Hirudinaria granulosa: The Indian cattle leech

Class *Hirudinea* comprises of leeches which are perhaps the most specialized annelids without parapodia and setae but with suckers. About 300 species of leeches are known to occur in the tropical and temperate parts of the globe. Most of them are freshwater, while some are marine or terrestrial. Most of leeches are ectoparasitic, living on the blood of vertebrates, while some are predaceous, feeding on worms, snails, insect larvae, etc.

The genus *Hirudinaria* includes four species of Indian cattle leeches *Hviridis, Hjavanica, H. manilensis and H. granulosa*. Late Prof. M.L. Bhatia (1941) has given a detailed monographic morphology of *H. granulosa,* the common Indian cattle leech. The description given below however, applies broadly to other species as well.

Hirudinaria granulosa

SYSTEMATIC POSITION

Leech: systematic position (YOUTUBE)

Phylum.	Annelida
Class.	Hirudinea
Order.	Gnathobdellida
Family.	Hirudinae
Genus.	*Hirudinaria*
Species.	*granulosa*

HABITS AND HABITAT (ECOLOGY)

Leech: habits and habitats (YOUTUBE)

Leech: introduction (YOUTUBE)

Hirudinaria granulosa, the Indian cattle leech, is found in India, Myanmar, Sri Lanka, Pakistan and Bangladesh. It occurs in freshwater ponds, lakes, tanks, swamps and slow streams, where it either swims

by vertical undulations or grips objects with its suckers and moves by looping Like most ectoparasitic leeches, it has a blood-sucking (sanguivorous) habit, feeding on the blood of fish and frogs and also of cattle and men, who happen to enter the water inhabited by it.

Though hermaphroditic, leeches copulate to bring about cross-fertilization. Eggs are deposited in cocoons. Development is direct, i.e., there are no free larval stages in the life history.

EXTERNAL MORPHOLOGY

Leech: external characters - morphology (YOUTUBE)

[I] Shape and Size

Hirudinaria has a soft, vermiform, elongated and dorso-ventrally flattened body, ordinarily 10 to 15 cm long, but a full-grown specimen may even measure upto 35 cm in length. Body is broader near the posterior end and narrow at the anterior end. It is capable of causing great alterations in form and proportion, being ribbon-shaped when extended and almost cylindrical when contracted. In a normally-stretched leech, the dorsal surface remains somewhat convex with the ventral surface more or less flat. A transverse section through the body is almost oval in outline. Skin is moist and slimy due to abundant secretion of mucus, which helps in cutaneous respiration

[II] Colouration

Body of leech is brightly coloured with characteristic markings. Dorsal surface is coloured olive-green and ventral surface orange-yellow or orange-red. On the sides are conspicuous stripes of orange or yellow, bounded ventrally by broad black stripes and dorsally by black spots arranged in a series of the second and fifth annuli of each segment.

[II] Segmentation

Body of leech is metamerically divided into 33 segments or somites. Except the first two and the last seven, each segment is further superficially subdivided into rings or annuli by closely-set grooves or furrows. A typical segment possesses five annuli. Segments with less than five annuli are referred to as incomplete. A temporary clitellum is formed by segments 9th, 10th and 11th, during breeding season.

[IV] Receptors

Surface of each annulus is divided by fine longitudinal furrows into rectangular areas, each bearing a minute and elevated sensory papillathe annular receptor. There are about 18 such receptors on dorsal and 18 on ventral side of each annulus. Besides these, there are large sensory papillae, called segmental receptors or sensillae, 4 pairs on dorsal and 3 on ventral side in the first annulus of each segment. A pair of eyes is borne on dorsal surface by the first annulus of each of the five segments, which are termed the ocular segments. The 5 pairs of eyes appear as a semicircle of black dots at the anterior end.

[V] Suckers

Each end of the body bears a hollow muscular
organ, the sucker:

1. Anterior sucker. Anterior or cephalic
sucker comprises the prostomium and three anterior body-somites. It is oval in outline with a ventrally directed, cup-like hollow, called the pre-oral chamber, at the bottom of which lies the mouth,

2. Posterior sucker. Posterior end of body also bears a circular and highly muscular disc, the posterior or anal sucker, also directed downwards. It is formed by the complete fusion of the last seven body segments (27 to 33) arranged in concentric rings.

Both the suckers are primarily meant for adhesion and locomotion. The anterior sucker also helps in feeding.

[VI] External Apertures

(i) Mouth is a narrow, triradiate aperture opening centrally in the preoral chamber of anterior sucker**(ii) Anus** is a small aperture opening mid-dorsally on the 26th segment at the base of posterior sucker. **(iii) Nephridia** open to the exterior by 17 pairs of nephridiopores, of which one pair lies ventrally on the last annulus of each of the segments from 6 to 22 **(iv) Male genital pore** is a mid-ventral opening, situated in a groove between second and third annali of 10th somite. Sometimes a thread like penis is seen protruding through this aperture **(v) Female genital pore** lies midventrally in between the second and third annuli of 11th somite.

[VII] Body Divisions

Body of leech can be distinguished into following six regions

1. Cephalic It is composed of first 5 or the ocular segments. It includes prostomium, anterior sacker, mouth and eyes Nephridiopores are absent. The segments one and two are uniannulate, segment three is biannulate and segments four and five are triannulate. The first three segments with prostomium form the upper lip.

2. pre-clitellar. It is formed by three segments (6,7 and 8) all bearing nephridiopores. Segment six is triannulate and the remaining two are quinquannulate, each having five annuli.

