemy neither touch alone, nor presence of food, causes discharge, but touch and presence of food together cause it. Thus, both mechanical stimulation, such as contact with prey, as well as chemical stimulation, emanating from an approaching prey, are involved in the mechanism of discharge. Exact nature of discharge remains unknown. Response is wholly local and not under the control of nervous system. Enzymes involved also remain unknown. Further, it is not known why a well fed Hydra fails to discharge nematocysts in the usual manner. Wall of nematocyst remains impermeable to water except at discharge. On stimulation the capsule wall suddenly increases its permeability. This causes a rapid intake of water and greatly increased osmotic pressure inside the capsule. As a result, the lid or operculum is forced open, the coiled thread tube turns inside out, and the entire nematocyst explodes to the outside. Contraction of contractile microtubules, surrounding the capsule, is also attributed by some workers to help in discharge. Probably the neuronal connections bring about coordinated discharge of nemato-cysts. As the thread tube everts, the barbs and spines present inside butt unfold to the outside. Thread tube once discharged cannot be withdrawn, so that exploded nematocysts cannot be used again. Their cnidoblasts migrate to the gastrovascular cavity and are digested. Discharged nematocysts are replaced within 48 hours.
4. Types of nematocysts. About 30 different kinds of nematocysts are found among different cnidarians. There kind is constant for the species and is of taxonomic value. Hydra has four basic types of nematocysts serving different functions, as follows:
(a) Penetrant. Penetrant or stenotele is the largest (16 M in diameter) and most complex nematocyst. It is pear-shaped occupying almost the entire inner space of cnidoblast in which it lies. Its thread is a long and hollow tube, coiled transversely and bearing three large stylets and three rows of small spines at its stout base. Thread tube is open at the far end like a hypodermic needle. When discharged, it shoots out with such explosive force that it pierces the body of prey and injects the poisonous fluid (hypnotoxin) that paralyzes the victim or kills it outright. Hydra then seizes its prey with tentacles and draws it into mouth.
(B) Volvent. Volvent or desmoneme is a small (9 м long) and pear-shaped nematocyst resembling a miniature bola. It contains a short, thick, spineless, smooth and elastic thread tube forming a single loop and closed at the far end. When discharged, it tightly coils around small projections such as hairs or bristles of prey, thus impeding its movements. Volvents are also useful in capturing the prey

(c) Stereoline glutinant. Small glutinants or atrichous isorhizas (9 M) are oval or elongate nematocysts. Butt is absent. They discharge a straight and unarmed thread tube open at the tip and used for attachment.

(d) Streptoline glutinant. Large glutinants or holotrichous isorhizas (9) are oval or cylindrical. Thread tube is long with a narrow butt and forms three or four transverse coils. It is pointed and open at the tip. It bears a spiral row of small spines and may coil upon discharge.

Glutinants secrete a sticky substance possibly used in locomotion by fastening the tentacles of Hydra to solid objects, when somersaulting as well as in food-capture. They are also used to impede the progress of small animals when the projectiles are stuck to their appendages.

LOCOMOTION

Hydra: Locomotion (YOUTUBE)

Hydras are essentially sessile animals. They live attached by their pedal discs to objects in water. Brown and white hydras can remain fixed at one spot for a considerable time, but green hydras often move about from place to place by several ingenious devices. They twist about or perform movements to change their location either in response to light or some chemical stimulus or to obtain food. As gastrodermal muscle fires are less developed, movements are largely due 10 contractions of the epidermal muscle fibres. Hydra shows movements of the following type.

1. Expansion and contraction. Hydra, attached to a substratum in water, frequently expands and contracts itself at intervals. This behaviour of Hydra is called contraction burst. It is initiated by a pacemaker located near the base of hypostome. These movements help to bring food organisms in contact with tentacles which are waved all around in water. Also, contraction of one side and elongation of other side of body or tentacles result in the bending and swaying movements which assist in the capture of prey.

