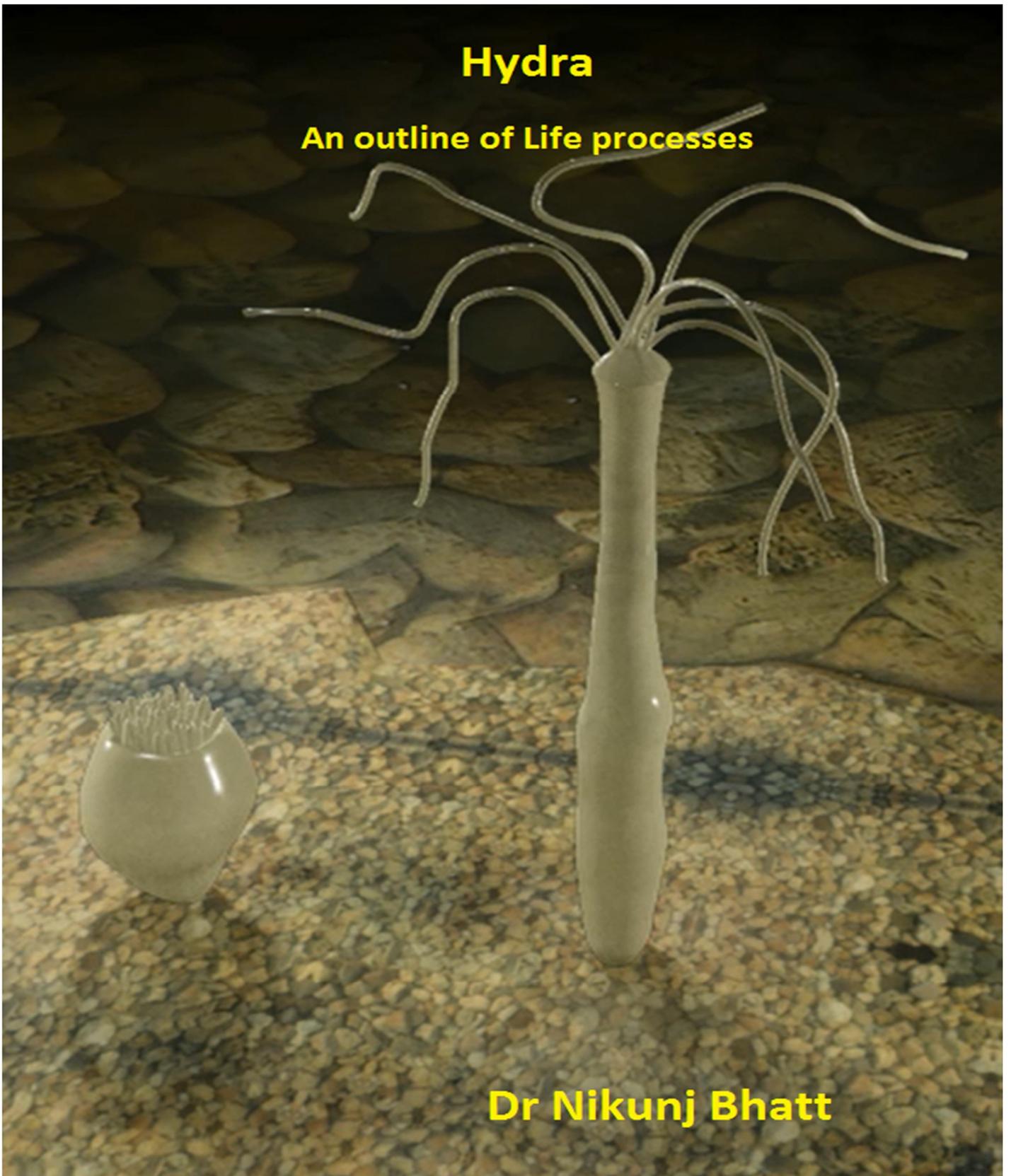


Hydra

An outline of Life processes



Dr Nikunj Bhatt

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Hydra: An outline of Life processes

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2014
International **E - Publication**

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ISBN: 978-93-83520-89-2

Preface

Hydra; An outline of Life processes is one of the excellent creation by my friend Dr. Nikunj Bhatt. I appreciate his work, because this book become very handy for students and teachers for ready reckoner. This book is not having very deep and lengthy content so it will become very user friendly to the students of under Graduation which is another most important aspect of this book.

The figures are very dynamic and provide a real time effect by three dimensions effects, which will certainly attract the students to refer not only during examinations but at the time of routine study.

Dr Bhatt is being an excellent author in Biological Sciences, he wrote "Spiders: The Orb- web weaver", "Amoeba proteus: An outline of Life processes" and a editing of a seminar proceeding "Nurturing Quality in Higher Education through IQAC" organized by him at his Institution.

Dr Bhatt is also a good orator and delivered many keynote and expert lectures in the field of Quality Education.

Dr Bhatt is a Member of peer team as an Assessor depute by Knowledge Consortium of Gujarat, Government of Gujarat. He also developed an e-content in the Zoology for under graduate students funded by MHRD, Government of India.

I wish him in future endeavours

Prof. Nayan Jain

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Introduction:

Coelenterata (or Cnidaria) is the phylum of acoelomate and radially symmetrical lower invertebrates (Radiata). Coelenterate animals are represented by two morphologically different types of individuals, polyps and medusae (i) Polyps are sessile with a tubular bo (e.g. Hydra), whereas (ii) medusae are free swimming with an umbrella or bell-shaped bo (e.g. Aurelia, Metridium). Some coelenterates pE through both stages in their life- cycle with alternations of generations (e.g. Obelia).

Hydra belongs to the most primitive class Hydrozoa of phylum Celenterata..It is simple in form and structure and serves as a good example for the study of coelenterate organization beginners. There are several species of hydras. Follow description applies in particular to *H. vulgaris* the common Indian species, and in general to all the species of hydras.

SystematicPosition

Phylum	Coelenterata
Class	Hydrozoa
Order	Hydroida
Suborder	Anthomedusae
Genus	Hydra
Species	vulgaris

Occurrence

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.



Figure 1

External Morphology

Shape and Size:

Hydra is a polpy-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

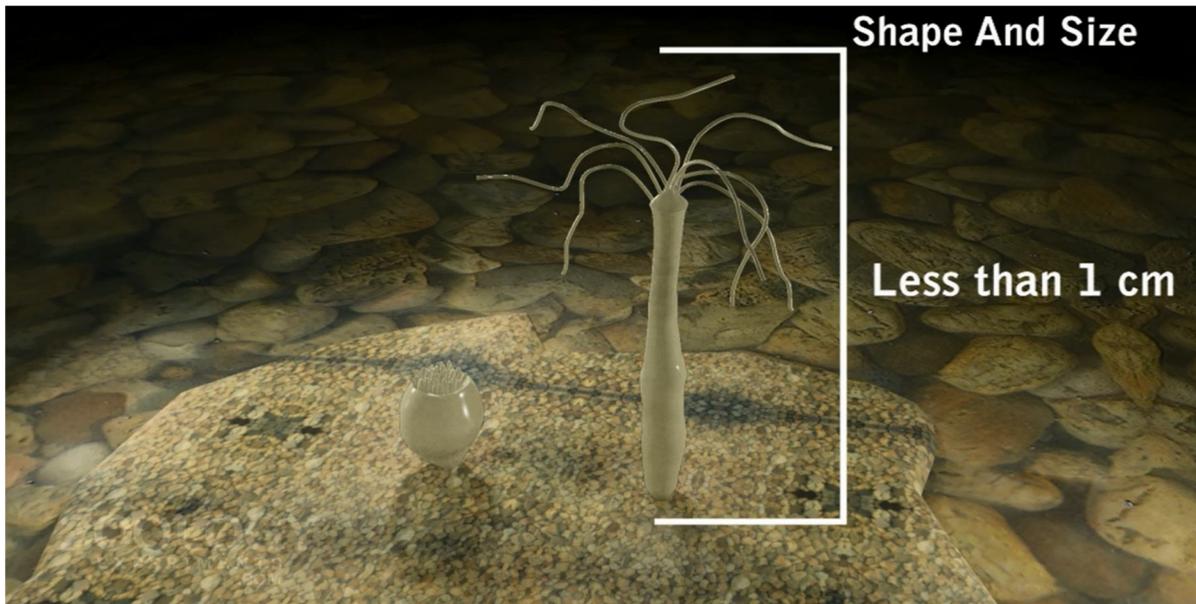


Figure 2

Coloration:

Most commonly occurring Indian species *H. vulgaris* is colourless. *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*, formerly called *H. viridis*, is the green Hydra its bright green colour is not because of chlorophyll-containing chloroplasts, but due to presence of symbiotic zoochlorellae *Chlorella vulgaris*, a unicellular green alga, that lives in its gastrodermal cells. The hydra derives oxygen from the photosynthetic activity of this alga while the latter receives its carbon dioxide supply from the metabolic activity of the former.

Pedal Disc:

Proximal or aboral end of its body is closed, flattened and termed pedal disc or basal disc. This is used for temporary attachment to a substratum. It consists of a glandular zone which secretes adhesive substances for attachment and also a gas bubble for floating.