3.Clitellar. It comprises of three segments (9.10 and 11), which possess highly glandular walls and nephridiopores. A permanent clitellum does not exist in Hirudinaria but it develops temporarily during breeding season around this region. Male and female genital pores lie mid- ventrally on 10th and 11th segments, respectively. Segments are quinquannulate

4. Middle. It is the largest region comprising 11 segments (12 to 22), all quinquannulate and possessing nephridiopores.

5. Caudal. It is without nephridiopores and includes four incomplete segments (23 to 26), of which the 23rd is triannulate and the restr biannulate. Segment 26 also bears the mid-dorsal anal aperture.

6. Posterior sucker. It is composed of seven segments (27 to 33), arranged in concentric rings, and each represented by a single annulus.

BODY WALL

Body wall of leech includes five layers: (i) cuticle, (ii) epidermis, (iii) dermis, (iv) muscular layer and (v) botryoidal tissue.

[I] Cuticle

It is the outermost, thin, delicate, transparent, colourless, and moderately elastic protective covering, secreted by the underlying epidermis. It is slightly thicker on dorsal surface and is perforated all over by openings of epidermal glands. It is cast off from time to time in the form of thin transparent shreds especially after a heavy meal, and renewed. It is also shed if the leech is placed in dirty water.

[II] Epidermis

Lying below cuticle is the epidermis which consists of a single layer of hammer-shaped cells. These cells are broad, flattened and pentagonal towards the outer, and narrower towards their inner ends. Outer ends fit closely while the nucleated inner ends have interspaces containing fibrous connective tissue, pigment cells and haem coelomic capillaries, forming a vascular and respiratory membrane.
Some epidermal cells become modified to form unicellular glands and multicellular receptor organs.

[III] Dermis

It lies between epidermis and muscles and consists of a network of fibrous connective tissue. Besides, it contains connective tissue cells, pigment and fat cells, scattered muscle fibres, haemocoelomic capillaries and basal portions of epidermal slime glands.

[IV] Muscles

Musculature is well developed and forms the largest part of body wall. Muscles form either continuous layers or separate bundles, (i) Circular muscles form the outermost thin layer lying circular muscles and relaxation of longitudinal beneath the dermis. Next to them is a layer of (i) oblique muscles Beneath them are found many layers of (i) longitudinal muscles, which form the greatest part of musculature. Besides, a number of isolated muscle bundles run either diagonally through body or in straight lines from dorsal to ventral surface. A pair of such (iv) dorsal ventral muscles run vertically in each segment by the sides of

alimentary canal, while those lying near the flanks are termed the (v) vertical muscles Their ends spread out and terminate just beneath the epidermis. Numerous (vi) radial muscles run from the interior of body to the surface.

A muscle fibre of leech is an elongated, fusiform and tubular cell consisting of an outer contractile cortex or myoplasm enclosing an inner, Don-contractile medulla or sarcoplasm, which is composed of finely granular protoplasm containing an oval nucleus.

[V] Botryoidal Tissue

Beneath the longitudinal muscles and immediately surrounding the alimentary canal is found the characteristic botryoidal tissue. This tissue fills the entire coelom except a few spaces termed the haemocoelomic spaces. It is composed of a network of large branching tobular cells arranged end to end. Walls of cells are loaded with a dark brown pigment while their intracellular canals contain a red fluid (haemocoelomic fluid) in life. It is probably excretory in function.

LOCOMOTION

Leech: locomotion (YOUTUBE)

Leeches performs two types of movements (i) looping or crawling movement on substratum, and (ii) swimming in water.

[I] Looping or Crawling Movements

These are performed with the help of muscles and suckers which serve for attachment. First, the leech fixes its posterior sucker firmly onto the substratum, aided by the slimy secretion of sucker glands (A). This initiates contraction of circular muscles and relaxation of longitudinal muscles so that anterior part of body is extended forward as far as possible (B). Next, the leech fixes its anterior sucker. Now the relaxation of circular muscles and contraction of longitudinal muscles release the posterior sucker from its hold and shortens, the body (C)As posterior end is brought forward close to the anterior end, the body is raised up in the middle forming a loop (D). Once more the posterior sucker is fixed, anterior sucker released and the whole process repeated (E)This is a type of activity often called 'leech-like' locomotion.

[II] Swimming Movements

Leech swims very actively and gracefully in water. During swimming, the body becomes dorso- ventrally flattened and performs successive undulating movements. The undulating waves pass longitudinally over the body.

DIGESTIVE SYSTEM

Leech: digestive system (YOUTUBE)

[1] Alimentary Canal

Alimentary canal of leech is a complete straight tube of varying diameter, extending from mouth anus. It is differentiated into buccal cavity, pharynx, oesophagus, crop, stomach, intestine and rectum. Buccal cavity, pharynx and rectum are lined internally by ectodermal epithelian covered by cuticle. They form stomodaeum and proctodaeum, respectively, while the rest of gut is lined internally by endodermal epithelium and forms the mid-gut or mesenteron,

Greater part of alimentary canal (crop) is concerned with storage of uncoagulated ingested blood, while only a small portion is concerned with digestion and absorption. This modification is strictly in accordance with the sanguivorous habit of leech.

1. Pre-oral chamber and mouth. The pre-oral chamber is a cup-like depression on the ventral side of oral sucker. Its roof is formed by a membrane-like velum bearing a triradiate opening, the mouth, in the centre. One ray or chink of mouth is medio-dorsal, while the other two are ventro-lateral. Velum forms three lips around the mouth, one between two adjacent rays, so that there are two dorso-lateral and one longitudinal mid-ventral lip.