2. Looping. Hydra can also move from place to place in search of food. Usually the body first extends and then bends over, so that the tentacles attach to the substratum with the help of adhesive glutinant nematocysts. Then the pedal disc is released and brought up closer to circlet of tentacles and then attached. Now tentacles loosen their hold and body becomes erect again. The whole process, which is repeated again and again, appears like a series of looping movements of a caterpillar or leech.

3. Somersaulting. In another common and rapid method of progression, Hydra somersaults like an acrobat. The tentacular end is brought forward and attached to the substratum. The pedal disc is freed and moved upwards, thus causing Hydra to assume an inverted posture.

Now, pedal disc is moved forward and attached to a new position. By freeing the tentacular end the animal again assumes its upright position.

The animal performs a series of somersaults by repeating the process.

4.Gliding. For moving a short distance along a smooth surface, Hydra simply slides along on its basal disc like a snail, aided by secretions from mucous glands. It can slide or glide slowly over

substratum due to creeping amoeboid movement of cells of pedal disc. Considerable distances are sometimes covered in this manner.

5. Walking. Occasionally, Hydra becomes inverted, stands on its tentacles and moves in an inverted condition, using its tentacles as legs.

This type of movement takes place on some object such as leaf and in leisurely hours.

6. Climbing. While changing location in a limited area, Pelmatohydra oligactis can even climb by attaching its long tentacles to some object, releasing the foot, and then contracting the tentacles, so that the body is lifted up.

7. Floating. Occasionally, Hydra throws its body free and floats on water surface with waves. Sometimes Hydra attaches to a floating leaf or twig by its pedal disc.

8. Surfacing. Sometimes Hydra uses a gas bubble secreted in mucus by the cells of pedal disc, to rise in water and float at the surface. If gas bubble bursts, the mucous threads sustain the body on water surface due to surface tension.

9. Swimming. It is said that sometimes Hydra frees itself from substratum and swims in water by undulating, wavelike movements of tentacles and body.

NUTRITION

1. Food. Hydra is almost exclusively carnivorous.

Small aquatic animals such as insect larvae, crustaceans (e.g., Cyclops, Daphnia) and annelid worms form the bulk of its food. It may swallow preys larger than itself, such as young fish and tadpoles. Hydra can damage trout nurseries by preying upon the newly hatched young. It can also feed on small bits of meat in an aquarium.

2. Ingestion. Coelenterates are the first animals to use projectiles, called nematocysts, for capturing animals. A hungry Hydra waits for its food to come to it. It normally rests with its basal disc attached to some object, while its body and tentacles extend out in water, controlling a considerable amount of hunting territory. When a small passing organism, touches a tentacle, dozens of nematocysts are discharged into it at once. The volvents coil around bristles and other appendages on the prey, while glutinants fastens to its surface, thus holding it fast. The penetrants puncture the victim and inject the paralyzing hypnotoxin. The tentacles, holding the prey, now contract and bend inwards drawing the paralyzed prey towards the mucus-lined mouth, which opens widely to swallow it. Mucous secretions help in swallowing and the mouth can be greatly distended. Contractions of hypostome and body wall (peristaltic movements) force the food down into gastrovascular cavity where digestion takes place.

The food reaction varies greatly according to the state of the animal. A very well-fed Hydra will not react to food while a hungry Hydra will respond even when a chemical stimulus, such as beef juice, is added to the water. A chemical, called glutathione, usually found in the tissue fluids of most animals, is necessary to evoke feeding reaction. Thus, Hydra engulfs only those animals which have glutathione in their body.