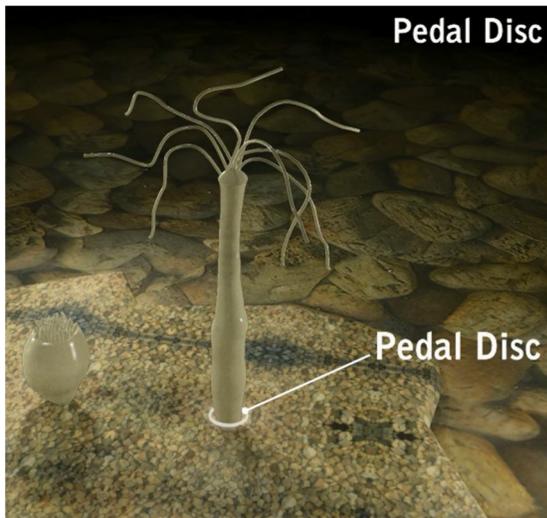


Figure 3

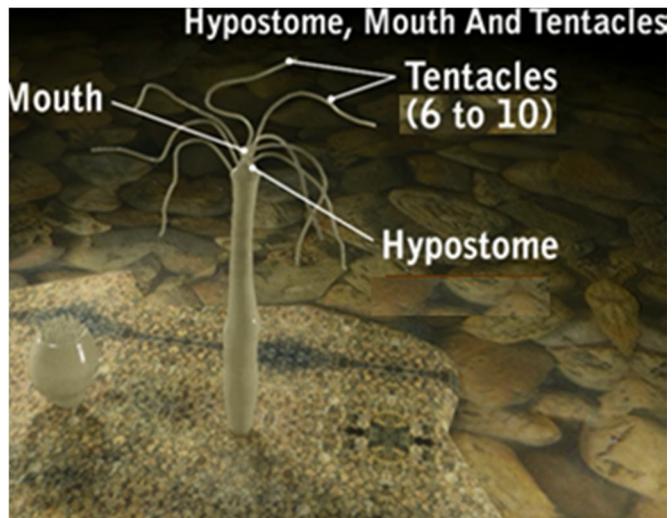


Figure 4

Hypostome, Mouth and Tentacles:

Distal or free opposite end of body is produced into a conical elevation, the hypostome. It contains a circular aperture or mouth at its apex. Hypostome 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.

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.

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.

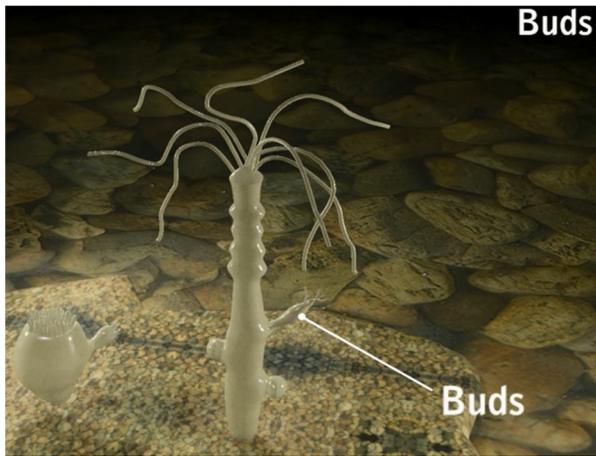


Figure 5

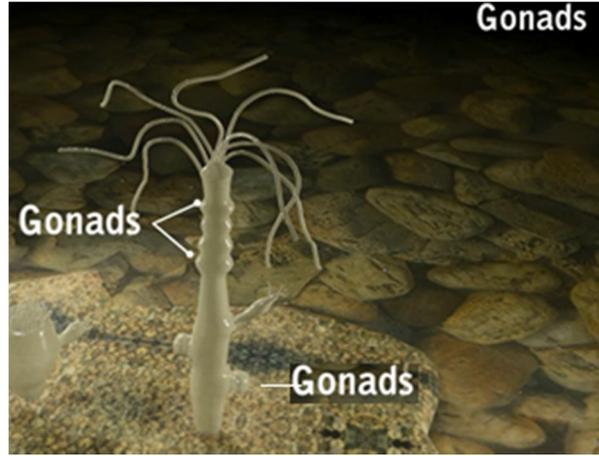


Figure 6

Internal Morphology

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

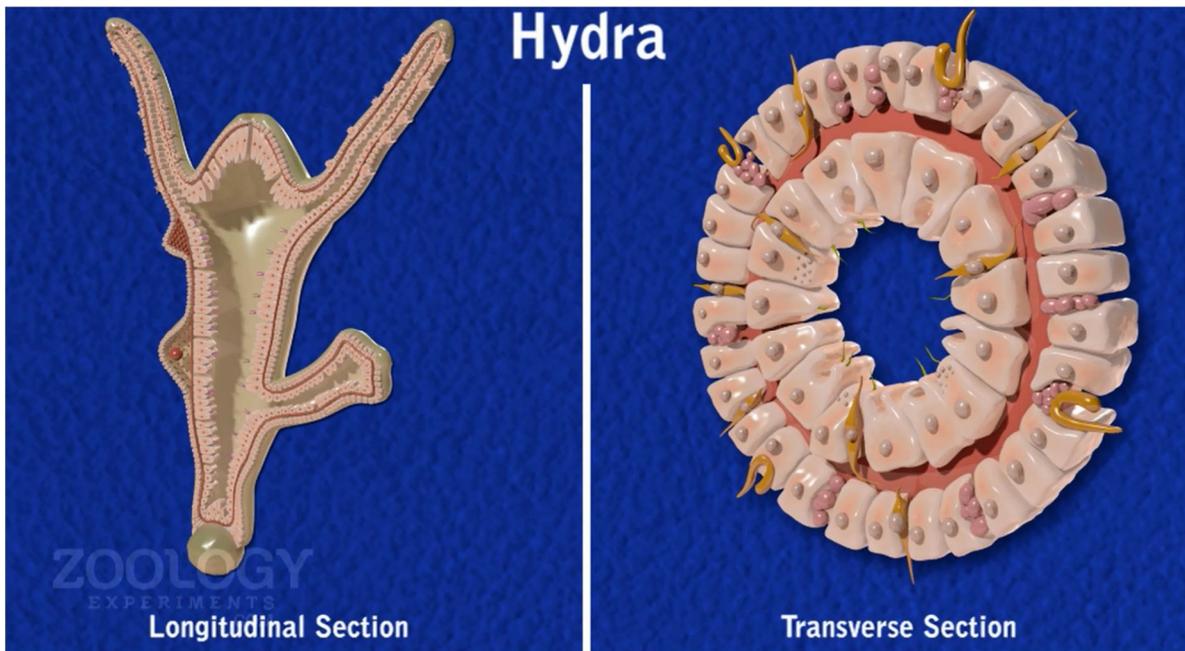


Figure 7

Gastrovascular cavity

Sections of Hydra show a central cavity or coelenteron (Gr., koilos, 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 Hydra an outline life process

tentacles as their lumen. There is no anus and no excretory pore.

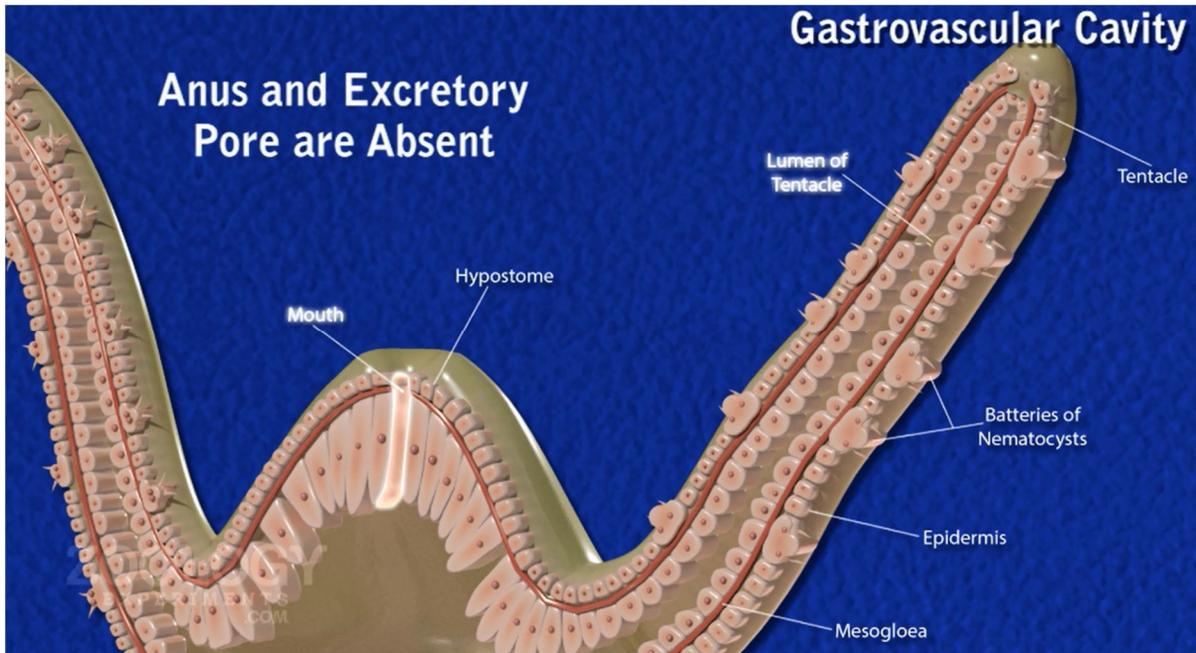


Figure 8

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:

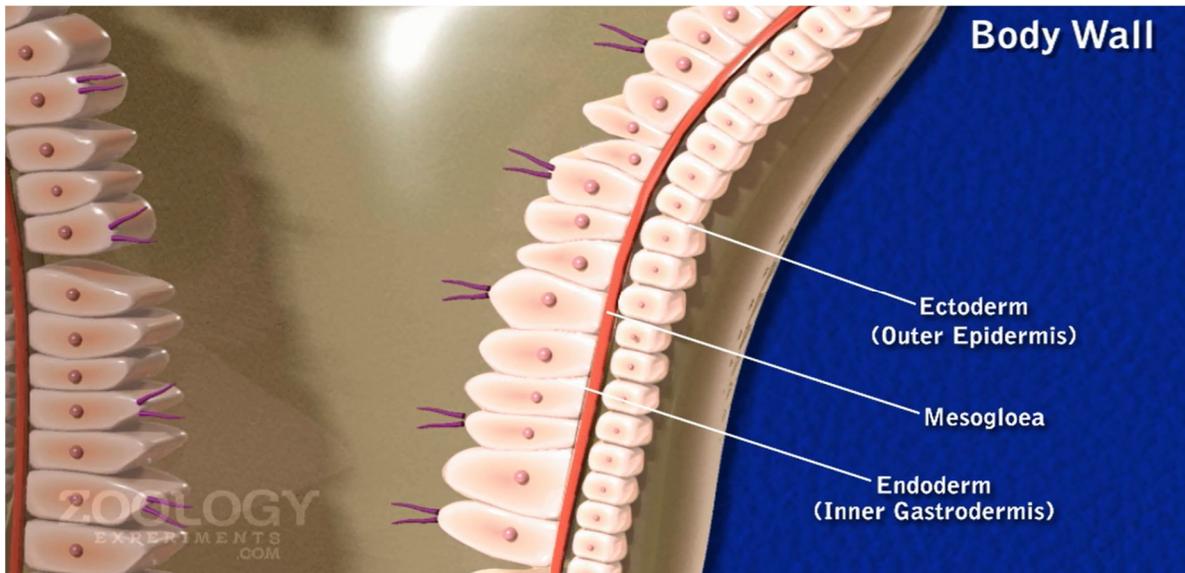


Figure 9

1. Epithelia-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.

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.