2. Buccal cavity. Mouth leads into buccal cavity, which is a short chamber behind velum. In its mucous lining are embedded three cresentic jaws, arranged in a triangle. There is one jaw behind each ray or chink of mouth, so that one jaw is mid-dorsal and the other two ventro-lateral in position. Each jaw is a laterally compressed muscular cushion, covered with fine cuticle which is thickened at the free edge to form a ridge bearing minute teeth or denticles in a single row. Such jaws are termed monostichodont. Number of denticles is 103-128 on the median jaw and 85-115 on a lateral jaw. On each flat side of a jaw are about 42-45 button-shaped protuberances, the salivary papillae, each bearing numerous openings of salivary glands.

Jaws are moved by muscles and work as semicircular saws. Acting together, they produce the characteristic triradiate bite or Y- shaped wound in the skin of host

3. Pharynx. Buccal cavity leads into a highly muscular pharynx. It is an oval sac extending from the 5th to 8th segments. Its inner surface bears longitudinal folds. Externally, it is surrounded by large masses of unicellular pyriform salivary epidermis- glands, whose ductules, in bundles, run anteriorly and enter the three jaws to open on their salivary papillae. Secretion of these glands contains hirudin or anticoagulin which prevents coagulation of blood while the leech is feeding. Numerous radial muscles connect the wall of pharynx with the body wall.

4. Oesophagus. It is a remarkably short and narrow tube through which pharynx leads into cropIt has a very narrow lumen and a much folded epithelial lining.

5. Crop. It comprises the largest portion of alimentary canal. It is a thin-walled extensive tube, occupying about two-third of the visceral space and extending from 9th to 18th segment. It is divided by narrow constrictions into a series of 10 (sometimes 11) chambers, communicating by more or less circular apertures surrounded by sphincters. Each chamber consists of a small anterior part and a broad posterior part and a broad posterior part, bearing a pair of lateral backwardly directed blind outgrowths, or storing pockets,

called caeca or diverticula. Crop chambers and caeca gradually increase in size towards the posterior side. The last or 10th chamber is the biggest, and its caeca extend as two greatly elongated blind sacs along the intestine, as far as, or even beyond the 22nd segment.

Crop and its diverticula are capable of great dilation to store enormous quantity of blood which can be digested slowly.

6. Stomach. Posteriorly. the last chamber of crop ends into a funnel-shaped tube. It leads through a sphinctered aperture into a small heart- shaped stomachl ying in the 19th segment. Mucous lining of stomach is thrown into anastomosing transverse folds.

7. Intestine. Posteriorly, the stomach leads into intestine. It is a thin-walled, straight narrow tube running from 20th to 22nd segment. Its inner lining is thrown into numerous spiral folds and villi- like processes which increase its absorptive surface.

8. Rectum. Intestine is followed by a somewhat dilated and thin-walled rectum lying from 23rd to 26th segment. It runs slightly upwards and opens to the exterior through a small anus placed mid-dorsally on the 26th segment. Rectum has an internal ciliated cuticular lining and is without folds.

[II] Food, Feeding and Digestion

1. Food. Hirudinaria has a sanguivorous habit, sucking blood of cattle and other domestic animals which visit waters harbouring them.

2. Feeding or ingestion. A feeding leech firmly adheres to the victim by its posterior sucker and then applies its anterior sucker. The three jaws are protruded through mouth and moving like saws, make the characteristic triradiate or Y-shaped painless incision in the skin of host. Cutaneous vessels are laid open and the oozing blood is sucked in with the help of pre-oral chamber, buccal cavity and muscular pharynx. Contraction of radial muscles, around pharynx, dilates the pharyngeal cavity resulting in the suction of blood. The active substance, hirudin or anticoagulin, present in salivary secretion poured on wound, prevents the clotting of blood which continues to flow regularly for some time, even after the leech has detached itself.

A leech can suck, at a single meal, several times its own weight of blood, which is enough for the animal for several months or even a year. After feeding it drops off its victim, seeks a dark and concealed shelter and digests at leisure.

3. Haemolysis and digestion. The ingested blood is stored uncoagulated in crop and its diverticula. Blood gets haemolysed in crop, i.e., the blood corpuscles break down and their haemo-globin goes into solution. Water from haemolysed blood is absorbed and blood becomes jelly-like and dark red in colour.

Blood from crop passes drop by drop through the sphinctered aperture into stomach, where it turns green. Digestion takes place in stomach and intestine. Exact mechanism of digestion is not known. Heise (1909) reported a proteolytic enzyme in leech. Working on Hirudo, Bupsing and others (1953) discovered that digestion is brought about entirely by gut bacteria.

[III] Absorption and Egestion

1. Absorption. Digested blood is absorbed slowly in stomach and intestine, the walls of which have numerous folds and haemocoelomic branches. Complete digestion and absorption of a full meal may take about a year or even more.

2. Egestion. Undigested food is stored temporarily in rectum. Egestion, is accomplished through anus.

COELOM

A true perivisceral coelom or a body cavity around alimentary canal, as found in earthworm and Nereis is absent in leeches. It is greatly obliterated and filled with the characteristic botryoidal tissue. However, the original coelom in Hirudinaria is represented by four longitudinal channels, their branches and capillaries, and numerous spaces, some of definite, but others of doubtful coelomic nature.

The coelomic fluid, running through the channels and their branches, contains colourless amoeboid corpuscles and is coloured red due to haemoglobin dissolved in it. This blood-like coelomic fluid is called the haemocoelomic fluid and the channels are termed the haemocoelomic channels which together form the haemocoelomic system.