3. Digestion. Digestion is both extra-cellular and' intracellular, and occurs in two stages.

(a) Extracellular digestion. First, the prey is killed by the action of digestive juices secreted by the gland cells of gastrodermis. Churning movements caused by the
expansion
contraction of body wall and lashing movements of flagella of nutritive-muscle cells thoroughly mix up the digestive juices with food which is broken into smaller particles suspended in a meaty broth. Digestive enzymes now act upon the disintegrating food. A proteolytic enzyme similar to trypsin partly digests proteins into poly peptides. This type of digestion, occurring in the cavity, outside gastrodermal cells, is called extracellular digestion and is purely proteolytic. It also takes place in the stomach and intestine of most multicellular animals like frog, earthworm, etc. It is met with in Hydra for the first time.
(b) Intracellular digestion. Smaller fragments of food are engulfed by nutritive-muscle cells by means of pseudopodia and digested within food vacuoles. This is intracellular digestion as it occurs regularly in Protozoa and Porifera. Studies have revealed that food vacuoles undergo both acidic as well as alkaline phases, and digestion of protein is completed by other proteolytic enzymes. Digestion in Hydra, therefore, is quite interesting, since it combines the digestive procedures of forms lower (Protozoa) as well as higher (Vertebrates) than itself. Retention of intracellular digestion is probably due to its aquatic mode of life, as the digestive juices get diluted in the gastrovascular cavity.
4. Absorption. Soluble products of digestion are distributed by diffusion from cell to cell.
Some gastrodermal cells containing food vacuoles may become detached and move freely to distribute the digested food to all parts of body.
Gastrovascular cavity thus serves for both digestion and circulation.
Hydra can digest proteins, fats and some carbohydrates but not starch. Reserve food materials, chiefly glycogen and fats, are stored in some of the gastrodermal cells.

1. Egestion. Indigestible residues, like exoskeleton of Crustacea, are egested through mouth, for there is no anus. Egestion occurs by a sudden squirt due to muscular contraction of body, so that the debris is thrown at a distance.

Respiration, Excretion and Osmoregulation

Hydra has neither blood and blood vessels, nor organs of excretion and respiration, which are carried on individually by each cell. Due to thinness of body wall and circulation of water in gastrovascular cavity, most cells of body remain freely exposed to the surrounding water.
Therefore, exchange of oxygen and carbon dioxide, and excretion of waste nitrogenous matter (chiefly ammonia) occurs directly by diffusion through cell membranes in the outside world. Condition in Hydra favours an influx of surrounding water into its body cells. There is no evidence of any organ's osmoregulation. Therefore, it is not understood how water balance is maintained in the body cells of Hydra.

Nervous System

Hydra possesses a very primitive type of nervous system. It includes bipolar and multipolar nerve cells or neurons lying immediately above the muscle processes and forming an irregular and discontinuous nerve net or nerve plexus. Neighboring nerve cells are not fused together, but their processes or neurites form synaptic junctions. Such a serve net is called a synaptic nerve net. Nerve cells are numerous around mouth and on pedal disc but show no groupings in the form of a nerve controlling centre like brain or nerve ring. A difference from higher animals is that the nerve net of Hydra is unpolarized so that impulses can pass in all directions (diffuse transmission). In briel, nerve net shows diffuse unpolarized transmission, autonomy of parts and paucity of reflexes. It has been reported that nerve cells of epidermis and gastrodermis form two separate nerve nets which are interconnected. Their processes are connected to the sensory cells, which act as receptors for external stimuli, and to epithelio and endothelio-muscle cells which act as effectors by contracting their muscle processes. Such a combination of muscle processes of epithelio-muscle cells, sensory cells and nerve nets is referred to as neuro-muscular system. This is just the beginning in the evolution of nervous system.

Behaviour

Hydra: Behaviour (YOUTUBE)

Hydra reacts to various kinds of internal as well as external stimuli.

[I] Reactions to internal stimuli

in response to internal stimuli, Hydra shows spontaneous movements of body and tentacles. At regular intervals body, or tentacles, or both contracts suddenly and rapidly and then slowly expand in a new direction. In a well-fed Hydra, such movements are slow. These movements are produced by muscle processes when they are stimulated through nerve net.

[II] Reactions to external stimuli

Hydra responds positively as well as negatively to an external stimulus, depending upon its type and intensity.

If the stimulus is strong, the

animal usually responds negatively. Movements are produced by the contractile muscle processes in the wall, when they are stimulated through nerve net.

1. Contact. When a floating or swimming Hydra comes in contact with a substratum, it gets attached to it with its pedal disc. Application of a localized stimulus, such as touching of a tentacle with a pointed needle, causes the contraction of one or all the tentacles together with or without

body. A mild stimulus affects only the part of body touched, while a strong stimulus affects the whole body.