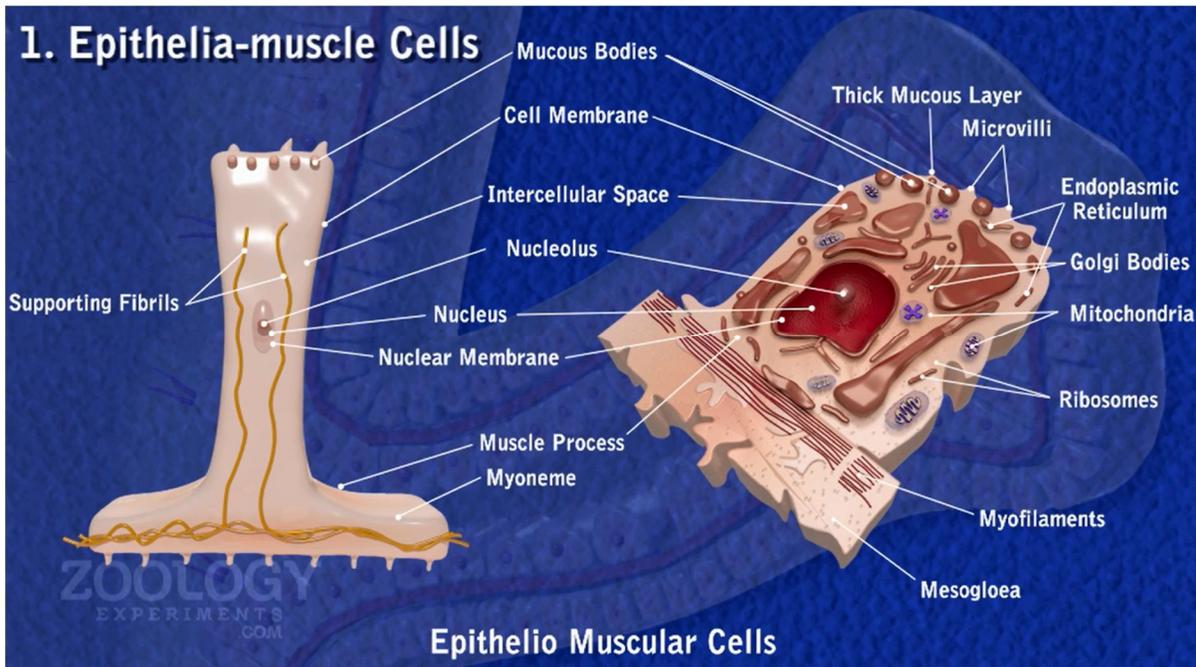


Figure 10

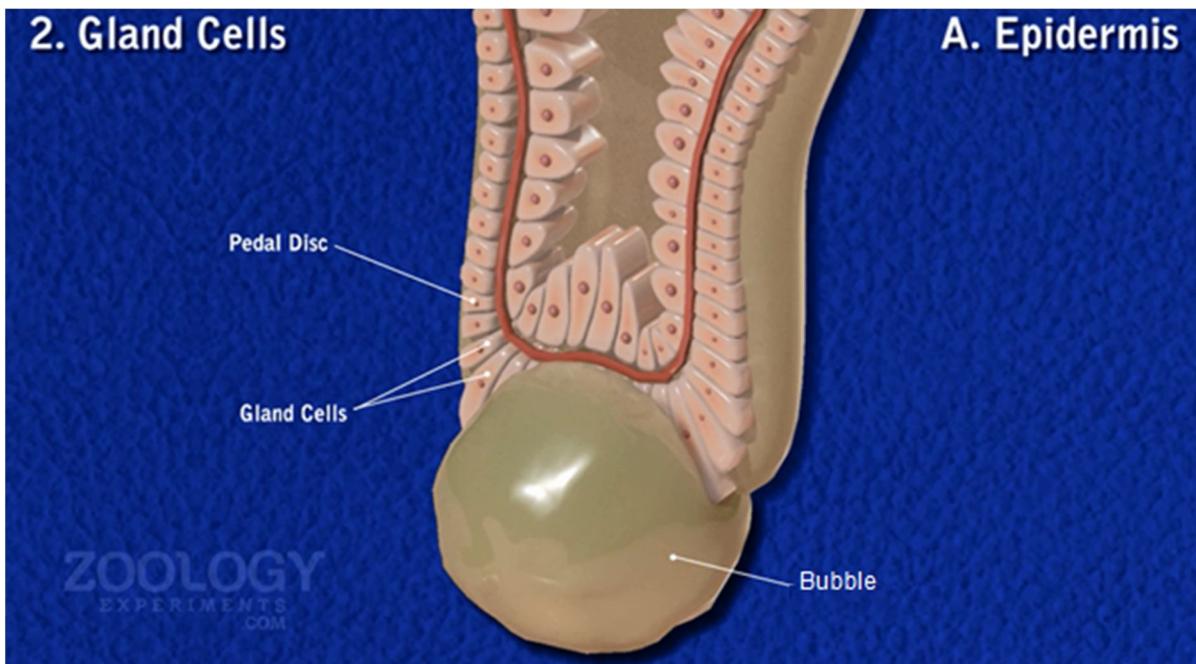


Figure 11

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 5 μ 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 any other kind of cells such as reproductive, glandular, 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.

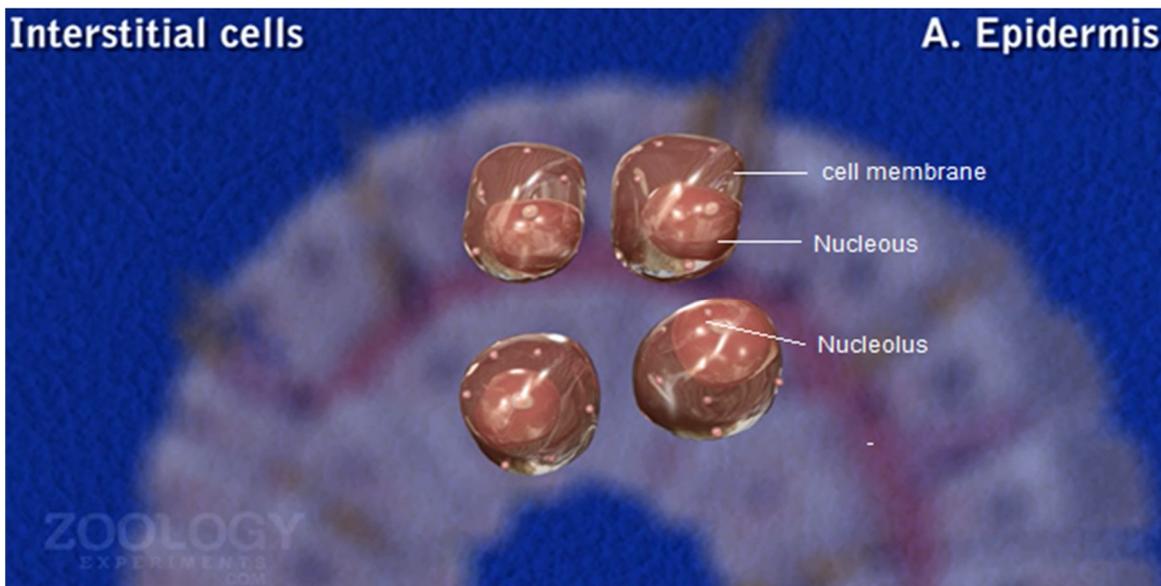


Figure 12

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

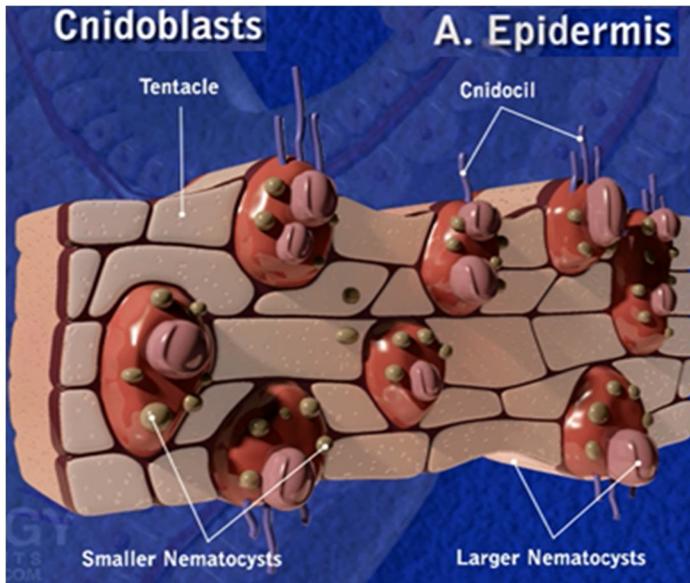


Figure 13

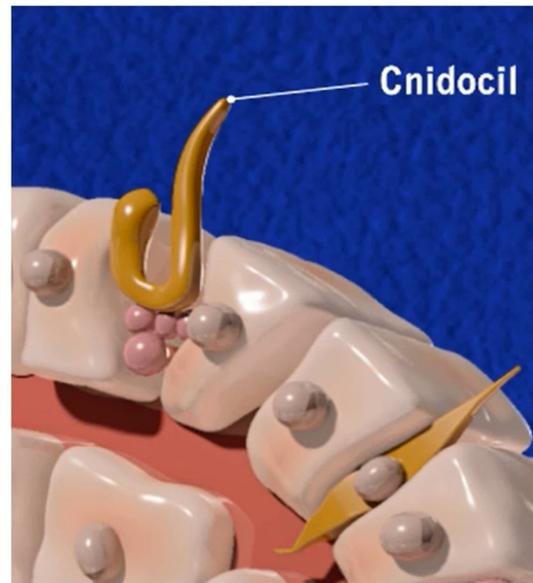


Figure 14

form of a capsule enclosing a 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 in another place 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 nodulated 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.