Thus, in Hirudinaria, there are no true blood vessels, their function being taken up by the haemocoelomic system.

Coelomic spaces enclosed within testis sacs and ovisacs, around vasa deferentia and lying in between viscera, contain a colourless fluid without respiratory pigment or haemoglobin. These spaces represent the true coelom in Hirudinaria.

HAEMOCOELOMIC SYSTEM

[1] Haemocoelomic Channels

Haemocoelomic system of Hirudinaria mainly consists of four longitudinal sinuses or channels: one dorsal, one ventral and two laterals, and their branches. As already referred to, these channels are not true blood

vessels but remnants of original coelom. Dorsal and ventral channels have non- contractile thin walls made of connective tissue and coelomic epithelium. Lateral channels secondarily acquire contractile and thick muscular walls and appear like true blood vessels.

Through the haemocoelomic channels circulates the red-coloured haemocoelomic fluid containing amoeboid corpuscles and dissolved haemoglobin. The amoeboid corpuscles or coelomocytes are phagocytic in nature.

1. Dorsal channels. It runs mid-dorsally, below body wall, attached to the alimentary canal. It takes up a sinuous course. Anteriorly it runs up to 6th segment, where it breaks up into smaller branches and capillaries, which extend into the first five segments. Posteriorly, it bifurcates in 22nd segment, the two branches passing ventrally around rectum to join the posterior dilatation of ventral channel.

Dorsal channel has a thin, non-contractile, wall and devoid of valves and its haemocoelomic fluid runs from posterior to anterior side. It is a distributing channel. It gives out two types of branches.

(a) Dorso-laterals. Two pairs of dorso-lateral branches arise ventro-laterally from dorsal channel in each, segment. Each branch runs outwards to form a capillary plexus in dorsal and dorso-lateral regions of the body wall.

(b) Dorso-intestinals. These are numerous small branches arising mid-ventrally from dorsal channel, all along its length. These supply the gut wall.

2. Ventral channel. It runs mid-ventrally beneath alimentary canal, from one end of body to other, along a straight course. It is wider than dorsal channel and encloses the entire central nervous system including nerve ring and ventral nerve cord. It is somewhat dilated around the segmental nerve ganglia and the terminal ganglionic mass.

Like the dorsal channel, the ventral channel has a non-contractile and is also devoid of valves and acts as a distributing channel. Haemocoelomic fluid in it flows from anterior to posterior side. It gives out two pairs of branches in each segment.

(a) First pair. First pair or cutaneous branches are given out at the level of segmental nerve ganglion. Branch of each side at once bifurcates into a ventral branch, forming a capillary network in the ventro-lateral region of body wall, and an abdomino-dorsal branch, which runs vertically upwards with the dorso - ventral muscle and forms dorso-lateral cutaneous plexus.

b) Second pair. Second pair or nephridial branches are given out just behind the segmental ganglion of ventral nerve cord. Nephridial branch of each side runs outwards, and reaching over the testis sac of its side, it widens into two or three closely set saccules, the peri-nephrostomial ampullae, containing a ciliated organ. The branch then continues outwards to supply the body wall, sending on its way, a small branch to the nephridium.

Ciliated organ manufactures coelomic of the laterals corpuscles for the haemocoelomic system and its cilia are believed to help in the circulation of haemocoelomic fluid.

There are only 11 pairs of nephridial branches, one pair in each of the segments 12 to 22, which contain testis sacs.

3. Lateral channels. There are two lateral haemocoelomic channels placed one on either side of alimentary canal. They are wide and uniform in diameter, with thick muscular and contractile walls and possess valves like true blood vessels. Haemocoelomic fluid flows in them from behind forwards. They are collecting as well as distributing channels.

In each segment, each lateral channel receives on its outer side two branches, latero- lateral and latero-dorsal, and gives off on the inner side one branch, the latero-ventral.

a) Latero-lateral. A short latero-lateral is formed by branches from lateral region of body wall and nephridia. It joins the lateral channel at the level of nephridial vesicle.

(b) Latero-dorsal. A large latero-dorsal is formed by branches from dorsal and dorso-lateral regions of body wall, gut wall and nephridium. It joins the lateral channel at the level of main lobe of nephridium. Two latero-dorsals of opposite sides are connected by a transverse loop above the dorsal channel. There are seventeen such loops, called the dorsal commissures of the lateral channels, one in each segment from segments 6 to 22. Latero-dorsal is also connected with the latero-lateral of its own side by a longitudinal lateral commissure.

Latero-laterals and latero-dorsals are collecting branches and their openings into lateral channels are guarded by valves.

(c) Latero-ventral. A latero-ventral arises from the inner side of lateral channel and at once gives off a branch to supply nephridium and ventro- lateral regions of body wall. Then it bifurcates into two diverging branches, anterior and posterior. These unite with their corresponding fellows of opposite side, beneath ventral channel, by the ventral commissures of the laterals, forming a characteristic rhomboidal figure. There are 18 such rhomboids, one in each segment from 6th to 23rd segment. Rhomboids of adjacent segments are also connected together by three longitudinal intersegmental commissures, one median and two lateral. Latero-ventrals supply branches to nephridia, ventral side of alimentary canal and reproductive organs.

Anteriorly, both lateral channels break up in 6th segment into capillaries, while posteriorly they open into the dilatation of ventral channel where all the four channels are in direct communication.

[II] Circulation of Haemocoelomic Fluid

Haemocoelomic fluid flows in a definite direction, from behind to front in dorsal and two lateral channels, and from in front to backwards in ventral channel. All the four channels are directly connected together

posteriorly in 26th segment. Dorsal and ventral channels are only distributing channels. While two laterals are distributing as well as collecting channels.