2. Light. Hydra responds negatively to both strong as well as weak light. It prefers to accumulate in regions of moderate light intensity.
Thus, animal has an optimum with regard to light. By trial and error, hydras seek areas of suitable light intensity.

3. Temperature. Hydra prefers cool or cold waters and disappears from surface waters when temperature reaches 20° to 25°C.

4. Electric current. When Hydra is subjected to a weak and constant electric current, its tentacular end bends towards anode and pedal disc towards cathode. Whole of body and tentacles then contract. When the animal is inverted with tentacles attached to substratum. the pedal disc bends towards anode and tentacular end towards cathode.
5. Water current. Hydra shows no reactions to water currents.

6. Chemicals. Hydra avoids strong and injurious chemicals.

REPRODUCTION

Hydra reproduces asexually by budding and sexually by formation of gametes.

1. Budding
Hydra: reproduction - budding (YOUTUBE)

During summer months, when the animal is well-fed and healthy, asexual budding is the usual method of reproduction. Near the middle or in basal part of body, a bulging appears as a result of repeated multiplication of epidermal interstitial cells. This grows as a bud with its wall consisting of epidermis and gastrodermis and the interior lumen in continuation with the parent's gastrovascular cavity. The bud enlarges, develops a mouth and a circlet of tentacles at its free end. When full grown, the bud constricts at the base and finally separates from the parent body. It feeds and grows into an adult Hydra.
Occasionally, several buds occur at the same time on a single parent, and these in turn may develop secondary buds, so that a group is formed which temporarily resembles a colonial hydroid.

2. Sexual reproduction

Hydra: reproduction - sexual reproduction (YOUTUBE)

Hydra reproduces sexually by the fusion of gametes, generally in autumn. Gonads develop temporarily from interstitial cells of epidermis which accumulate to form bulges in the body wall. In some species, male and female gonads occur in the same individual which is then known as hermaphrodite or monoecious Usually testes develop towards the distal end and ovaries towards the basal end of body. Most species (Pelmatohydra oligactis), however, are unisexual or dioecious, i.e., the individuals are either male or female and can be distinguished. The male is smaller in size and bears one to eight testes, while the larger female has only one or two ovaries. Even in hermaphrodite species, self-fertilization is avoided, because spermatozoa and ova mature at different times. As a rule, testes mature earlier than ovaries (protandrous condition).

1. Testes. Testes are conical. elevations of body wall, varying in number from a few to many. They are usually located near the distal or oral end of body, but when numerous, they may cover the greater length of body. Each testis is formed by local proliferation of interstitial cells of epidermis, which get covered from outside by a capsule formed of large epidermal cells.

Interstitial cells at the base are spermatogonia. They undergo typical spermatogenesis, and passing through primary spermatocyte, secondary. spermatocyte and spermatid stages become spermatozoa or sperms. Each sperm has a head containing nuclear material and a long vibratile tail. When mature, sperms are discharged by the rupture of testis wall at its apical nipple-like protuberance.

2. Ovaries. Ovaries develop a little later than testes. In green Hydra, usually one ovary is present, while in brown Hydra as many as eight ovaries are formed. These are ovoid structures, located near the basal end of body.

Ovary too is formed by the multiplication of interstitial cells which constitute the primary oogonia. But after sometime one centrally located cell, called oocyte, becomes larger and amoeboid, with a big nucleus. It feeds upon its smaller neighboring interstitial cells, which become yolk or reserve food, to be used up later while young Hydra is still without a mouth to feed. As a result, oocyte increases greatly in size. It undergoes two maturation divisions resulting in the production of two polar bodies and reduction of chromosomes to haploid number which is 15 in case of Pelmatohydra. The sperm also has 15 chromosomes.

Mature egg or ovum is a large spherical mass, laden with yolk granules and occupying most of the space inside ovary. One ovary usually contains a single ovum, but rarely there are found two (Chlorohydra viridissima), or even more (Hydra dioecia) ova. When an egg is ripe, the epidermis over it ruptured and widhawa to form a cup like receptacle containing a he exposed egg. ovum is not set free at once but remains attached to the parent by a broad base. A gelatinous protective sheath is secreted by the ovum around itself.