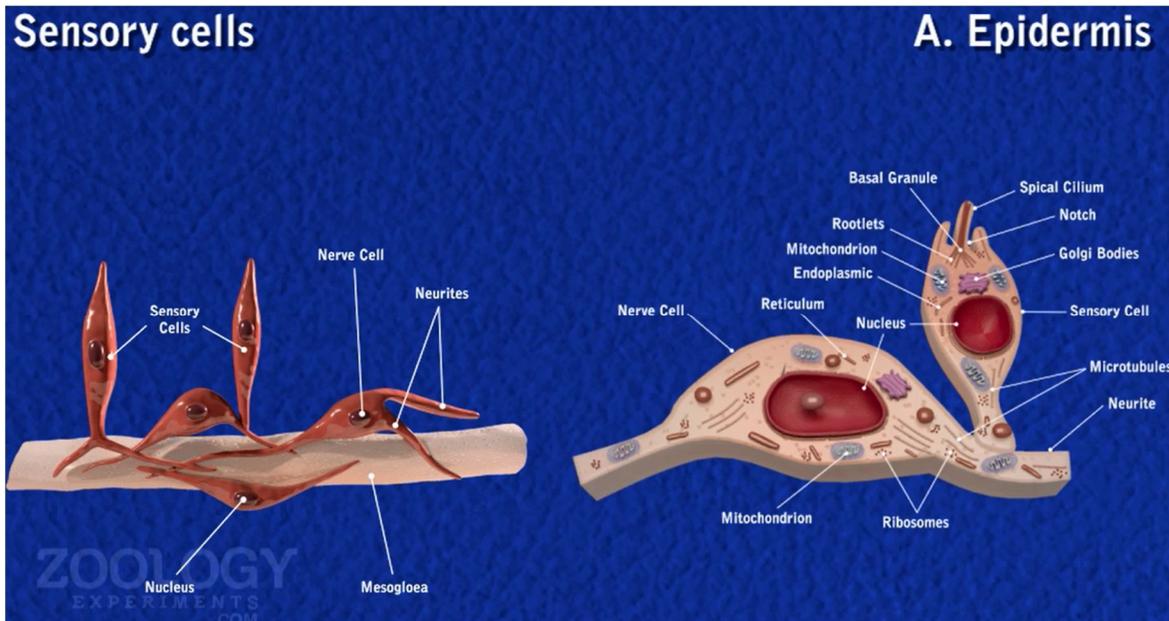


Figure 15

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.

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 Hydra an outline life process

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 mesogloea, thus forming a circular muscle layer. Each of these processes contain a muscle fibre or myoneme. Their contraction reduces the diameter of body and tentacles, which become narrower and longer. Contractile processes arc highly developed around mouth and bases of tentacles to form sphincters.

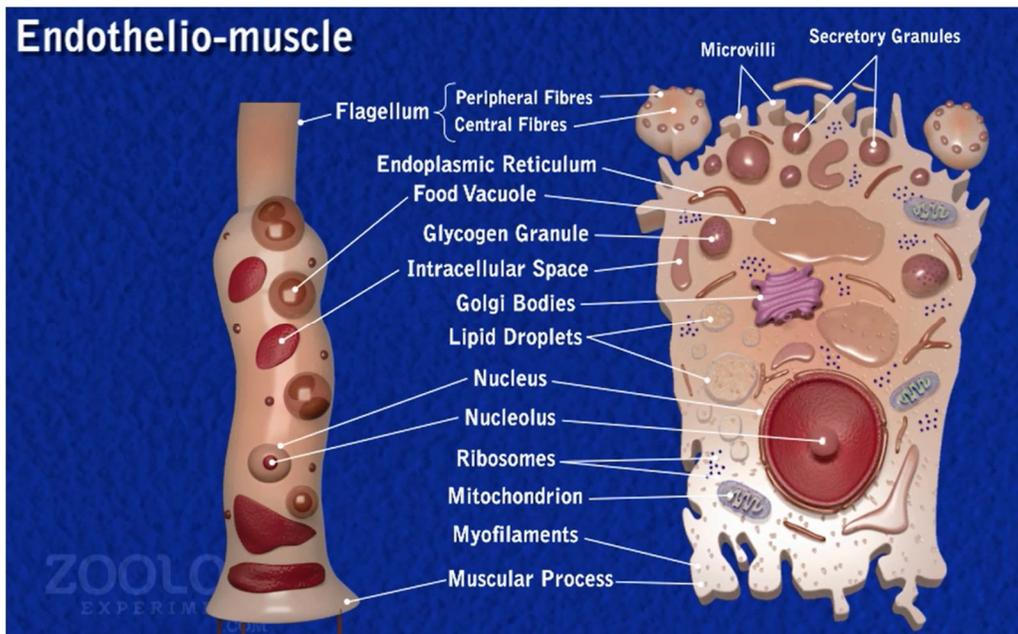


Figure 16

Free end of a nutritive-muscle cell, projecting into gastrovascular cavity, may bear long, whip-like flagella, usually 2 in number, by means of which the liquid food inside body-cavity is, kept 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.

2. Endothelio-gland cells:

Endothelio-gland cells are smaller than nutritive-muscle cells and occur 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.

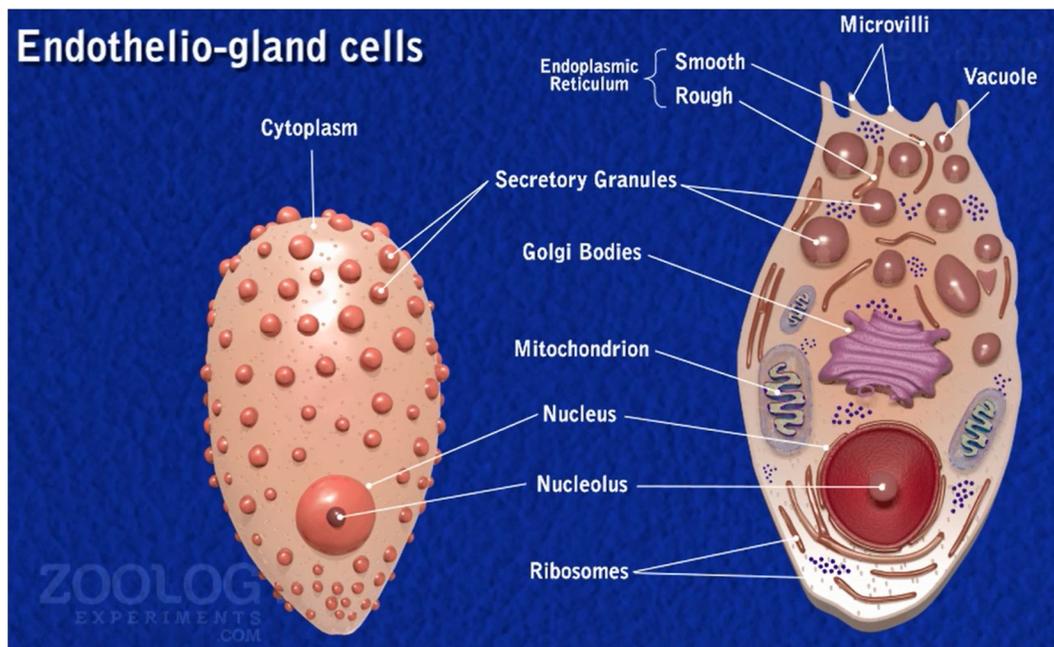


Figure 17

3. Interstitial cells:

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

need arises.

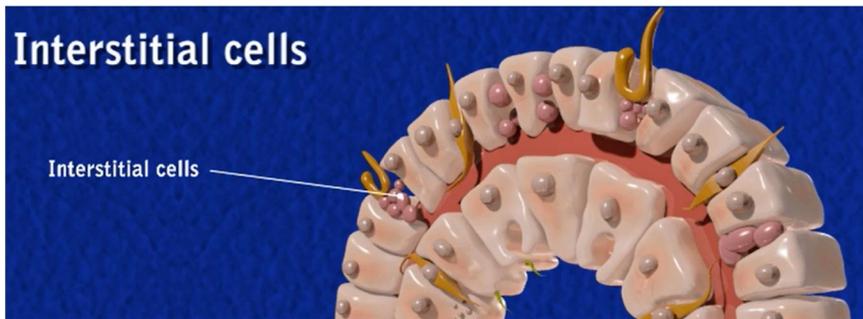


Figure 18

4. Sensory cells:

Large sensory cells are also found in gastrodermis. They are supposed to be stimulated by the entry of prey into gastrovascular 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 + glos, glue) of Hydra is a non-cellular thin layer, sandwiched between epidermis and gastrodermis, which secrete it. It consists of a 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.