The dorsal channel supplies haemocoelomic fluid to the dorsal and dorso-lateral body wall and gut wall from where it is collected by latero- dorsals into lateral channels. From alimentary canal, fluid is drained by two latero-intestinals that pour it through dorsal commissures of laterals into lateral channels.

Ventral channel supplies fluid to the mid- dorsal, ventro-lateral and ventral parts of body wall and nephridia. Fluid from these parts is collected by latero-lateral and latero-dorsal branches of lateral channels.

Lateral channels supply nephridia, reproductive organs, floor of gut and ventral body wall through latero-ventral branches. Fluid from all these parts is brought back to the lateral channels through latero-lateral and latero-dorsal branches.

RESPIRATION

There are no special organs of respiration in, *Hirudinaria*. Besides being a protective covering. the skin also acts for respiratory function Capillaries containing haemocoelomic fluid extend in between the cells of epidermis, which acts as a permeable membrane, through which exchange of gases takes place by diffusion. Carbon dioxide of haemocoelomic fluid passes out and oxygen dissolved in water goes in. Skin is always kept wet by the surrounding water, while mucus secreted by epidermal slime glands also prevents it from drying on exposure.

EXCRETORY SYSTEM

Leech: excretory system (YOUTUBE)

Excretory system consists of 17 pairs of small coiled tubes, the nephridia, arranged segmentally, one pair in each segment from 6th to 22nd. Nephridia are of two types: () testicular, and (ii) pre-testicular.

[I] Testicular Nephridia

Posterior 11 pairs of nephridia, lying one pair in each segment from 12th to 22nd, are termed testicular nephridia, due to the presence of a pair of testis sacs in each of these segments. A typical testicular nephridium is a horse shoe-shaped structure traversed by a complicated system of canals. It consists of 6 parts: (i) main lobe, (ii) vesicle and vesicle duct, (iii) apical lobe, (iv) inner lobe, (v) initial lobe, and (vi) ciliated organ.

1. Main lobe. Main lobe, forming the horse shoe proper, lies in a ventro-lateral position between two adjacent caeca of crop. It forms the major part of nephridium and consists of two unequal limbs. One limb is longer and anterior in position, and the other shorter and posterior. Cells of main lobe are big and polyhedral in shape.

2. Vesicle and the vesicle duct. A narrow vesicle duct arises from the inner ventral end of anterior limb of main lobe. It runs posteriorly to open into a large bladder or terminal vesicle, situated ventro-laterally behind the rest of nephridium. Vesicle is a large oval sac, with a non-contractile thin wall, internally lined by a ciliated epithelium. A short and narrow excretory duct, lined with a non-ciliated epithelium, leads from vesicle to open to the exterior through a rounded aperture, the nephridiopore. At its origin from vesicle, the excretory duct is provided with a sphincter muscle that controls the flow of excretory substances out of the vesicle. According to M.L. Bhatia (1940), bladder is lined by cilia. But, recent work by B. Dev has confirmed that the so-called cilia are in fact non-motile bacteria, the nephridial microflora, 2.8 to 7μ in length.

3. Apical lobe. Inner free end of posterior limb of main lobe is continued to form a stout apical lobe, lying antero-posteriorly beneath the crop. Its anterior end is slightly swollen and bent on itself like the handle of a walking stick. Its cells are big and traversed by regular intracellular canals.

4. Inner lobes. Extending between the anterior and posterior limbs of main lobe is a short incurrent lobe or inner lobe, which also runs forward along the outer side of apical lobe for about half of its length

5. Initial lobe. It is a long, narrow, transparent and cord-like structure, formed of a single row of elongated tubular cells and closely coiled around the apical lobe Its posterior end joins the main lobe, while its anterior end runs. inwards and reaches over the testis sac of its own side, where it ends blindly close to the perinephrostomial ampullae. The intracellular canal of initial lobe gives off many diverticula in each cell.

6. Ciliated organ. Inside peri-nephrostomial ampullae lies a peculiar structure, the ciliated organ. It is suspended from the inner walls of ampullae by 4 to 5 strands or trabeculae. It corresponds to the funnel or nephrostome of a typical annelid nephridium, but is a greatly modified, and compound structure.

Ciliated organ consists of a spongy central reservoir and ciliated funnels. The reservoir contains the central mass of connective tissue cells which manufacture the coelomic corpuscles. Outer wall of central mass, made of a single layer of cells, bears numerous minute pores. A ciliated Funnel fits into each pore on the outside. Each Tunnel is like an ear lobe, with about one-fourth of its margin incomplete. Funnel covered with outwardly directed cilia on its outer margin and inner surface. In the embryo, ciliated organ has a distinct cellular connection with the nephridium. But, in adult Hirudinaria, it loses the connection as well as excretory function and becomes a part of the haemocoelomic system for which it manufactures coelomic corpuscles.

Histology of nephridium. Lobes of nephridium consist of a mass of gland cells, traversed by an anastomosing system of canals, The initial lobe, formed by a single row of tubular cells arranged end to end, encloses a continuous intracellular canal. It opens into the central canal of the main lobe just before its entry into the vesicle duct. All the other lobes are traversed by a continuous central canal, which starts at the anterior part of apical lobe and after taking up a complicated route through the various lobes, enters the vesicle duct near the anterior limb of main lobe. All along its length, the central canal receives numerous fine intracellular canaliculi from the surrounding cells. Canaliculi of adjacent cells anastomose to form an intricate meshwork throughout the nephridium.