3. Fertilisation. Ripe sperm, discharge from testes swim about in water until they approach an extruded ovum and surround it. several sperms may penetrate the gelatinous covering spot only one enters the ovum and fuses with Completely. This process is called fertilization in situ , and the fertilized egg is called zygote. Male and female nuclei unite to form the fusion or zygote. nucleus. The ovum die and degenerate, unless fertilization occurs within a short time after it is exposed.

4. Development. Development begins soon after fertilization, while the egg or zygote is still attached to the parent, by undergoing cleavage or segmentation.

(a) Cleavage. As egg has little yolk, cleavage is indeterminate, total and equal (holoblastic), resulting in equal-sized cells called blastomeres.

(b) Blastulation. Cleavage results in the formation of a hollow spherical ball, called blastula or coeloblastula. Its central narrow cavity is termed blastocoel.

Equal-sized cells or blastomeres are arranged in a single surface layer.

(c) Gastrulation. Some cells of blastula wall detach and migrate inwards (multipolar ingression). While other cells form outer and inner cells by tangential division (primary delamination). As result blastocoel completely filled by new cells and the hollow blastula converts into a solid gastrula. it is made of a single layer of outer cells forming ectoderm, an inner solid mass of cells forming endoderm. As described above, gastrulation or formation of endoderm in Hydra is partly by multipolar ingression and delamination.

partly by primary

(d) Encystation. Soon a new cavity, called gastrocoel or archenteron, appears in the central solid mass of endodermal cells. Meanwhile, the ectodermal cells secrete a two-layered protective shell or cyst around gastrula. Outer layer of cyst wall is thick, horny or chitinous and spiny, while inner layer is a thin gelatinous membrane. Different species of Hydra can be identified by the specific pattern of their cysts. At this stage, encysted gastrula usually drops off the parent and either sinks in mud at the bottom of pond or adheres by means of its spikes to any solid object it contacts with. In P. oligactis, gastrula is shed from ovary before the formation of shell, and fastened to aquatic plants by its sticky gelatinous covering.

Encysted embryo remains dormant and unchanged for several weeks, until next spring. It withstands drying and freezing and carries the race through droughts and winters. It is also probable that this resting stage serves for dispersal, for it can be carried by wind, or in mud on feet of animals to other ponds in which water is present.

(e) Hatching. With the advent of favorable conditions of water and temperature, development is resumed. Interstitial cells arise in ectoderm and mesogloea is secreted between two cellular layers. The embryo elongates, and a circlet of tentacle buds develops at one end with à mouth appearing in their midst. As embryo increases in size, the shell or cyst ruptures and a Young Hydra with tentacles hatches out. Soon it grows into an adult. There is no free larval stage
in the development of Hydra.

Regeneration

Hydra: regeneration (YOUTUBE)

Regeneration is the ability of an organism to replace its lost or damaged body parts. It usually Occurs after an accident, but can be induced Hydra has great artificially by mutilation. As discovered long ago Power of regeneration as discovered long ago by Abraham Trembley in 1745.Hydra has been a favorite Since then, experimentations on regeneration. material for If a living Hydra animal is cut into two, three or more pieces, each missing part grows and becomes a complete animal. A fragment of Hydra, measuring 1/6 mm. or more in diameter, is capable of regenerating an entire individual. Regeneration is not reproduction because it is not a normal method of multiplication. Regeneration of hydras is made possible by the amazing generative powers of totipotent interstitial cells. One characteristic feature of regenerating piece in Hydra is that it retains polarity. End nearer to mouth develops mouth and tentacles, while the end nearer to base forms a new pedal disc. Parts of one Hydra may be easily grafted upon another provided they are of the same species. Grafting can be done in various arrangements producing bizarre effects. Trembley observed that if head end of a Hydra is split in two and the parts are separated slightly, it results into a Y-shaped specimen, or "two-headed" individual. By further splitting heads, Trembley succeeded in producing a "seven-headed" Hydra. It was the great regenerative power of these animals which won for them the name "Hydra", after a Greek mythical monster which was finally destroyed by Hercules. According to the legend, "Hydra" had nine heads and no sooner did Hercules cut one off, instead two grew in its place.