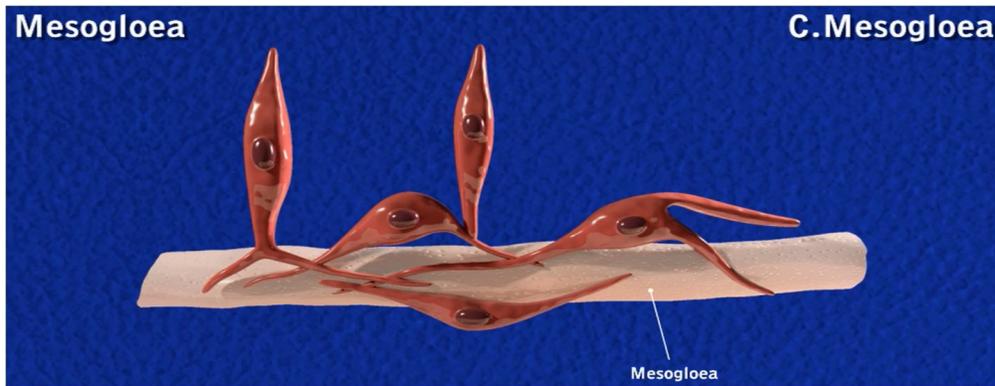


Figure 19

Locomotion

Hydras twist on or perform movements to change their location either in response to stimulus or to obtain food.

As gastrodermal muscle fibres are less developed, movements are largely due to contractions of the epidermal muscle fibres. Hydra shows movements of the following type.

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.

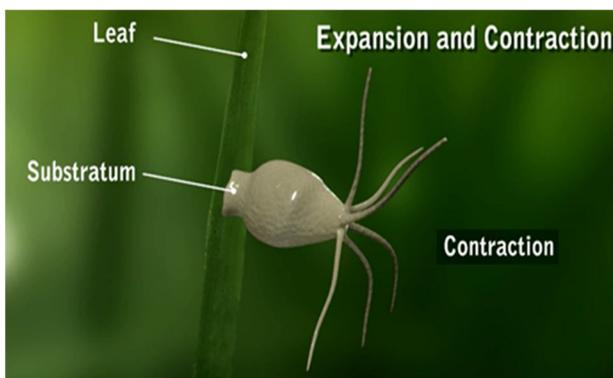


Figure 20

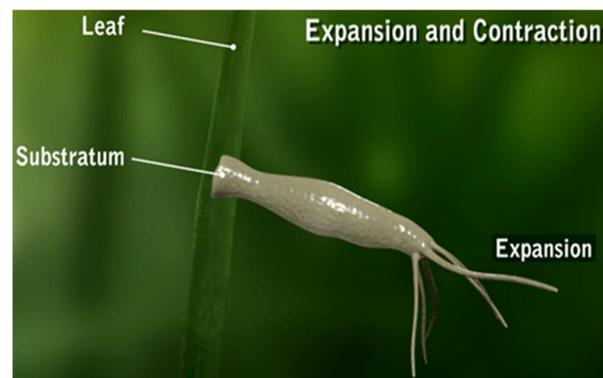


Figure 21

Looping:

Hydra moves one place to another in search of food. generally 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 detached from substratum and brought up closer to crown of tentacles and then attached. Now tentacles loosen and body becomes erect again. The whole process, which is repeated often times, and appears like a series of looping movements of a caterpillar or leech.

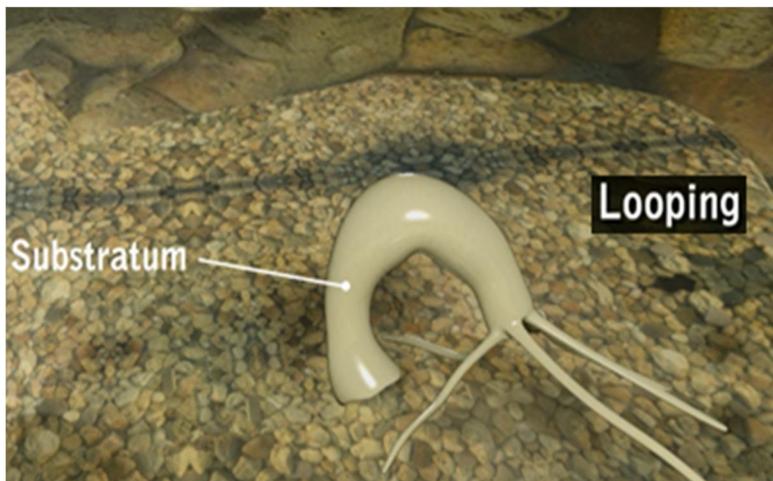


Figure 22

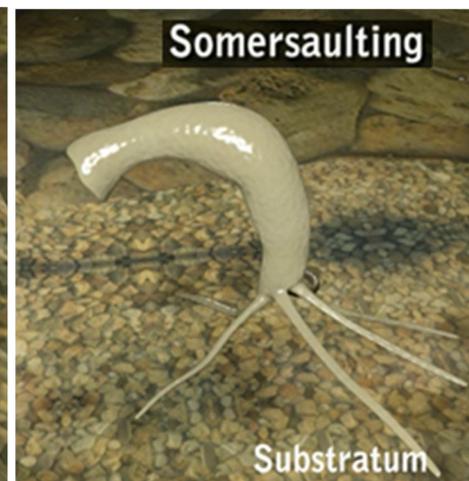


Figure 23

Somersaulting:

Hydra somersaults like a gymnast. The tentacular end is brought forward and attached to the substratum. The pedal disc moved upwards, thus causing Hydra to an inverted posture. Now, pedal disc is moved forward and attached to a new position. By freeing the tentacles end the animal again assumes its upright position. The animal performs a series of somersaults by repeating the process.

Gliding:

For a short distance alongside a smooth surface, it slides down on its basal disc like a snail or amoeba, secretions from mucous glands help to lubricate the surface .

Walking:

Sometimes, Hydra becomes inverted, set on its tentacles and moves in an inverted condition, using its tentacles like legs. This type of movement takes place on some object such as leaf and in relaxed condition.



Figure 24

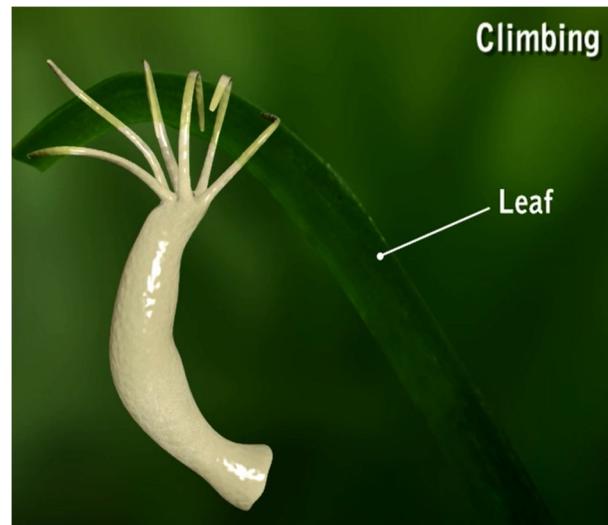


Figure 25

Climbing:

Hydra other than vulgaris can show climbing by attaching its long tentacles to some object, releasing the foot, and then contracting the tentacles, so that the body is lifted up. While changing location in a limited area.

Floating:

Rarely, Hydra shows free and floats on water surface with waves, Sometimes Hydra attaches to a floating leaf or twig by its pedal disc

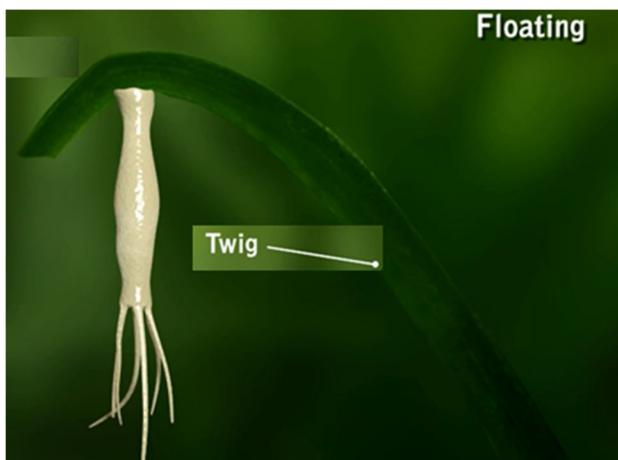


Figure 26

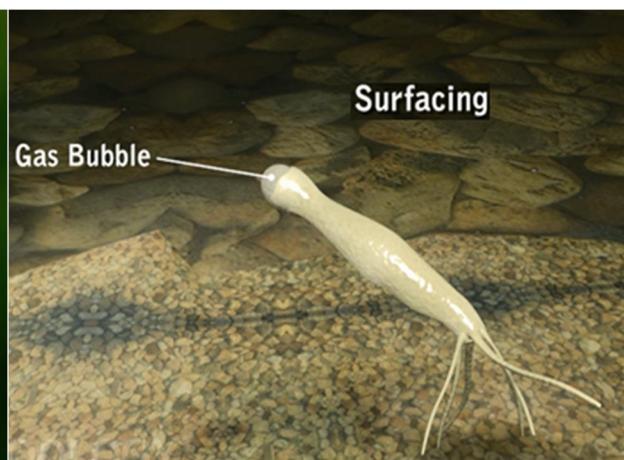


Figure 27

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.

Swimming:

It is said that sometimes Hydra frees itself from substratum and swims in water by undulating, wave-like movements of tentacles and body.



Figure 28

Behaviour

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

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.

Contact:

During swimming or floating Hydra comes in contact with a solid rock, it gets attached to it with its pedal disc. This is localized stimulus, while a strong stimulus affects the whole body.

Light:

Hydra shows negative response to both strong as well as weak light. It prefers to
Hydra an outline life process

gather in regions of moderate light intensity. By trial and error, hydras try to find areas of suitable light intensity.