[II] Pre-testicular Nephridia

First six pairs of nephridia are termed pre- testicular nephridia owing to their location in segments 6 to 11 without testis sacs themselves, but in front of those containing testis These nephridia resemble testicular nephridia in all respects except that their initial lobes end loosely in general connective tissue on their side of ventral nerve cord. There are no testis sacs, peri-nephrostomial ampullae and ciliated organs in their segments.

[III] Physiology of Excretion

The ciliated organ, as already noted, is separated from nephridium in the adult. It has no excretory function, but manufactures coelomic corpuscles or coelomocytes of the haemocoelomic system. Coelomocytes are phagocytic and engulf particulate matter, but their ultimate fate is uncertain.

Nephridium proper is truly excretory in function and serves to eliminate excess of water and nitrogenous wastes (mostly ammonia and small quantities of urea). Thus, leech is predominantly ammonotelic. Nephridium is profusely supplied with branches of haemocoelomic channels. Its gland cells separate waste products from haemocoelomic fluid. Excretory fluid is finally collected into terminal vesicle to be discharged to outside through the nephridiopore.

Several workers have also attributed an excretory function to the botryoidal tissue, the intracellular capillaries of which communicate with the haemocoelomic vessels.

NERVOUS SYSTEM

Leech: nervous system (YOUTUBE)

It is of the typical annelidan type, consisting of usual three parts: (i) central, (ii) peripheral and (iii) sympathetic.

[I] Central Nervous System

Entire central nervous system lies within the ventral haemocoelomic channel and consists of: (a) an anterior nerve ring, (b) a ventral nerve cord, and (c) a terminal ganglionic mass. Brain is rather smaller and segmental ganglia more distinct than those of earthworm.

1. Anterior nerve rin. It includes a small dorsal brain, formed of a pair of fused cerebral or supra-pharyngeal ganglia, lying dorsally above the anterior part of pharynx, just behind the median dorsal jaw in 5th segment. It is connected by a pair of short and stout lateral peripharyngeal connectives, one on either side of pharynx, with a ventral sub-pharyngeal ganglionic mass situated beneath pharynx in 5th segment. The more or less triangular sub-pharyngeal ganglionic mass is a composite structure made up of 4 pairs of

embryonic ganglia fused together. Cerebral ganglia and sub-pharyngeal ganglionic mass represent the ganglia of first 5 segments.

2. Ventral nerve cord. Ventral nerve cord arises from the posterior end of sub-pharyngeal ganglionic mass and runs backwards along the mid-ventral line, from 6th to 26th segment. Although it appears single, it is really double as in earthworm. It carries, at wide intervals, 21 well-formed ganglia, each located in the first annulus of its own segment.

Nerve cord is made up of nerve cells and their processes or nerve fibres. Nerve cells are confined to ganglia, where they surround the nerve fibres. The entire nerve cord is covered with a protective sheath, the neurilemma.

3. Terminal ganglionic mass. Posteriorly, the ventral nerve cord ends in a large ovoid terminal ganglionic mass, situated within the posterior sucker. It is formed by the fusion of 7 pairs of embryonic ganglia of the last 7 segments that constitute the posterior sucker.

[II] Peripheral Nervous System

It consists of paired nerves arising from ganglia of central nervous system.

A pair of stout optic nerves arises anteriorly from brain or cerebral ganglia and runs forward to supply the 1st pair of eyes, prostomium and roof of buccal chamber. Four pairs of optic nerves arise laterally from sub-pharyngeal ganglionic mass and supply the 2nd, 3rd, 4th and 5th pairs of eyes, respectively. A few nerves arise ventrally from this ganglionic mass and supply the floor of buccal cavity, muscles of body wall, and segmental receptor organs of anterior 5 segments.

Each ganglion of ventral nerve cord gives off two pairs of nerves, the anterior laterals, and posterior laterals. Anterior laterals, arising anteriorly from ganglion, are stout nerves and branch to supply the nephridium vesicle, vas deferens, muscles of body wall, ventral receptors and two outer dorsal receptors of their own side. Posterior laterals, arising from the posterior part of ganglion, are also stout nerves which branch to supply the viscera, dorsal body wall, rest of dorsal receptors and testis sacs of their own side. Terminal ganglionic mass sends off several nerves supplying the receptor organs and other structures found in the posterior sucker.

3. Sympathetic or autonomic nervous system. It consists of an extensive nerve plexus lying beneath epidermis, within muscles and on gut wall. It joins, on one hand, with certain cells on both sides of peripharyngeal connectives, and on the other hand, with certain multipolar ganglion cells irregularly distributed over the entire plexus of gut wall.

SENSE ORGANS

Sense' organs or receptors of leech consist of modified epidermal cells. These are of four types (i) endings, (ii) annular receptors, (iii) segmental receptors, and (iv) eyes

[I] Free Nerve Endings

Free nerve endings occur all over the body, between epidermal cells, with their ganglion cells lying beneath the epidermis. These are probably chemoreceptors, detecting chemical changes in the surrounding water.

[II] Annular Receptors

Each annulus of body bears 36 very minute annular receptors, 18 on dorsal and 18 on ventral side, arranged in a transverse row. Each receptor projects as a minute papilla and consists of many flattened overlapping cells that receive their nerve supply from the lateral branches. They function as tangoreceptors or tactile organs.