Immortality in Hydra

P. Brien (1955) and others have observed that a Hydra is at least potentially immortal. Just below the tentacles there is a growth zone, where interstitial cells give rise to all other cells of body. With the formation of new cells, old cells are pushed towards the end of tentacles and pedal disc, from where they are shed outside. In about 45 days, the older body cells are replaced by new cells. This process of cell replacement is an endless process. It has also been shown that, if interstitial cells of growth zone are destroyed, the Hydra lives only for a few days.

Question

» Long Answer Type Questions

1. Give an account of histological structure of the body wall of Hydra.
2. Describe the various modes of locomotion in Hydra.
3. Give the structure of a nematoblast cell of Hydra, as revealed by electron microscope. Add a note on the various types of nematocysts and their functions.
4. Give a detailed account of reproduction in Hydra.

5. Write short notes on:(1) Behaviour of Hydra, (in) Immortality in Hydra, (ini) Nutrition in Hydra, (iv) Regeneration in Hydra.

» Short Answer Type Questions

1. What is mesoglea?
2. What are the five types of cells found in gastrodermis of Hydra and mention their functions.
3. Illustrate the structure of a cnidoblast.
4. Compare the life cycle of Hydra with that of Obelia.
5. List down 6 types of ectodermal cells present in the body wall of Hydra and mention their functions.
6. Draw a neatly labelled diagram of the T.S. of Hydra.
7. Hydra usually hermaphrodite, but cross fertilization occurs. How can Hydra prevent the self-fertilization?
8. What are the food for a hydra?
9. Give the names of the movement of a Hydra.
10. Who discovered the regeration power of Hydra.

» Multiple Choice Questions

1. The body of Hydra is
   (a) asymmetrical (b) bilaterally symmetrical
   (c) radially symmetrical (d) diploblastic and radially symmetrical

2. A chemical substance hypnotoxin is found in
   (a) Entamoeba histolytica (b) ectoderm of olynthus
   c) nematocyst of Hydra (d) venom of snake

3. Number of tentacles in Hydra is (a) 2-4
   (a) 2-4 (b) 6-10
   (c) 10-40 (d) 43-50

4.In Hydra, sperms and ova are formed from
   (a) cnidoblasts (b) interstitial cells
   (c) myotomes (d) tentacles

5.The most primitive nervous system is found in:
   (a) Hydra (b) Amoeba
   (c) sponge (d) earthworm

6.Which of the following animals has a nervous system but no brain:

(a) Amoeba (b) cockroach
(c) earthworm (d) Hydra

7.The nematocysts of Hydra are important for
(a) catching prey (b) paralysing prey
(c) testing the quality of food (d) testing the quality of water

8.The cavity in the body of Hydra is called:
(a) hydrocoel (b) haemocoel
(c) coelom (d) coelenteron

9. Hydra is an example of the type:
(a) monoblastic (b) diploblastic
(c) triploblastic (d) none of the above

10. Distinguishing feature of order hydroida to which Hydra belongs is:
(a) usually, 4-12 tentacles
(b) both polyp and medusa are included in life cycle
(c) polyp phase dominant and medusa phase is usually absent
(d) medusa phase is dominant

11. Hydra was first described by car
(a)Trembley (b) Linnaeus
(c) Leeuwenhoek (d) Lamarck

12. Internal cavity in body of Hydra is coelenteron
(a) not communicated with outside
(b) not extended into tentacles
(c) communicated with outside by mouth & aboral aperture
(d) communicated with outside by mouth only

13. Hydra can suddenly contract its body due to contraction
(a) nutritive muscular cells (b) epithelio-muscular cells
(c) gland cells (d) gastrodermis

14. Battery located in tentacles of Hydra are group of:
(a) nonfunctional cnidoblasts (b) interstitial cells
(c) cnidoblasts (d) functional cnidoblasts