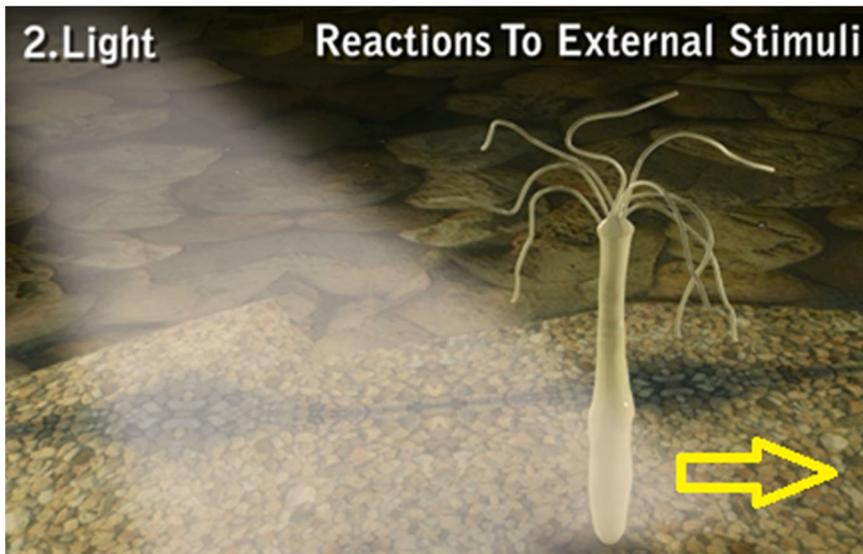


Figure 29

Temperature:

Hydra prefers cool or cold water and moves deep water when temperature reaches 20° to 25°C.

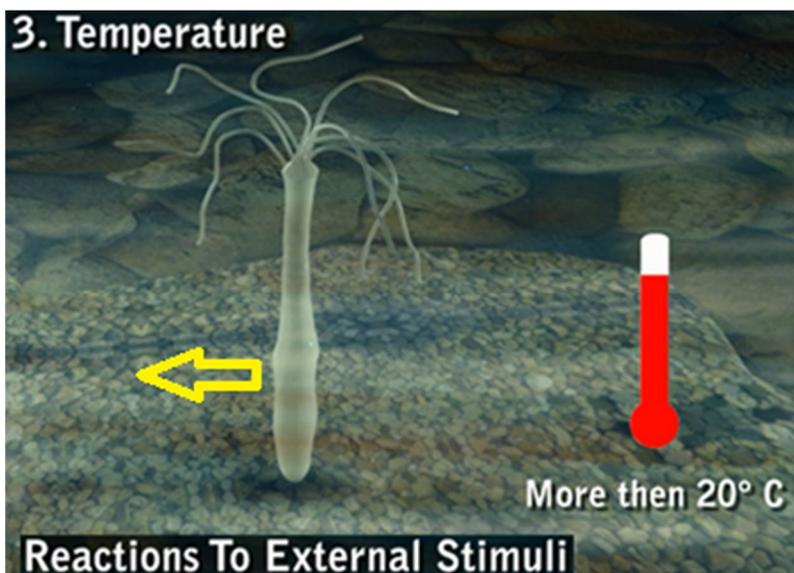


Figure 30

Electric current:

When Hydra is subjected to a weak and constant electric current, its tentacular

end bends towards anode and pedal disc towards cathode.

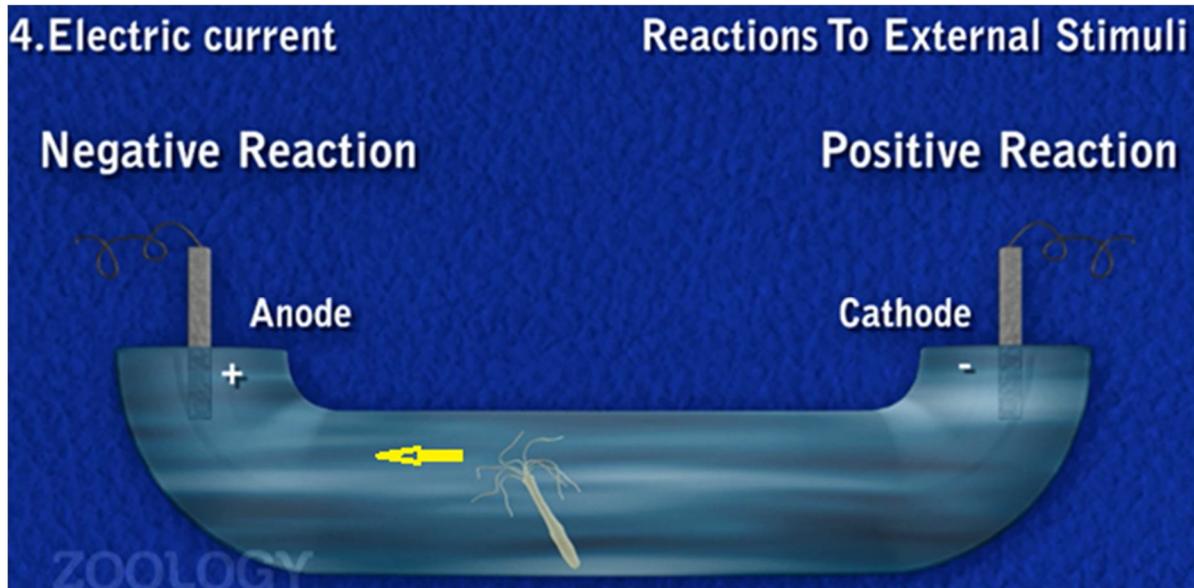
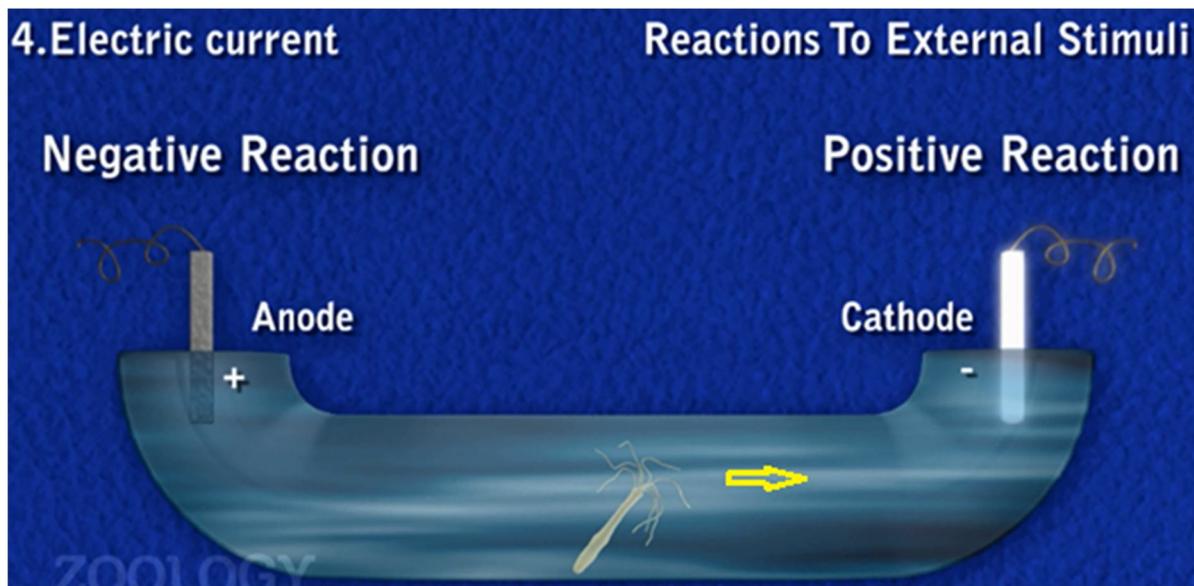


Figure 31

When the animal is inverted with tentacles attached to substratum, the pedal disc bends towards anode and tentacular end towards cathode.



Water current: Hydra shows no reactions to water currents.

Chemicals: Hydra stay away from strong and harmful chemicals

Reproduction

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

Hydra an outline life process

Budding:

During summer, when the animal is well-fed, healthy and with favorable environment, asexual budding is the usual process of reproduction. Near the basal part of body, a bulging appears with continues cell division of epidermal interstitial cells. This grows as a bud with its wall consists of epidermis and gastrodermis and the interior lumen in persistence with the parent's gastrovascular cavity. The bud enlarges, develops a mouth and tentacles at its free end. after full grown, the bud constricts at the base and finally separates from the parent body. It feeds and grows into an adult Hydra.

Sometime, several buds occur at the same time on a single parent, and these temporarily resembles a colonial hydroid.

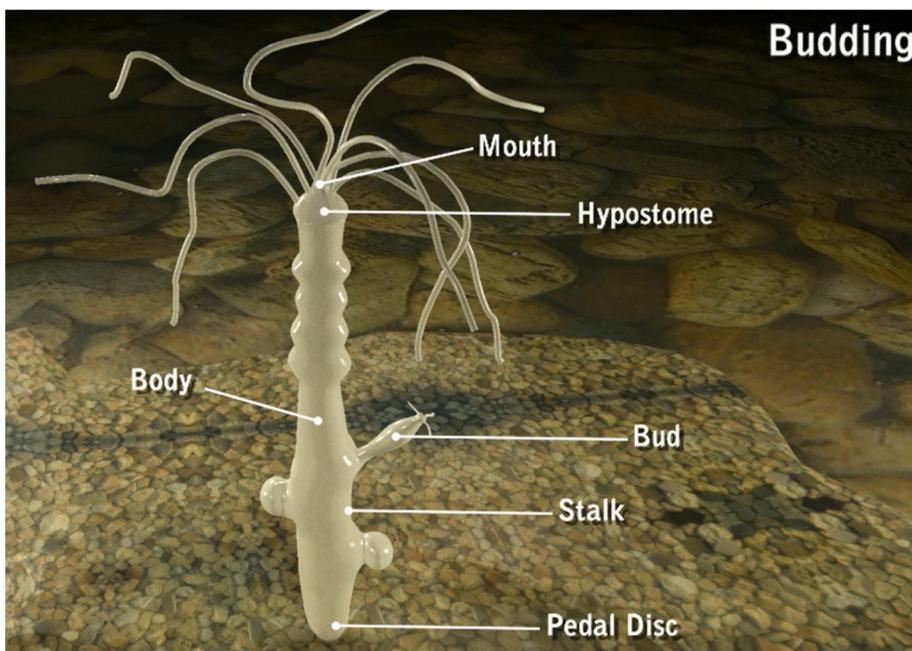


Figure 32

Sexual Reproduction:

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. Hydra is hermaphrodite Species; even though self-fertilization is avoided, because it is protandrous means spermatozoa and ova

mature at different times.