[III] Segmental Receptors

These are small whitish elliptical papillae borne upon the first annulus of each body segment, 4 pairs dorsally and 3 pairs ventrally. Each receptor consists of two types of cells: (1) tactile cells or tangoreceptors and (ii) light-sensitive cells or photoreceptors. There are 5 to 10 long. slender tactile cells, separated from one another and provided with hair-like processes at their outer free ends. The light-perceiving or photoreceptor cells, found only in the dorsal receptors, contain a cresentic hyaline substance in their cytoplasm. the optic organelle or lens. Each receptor receives nerve branch and functions both tangoreceptor and photoreceptor.

[IV] Eyes

There are 5 pairs of eyes, arranged as a semicircle of black spots, along the dorsal margin of the anterior sucker, one pair in the first annulus of each of the first 5 segments. Each eye is in the form of a cylinder or cup with its long axis perpendicular to body surface. Wall of cylinder is formed of black pigmented tissue, enclosing a large number of clear, refractile, photoreceptor cells arranged in longitudinal rows. Each cell has a small rounded nucleus embedded in a thin penpheral layer of cytoplasm, surrounding a crescentic hyaline lens or optic organelle. Outer free convex surface of eye is covered by transparent epidermal cells and cuticle forming a sort of cornea. An optic nerve enters each eye basally and runs along its median axis distributing branches to all the photoreceptor cells.

All the eyes are not of equal size. They become smaller posteriorly so that the 5th pair is the smallestEyes are differently directed and each can receive light only from one direction. It is not known whether the eyes form any image. Probably they only enable the leech to distinguish light from darkness and to locate the direction of source of light.

On the basis of their metameric arrangement and histological structure, Whiteman regards eyes to be serially homologous with the segmental sense organs. Moreover, the segments with eyes lack the usual segmental receptors.

REPRODUCTIVE SYSTEM

Leech: reproductive system (YOUTUBE)

Leeches do not reproduce asexually. earthworms, leeches are hermaphroditica i.e., each individual contains a complete set of well differentiated male and female reproductive organs Self-fertilization, however, does not occur Cross- fertilization preceded by copulation, is a rule.

[I] Male Reproductive Organs

These are: (1) testis sacs, (ii) vasa efferentia, (iii) vasa deferentia, (iv) epididymes, (v) ejaculatory ducts, and (vi) atrium.

1. Testis sacs. There are usually 11 pairs (rarely 12 or 13 pairs) of small, spherical testis sacs, one pair in each segment from 12 to 22, located ventrally, one on either side of the ventral nerve cord. Each testis sac is really a constricted off portion of coelom. From the walls of testis sacs, spermatogonia or sperm-mother cells bud off and give rise to spermatozoa that float in the enclosed coelomic fluid.

2. Vasa efferentia. Spermatozoa pass from each testis sac into a short sinuous duct, the vas efferens. It arises from the postero-lateral border of testis sac and runs outwards to join the common vas deferens of its side. All the vasa efferentia of one side open into the common vas deferens of that side.

3. Vasa deferentia. Each vas deferens is a slender, longitudinal, wavy duct, lying on ventral body wall parallel to the nerve cord, and extending forward from 22nd to 11th segment. Each vas deferens is enclosed within a tubular coelomic space, containing amoeboid corpuscles similar to those of haemocoelomic fluid.

4. Epididymes. Each vas deferens, in 10th segment, swells to form a highly convoluted mass, the epididymis or sperm vesicle. The two epididymes serve to store spermatozoa brought by the vasa deferentia.

5. Ejaculatory ducts. From the anterior and inner end of each epididymis arises a short and narrow ejaculatory ducts or ductus ejaculatorious.

6. Atrium. Ejaculatory ducts of both sides join a median pyriform sac, the atrium, extending into 9th and 10th segments, and opening outside by the male genital pore. Atrium consists of two parts a vase-like broad anterior prostate chamber and a neck-like narrow posteriorly directed penis sac, Prostate chamber has thick muscular walls which are covered externally by numerous unicellular prostate glands. Penis sac is a highly

muscular tube, containing a filamentous coiled tubular penis, which can be frequently seen protruding through the male genital pore.

From epididymes, spermatozoa pass into prostate chamber where they are glued together by the prostate secretion into bundles or packets, forming spermatophores, which are transferred through penis into vagina of the partner leech during copulation.

[II] Female Reproductive Organs Female reproductive organs are comparatively compact and include: (i) ovisacs, (ii) ovaries, (iii) oviducts, (iv) common oviduct, and (v) vagina.

1. Ovisacs. There is a single pair of hollow, globular, coelomic sacs situated ventrally in 11th segment, one on either side of ventral nerve cord.

2. Ovaries. Each ovisac is filled with coelomic fluid in which floats a minute, delicate, coiled, thread-like and nucleated ovary from which ova are budded off.

3. Oviducts. Base of each ovisac is continued into a short and slender tube, the oviduct, which runs inwards and backwards.

4. Common oviduct. Right oviduct passes beneath the ventral nerve cord and unites with the left one in 11th segment to form a single and median common oviduct. Place of their union is covered by a thick layer of unicellular albumen glands, opening into the common oviduct. Posterior part of common oviduct, which is free from albumen glands, is folded and leads behind into vagina.

5. Vagina. Vagina is a large and pear-shaped muscular bag, lying mid-ventrally in the posterior part of 11th segment. It increases in size and also becomes internally folded during breeding season. Anteriorly it bends upon itself and narrows into a short duct, which opens to the exterior mid- ventrally through the female genital pore on 11th segment.

Ova are budded off from ovaries into their ovisacs. From here they pass down the oviducts to the common oviduct where each is coated with albumen secreted by the albumen glands. Ova then are passed into vagina, where they are stored till fertilization takes place during copulation.