15. Most complicated nematocysts of Hydra are

(a) penetrants (b) volvents
(c) holotrichous (d) atrichous

16. Leech like locomotion in Hydra is

(a) walking (b) looping
(c) gliding (d) somersaulting

17. Glutathione is a chemical released from:

(a) prey tissues (b) Hydra to start ingestion
(c) tissues of injured prey (d) tentacles of Hydra

18. Digestion in Hydra is initially extracellular and then intra-cellular; the undigested food is egested through:

(a) individual cells after intracellular digestion
(b) opercula of nematocyst
(c) aperture of the pedal disc
(d) mouth

19. In embryonic development of Hydra the stereogastrula is:

(a) three layered solid mass
(b) two layered with coelenteron
(c) solid embryo
(d) single layered with blastocoel

20. Pseudopodia of Amoeba corresponds to which structure in Hydra regarding feeding

(a) mouth (b) nematocysts
(c)tentacles (d) epithelio-muscular cells

21. A piece of Hydra will regenerate if:

(a) there is part of basal disc and mouth
(b) the part has epidermis, gastrodermis and tentacles
(c) epidermis and gastrodermis is present in that
(d) only epidermis is present

22. Mouth serves for both ingestion and egestion in:

(a) Leucosolenia (b) Fasciola
(c) Hydra (d) Ascaris

23. The nitrogenous wastes in Hydra are:

(a) urea and uric acids, removed from whole body surface
(b) ammonia, removed from general body surface
(c) ammonia and urea, removed through mouth
(d) only urea, excreted through mouth

24. Discharge of nematocysts in Hydra depends upon:
(a) nervous control
(b) entrance of water in capsule
(c) enzymes and mechanical stimulation
(d) all these

25. Nerve cells of Hydra are:
(a) unipolar
(b) bipolar
(c) nonpolar
(d) none of these

26. The cell of Hydra that has poisonous fluid Hypnotoxin is
(a) cnidoblast (b) interstitial cell
(c) glandulo-muscular cells (d) none of these

27. Digestion in Hydra is
(a) extracellular (b) intracellular
(c) both (d) none

28. Hydra has no special structures for:
(a) locomotion (b) respiration
(c) nutrition (d) reproduction

29. In Hydra larval stage is
(a) planula (b) amphiblastula
(c) scyphistoma (d) none

30. In development of Hydra gastrulation is the result of:
(a) emboly (b) epiboly
(c) delamination (d) unipolar immigration

31. Hydra is:
(a) fresh water polyp (b) solitary and diploblastic
(c) radially symmetrical (d) all of these

32. Tentacles of Hydra are
(a) solid (b) eight
(c) not for protection (d) all of these

33. Tentacles of Hydra are contractile and does not help in
(a) locomotion (b) reproduction
(c) food capture (d) protection

34. Body wall of Hydra is made of:
(a) ectoderm (b) mesoglea
(c) endosarc (d) all of these

35. The correct statement for Hydra is:
(a) spongocoel as body cavity (b) pedal disc with tentacles
(c) Coelenteron is body cavity (d) nonfibrous mesoglea

36. Epidermis of Hydra is made of:
(a) cnidoblast (b) epithelio-muscular cells
(c) interstitial cells (d) all of these

37. The incorrect statement for Hydra is:
(a) cnidocil receives mechanical stimulus
(b) functional nematocysts are found in both cellular layers
(c) largest nematocyst is penetrant
(d) action of nematocyst depends upon enzyme

38. Hydra is a:
(a) triploblastic, radially symmetrical, coelomate organism
(b) diploblastic, radially symmetrical, pseudocoelomate organism
(c) triploblastic, bilaterally symmetrical, coelomate organism
(d) diploblastic, radically symmetrical, acoelomate organism

39. Excretion of nitrogenous wastes in Hydra takes place through:
(a) flame cells (b) nephridia
(c) nematocysts (d) diffusion across the general body surface

40. The body wall of Hydra has:
(a) neither sensory nor nerve cells
(b) sensory cells but no nerve cells

(c) nerve cells but no sensory cells
(d) both sensory and nerve cells

41. Hydra has the ability to assume an inverted position and to move on its tentacles. Such a method of locomotion is called:

(a) somersaulting (b) gliding
(c) walking (d) looping

42. The developing embryo in Hydra drops down from the body of the parent;

(a) soon after formation of the zygote
(b) after formation of the blastula
(c) after formation of the stereogastrula
(d) only after it has developed into a young Hydra

43. In the nutritive muscular cells of Hydra algae such as Zoochlorellae and Sooanthallae are found. They live as

(a) parasites (b) symbionts
(c) saprophytes (d) commensals

44. Which one of the following types of cells in Hydra bears both flagella and pseudopodia

(a) Secretory cells (b) Gland cells
(c) Epithelial cells (d) Nutritive cells

45. Hydra can be called a

(a) coelomate (b) acoelomate
(c) pseudocoelomate (d) none of these

46. Hydra has no special structure for:

(a) respiration (b) food capture
(c) attachment (d) offence and defence

47. Zoochlorella in musculo-nutritive cells of Hydra live as:

(a) symbionts (b) commensals
(c) parasites (d) predators

48.The rapid method of locomotion in Hydra is:

(a) gliding (b) looping
(c) somersaulting (d) walking

49. The largest nematocyst of Hydra is:

(a) penetrants (b) holotrichous isorhizas
(c) volvents (d) atrichous isorhizas

50. In Hydra, the mucous for attachment is secreted by.

(a) cnidoblasts (b) glandulo-muscular cells
(c) interstitial cells (d) epithelio-muscular cells

51. In Hydra, both flagella and pseudopodia are found in:

(a) gland cells (b) epithelio-muscular cells
(c) interstitial cells (d) nutritive-muscular cells

52. Hydra was discovered by

(a) Leeuwenhoek (b) Linnaeus
(c) Grant (d) Trembley
(e) Aristotle

53. Which of the following is not found in Hydra?

(a) regeneration (b) fertilization
(c) gastrovasculation (d) segmentation

54. In Hydra the coelenteron serves for:

(a) locomotion and excretion (b) excretion and circulation let
(c) digestion and circulation (d) digestion and storage

55. The mesoglea of Hydra contains

(a) nerve cells (b) sensory cells
(c) muscle cells (d) no cells

56. Regeneration in Hydra was discovered by:

(a) Lavern (b) Hymen
(c) Huxley (d) Tembley

57. The gastrula of Hydra is known as stereo-gastrula because it is

(a) solid (b) hollow
(c) two-layered (d) encapsulated

58. In Hydra between the epidermis and gastrodermis an intermediate structureless layer is found. This is known as:

(a) mesoglea (b) musculo-endothelial
(c) myo-epithelial layer (d) endoderm

59. Spermatogonia in Hydra develop from:
(a) interstitial cells (b) gastrodermis
(c) musculo-endothelial cells (d) gland cells

60. The digestion of food within the gastrovascular cavity of Hydra is called
(a) intercellular digestion (b) intracellular digestion
(c) extracellular digestion (d) extracorporeal digestion

61. The proximal end of Hydra has been an adhesive disc which secretes a sticky substance for
(a) protection (b) defence from enemies
(c) sexual attraction (d) attachment to the substratum of Hydra

Answer

1. (d) 2. (c) 3. (b) 4. (b) 5. (a) 6. (d) 7. (b) 8. (d) 9. (b) 10. (c) 11. (a) 12. (d) 13. (b) 14. (d) 15. (a)
16. (b) 17. (a) 18. (d) 19. (c) 20. (c) 21. (c) 22. (c) 23. (b) 24. (b) 25. (b) 26. (a) 27. (c) 28. (b)
29. (d) 30. (c) 31. (d) 32. (d) 33. (b) 34. (d) 35.(c) 36. (d) 37. (b) 38. (d) 39. (d) 40. (d) 41. (c)
42. (c) 43. (b) 44. (d) 45. (b) 46. (a) 47. (a) 48. (c) 49. (a) 50. (b) 51. (d) 52. (d) 53. (8) 54. (c)
55. (d) 56. (d) 57. (a) 58. (a) 59. (a) 60. (c) 61. (d).