Testes :

Testes are conical outgrowth of body wall, varying in number from a few to many. They are generally situated near the oral end of body, testis is formed by cell division of interstitial cells of epidermis, they get covered from outside by a capsule formed of large epidermal cells. Interstitial cells at the base are spermatogonia. They undergo usual spermatogenesis, developed primary spermatocyte, secondary spermatocyte and spermatid stages become spermatozoa or sperms. spermatozoa has a head and a long vibratile tail. When mature, sperms are discharged by the rupture of testis wall at its apical nipple-like knob.

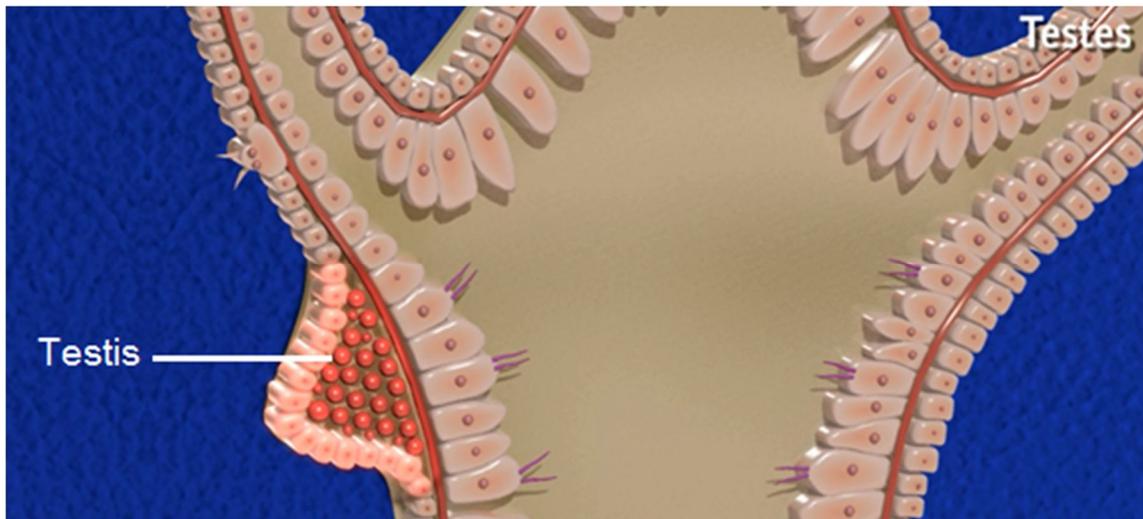


Figure 33

Ovaries:

Ovaries develop a little later than testes. These are ovoid structures, located near the basal end of body. Ovary is also 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 is nourished 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.

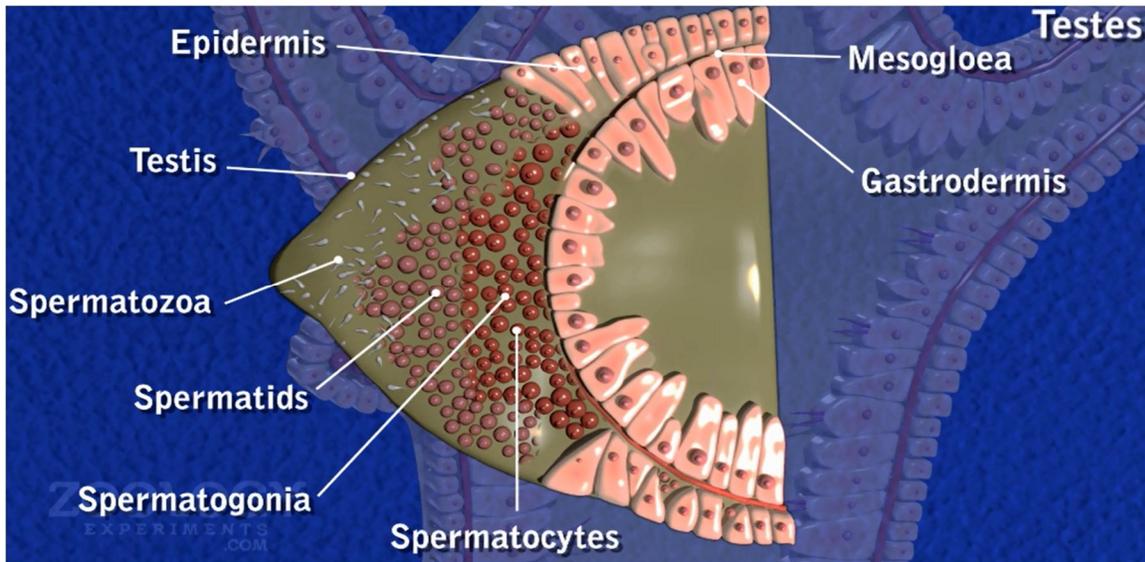


Figure 34

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. Mature egg or ovum is a large spherical mass, full with yolk granules. One ovary usually contains a single ovum, but rarely there are found two or more.

When an egg is ripe, the epidermis over it ruptures and withdraws to form a cup-like receptacle containing the exposed egg, Ovum is not set free at once but remains attached to the parent by a large base.

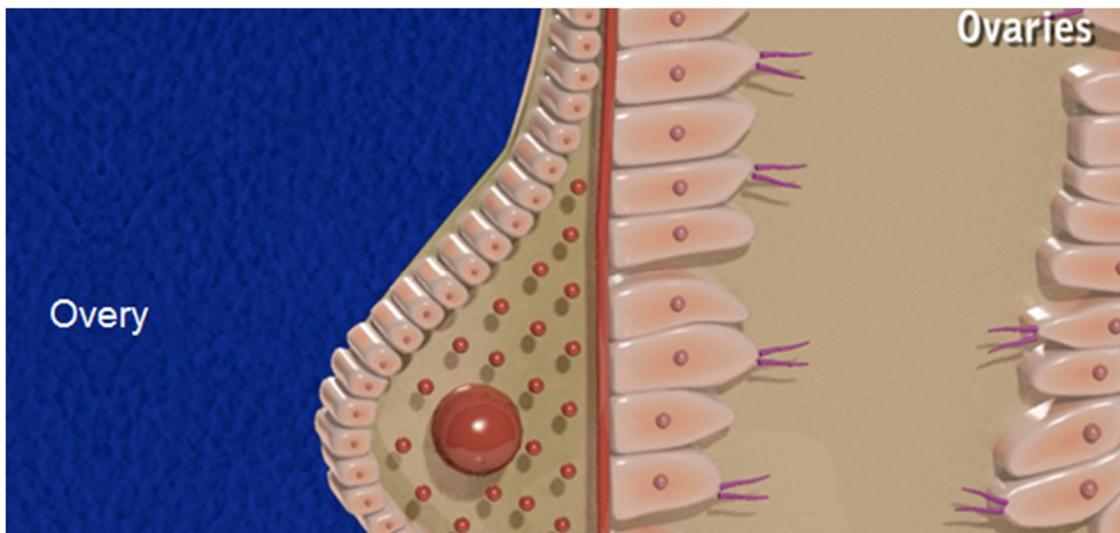


Figure 35

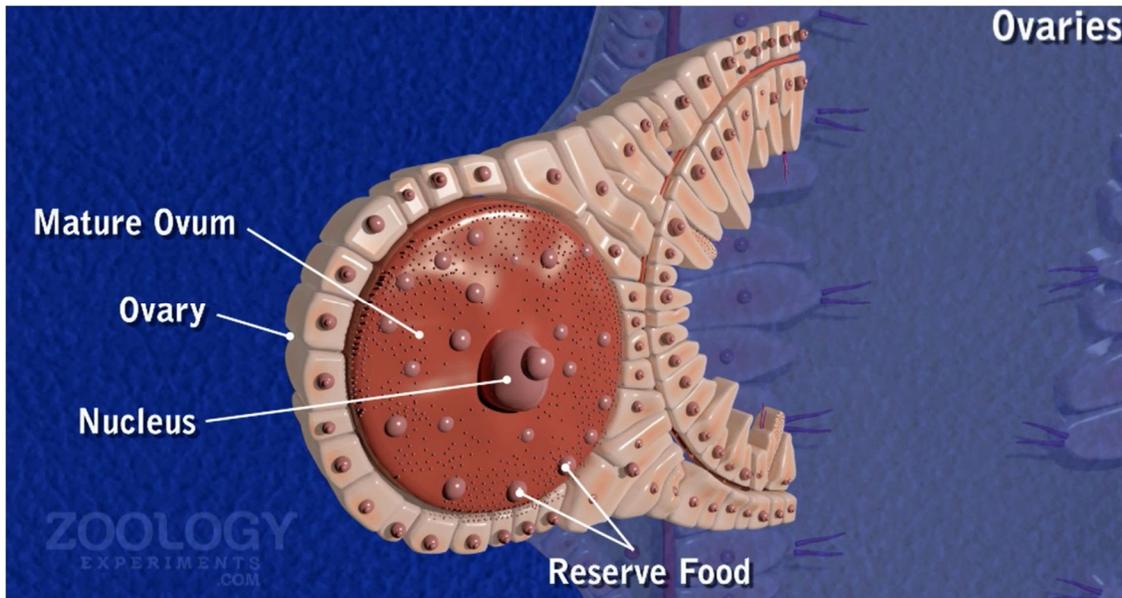


Figure 36

Fertilization:

Ripe sperms, discharged from testes, swim about in water until they approach an ovum and surround it. Numerous sperms may enter the gelatinous covering, but only one enters the ovum and fuses with it. This process is called fertilization, and the fertilized egg is called zygote.

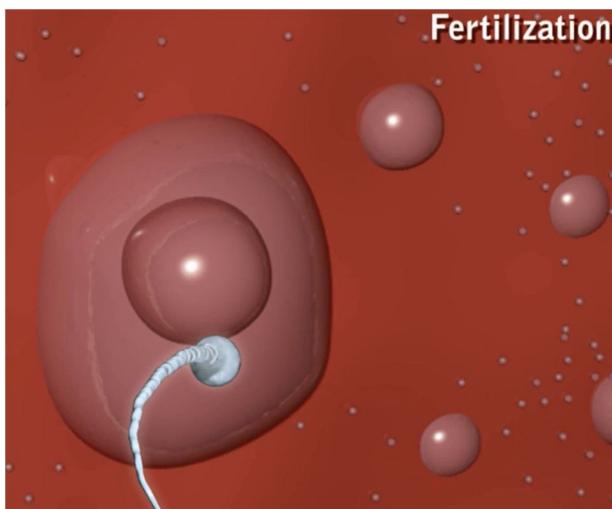


Figure 37

Development:

Development begins soon after fertilization, while the egg or zygote is still
Hydra an outline life process

attached to the parent, by undergoing cleavage or segmentation.

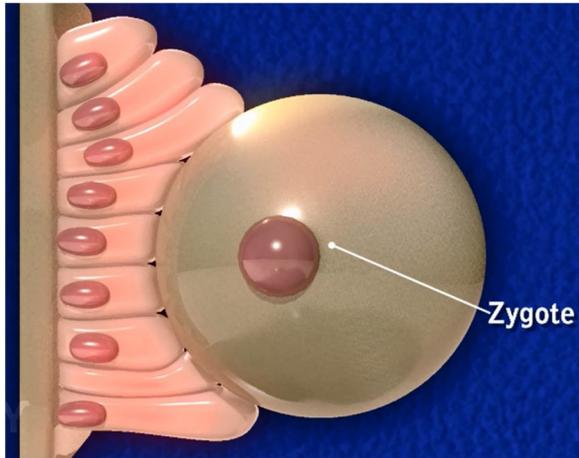


Figure 38

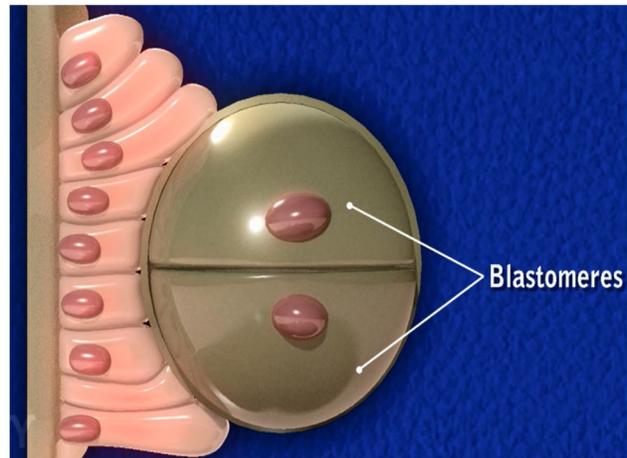


Figure 39

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

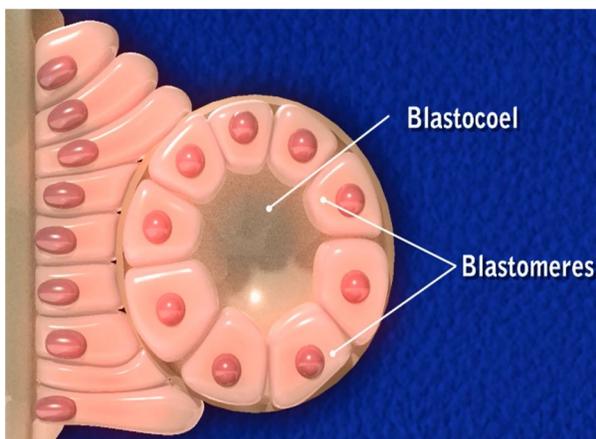


Figure 40

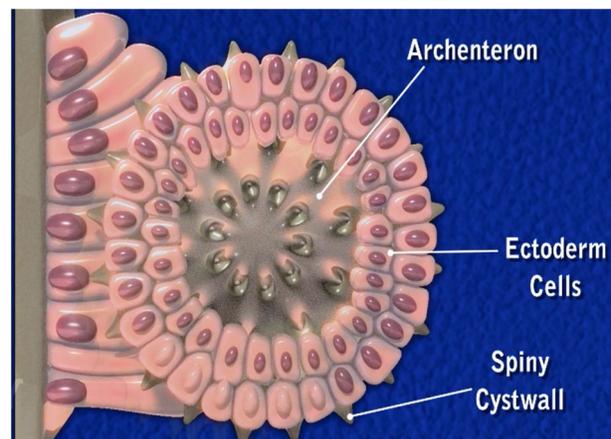


Figure 41

c) Gastrulation:

Some cells of blastular wait detach and migrate inwards (multipolar

ingression). While other cells form outer and inner cells by tangential division (primary delamination). As a result blastocoel is 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, and an inner solid mass of cells forming endoderm. As described above, gastrulation or formation of endoderm in Hydra is partly by multipolar ingression and partly by primary delamination.

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 *F. 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 favourable 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 a 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.

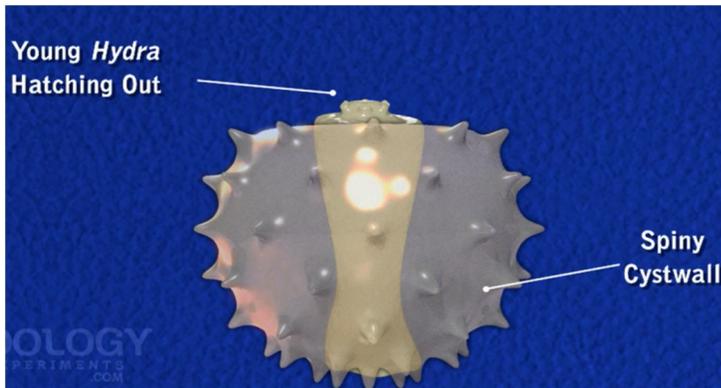


Figure 42

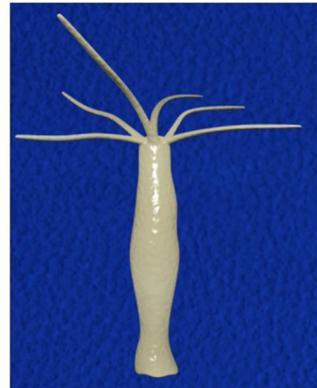


Figure 43

Regeneration

Regeneration is the capacity of an individual to replace its lost or damaged body parts. 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. We should not consider Regeneration as 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.



Figure 44

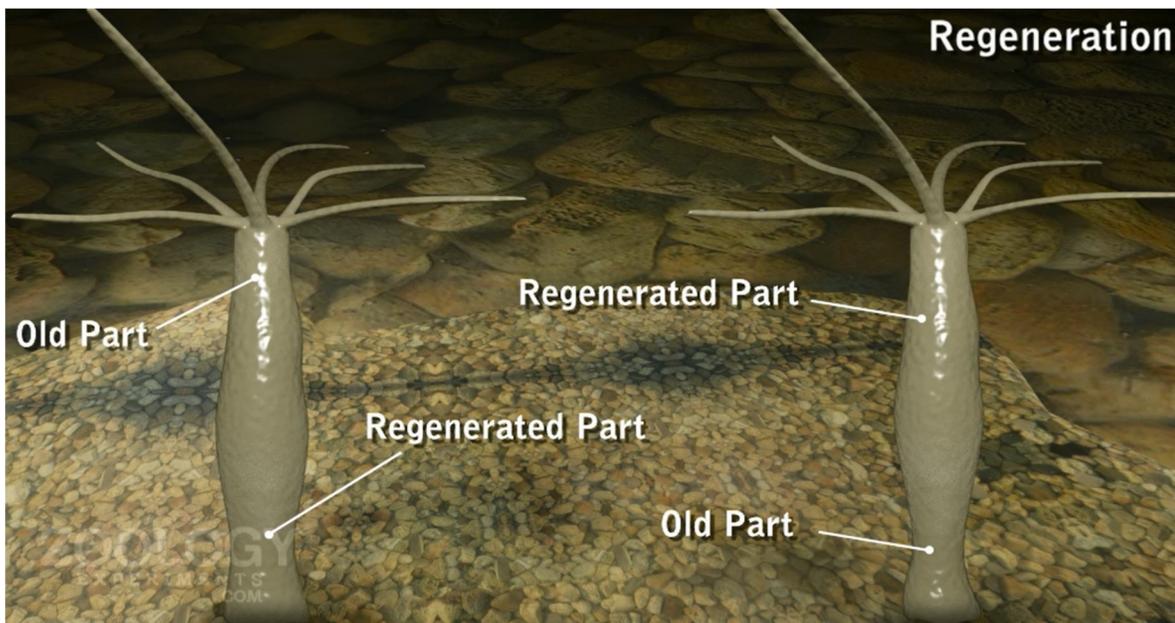


Figure 45

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.

Acknowledgements:

www.zoologyexperiments.com the website developed under the NME-ICT. This outline of *Hydra vulgaris* is the Chapter which will fully help to the students and teachers of Zoology for ready reckoner reference.

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www.zoologyexperiments.com