LIFE HISTORY AND DEVELOPMENT OF LEECH

1. Copulation. Copulation in leeches, which possess a penis, is similar to direct transmission of sperms, as seen in earthworms. Copulation takes place during March and April. Two leeches come in contact by their ventral surfaces in head-to-tail position, so that the male genital pore of one lies against the female genital pore of other. Penis of one leech enters the female genital pore of other and there is a mutual exchange of seminal fluid containing spermatophores, which enter the vagina of both the leeches. Copulation lasts for an hour after which the mates separate.

2. Fertilization. Internal fertilization takes place in the vagina of each individual and the fertilized ova are discharged into a cocoon for further development.

3. Cocoon formation. Cocoons are formed following copulation, during April, May and June. The cocoon or ootheca or egg-case is secreted in the form of a snow-white frothy girdle by the clitellar glands around segments 9, 10 and 11Clitellar glands also secrete an albuminous fluid which is deposited, with the fertilized ova, inside cocoon. The cocoon is then passed over the head of each individual. As the leech withdraws its anterior end by rhythmic movements, the prostomial glands secrete the two polar plugs of cocoon. Complete cocoon is formed in about six hours, after which it is laid in a moist place by the side of a pond or pool, but never in water. It becomes hardened on exposure to air.

A well-formed cocoon is a light yellow or amber-coloured barrel- shaped structure, about 25 to 30 mm long and 12 to 15 mm in diameter. Its wall consists of an inner thin tough membranous layer and an outer thick spongy layer. There is a distinct polar plug with a conical projection at each narrow end.

4. Development. Development within the cocoon, which may contain one to 24 embryos. Albumen contents of cocoon serve as food for the developing embryos. Cleavage is unequal and development is direct without any larval forms. At the time of hatching, polar plugs drops off and young leeches, resembling the adults, emerge. The whole process of development takes about a fortnight for completion.

Important questions

➤➤Long answer type questions

1. Describe the food, feeding mechanism and physiology of digestion in leech.

2. Describe the haemocoelomic system of *Hirudinaria*, and discuss the nature of the sinuses in the animal.

3. Give an account of the structure and function of a typical nephridium of *Hirudinaria*.

4. Give an account of the receptor organs of the leech.

5. Describe the reproductive organs of the leech *Hirudinaria.*

6. Write an essay on the parasitic adaptations in leeches.

7. Draw labelled full-page diagrams of the following: (i) T.S. through the middle region of *Hirudinaria*. (ii) the buccal cavity of *Hirudinaria.* (ii) T.S. through the epididymes and penis sac of *Hirudinaria*. (iv) Reproductive organs of *Hirudinaria.*

8. Write short notes on (i) Botryoidal tissue, (ii) Ciliated organ of leech, (iii) Cocoon-formation in leech, (iv) Locomotion in leech, (v) Medicinal importance of leech

➤➤Short answer type questions

1. Name the animal where the botryoidal tissue is present

2. What is hirudin?

3. What is the number of nephridia in Hirudo?

4. How many segments are present in the cephalic region of leech?

5. How many pairs of testes are there in Hirudo?

6. Enumerate the significance of crop in Hirudinea, within 5 sentences.

7. With the help of a diagram, describe an annulus in leech in 7 lines.

8. Compare the meganephridium of *Megascolex* with that of *Hirudinaria*

9. Describe the features indicating the adaptations of leech to lead an ectoparasitic life

10. Give an account of excretory system of leech.

11. Describe how leech moves',

12. Give an account of the *Hirudinaria.*

13. Describe the hacmocoelomic system of *Hirudinaria.*

14. Make a labelled diagram of the T.S. of leech through crop

15. Make fully labelled sketches of general internal anatomy of Hirudinaria. 16. Draw and label nephridium of Hirudo.

➤➤Fill up the blanks

1. The connective tissue in the body cavity of Hirudinaria is known as.....
2. Salivary secretion of leech contains an active substance called.....
3. Epidermis that lies below the cuticle of leech consists.....
4. In leech, the space between the body wall and the alimentary canal is filled with a kind of tissue called.....
5. The connective tissue within the body cavity of Hirudinaria is known as.....
6. The number of nephridia in Hirudo are …….
7. (a) The male reproductive opening in leech occurs in the annulus of the …… segment.
1. (b) The female reproductive opening in leech occurs in the annulus of the ……. segment.

➤➤True and false statements

1. Hirudin helps in digestion.

True/False/ Do not know

2. The number of segments is fixed in Hirudo.

True/False/ Do not know

➤➤Multiple choice questions

1. Saliva of leeches contain an anticoagulant called:

(a) haemoglobin

(b) hirudin

(c) heparin

(d) histamine

2. Common cattle leech belongs to the genus:

(a) Megascolex

(b) Neanthes

(c) Arenicola

(d) Hirudo

3. The saliva of leech has an anticoagulant called:

(a) heparin

(b) hirudin

(c) chloragosomes

(d) none of these

4. How many chambers are found in the crop of leech?

(a) six

(b) eight

(c) nine

(d) ten

5. Leech is a blood sucking animal, nutritionally, therefore leech is:

(a) herbivorous

(b) carnivorous

(c) sanguivorous

(d) omnivorous

6. In which segment do you find the ovisac in leech?

(a) 8th (c) 15th

(b) 11th (d) 13th

7. Which segment possess nephridia in *Hirudinaria*?

(a) 7-10th segments (b) 6-22 segments
(c) 10-20 segments (d) 7-18 segments
8. Female genital opening of Hirudinaria is present in:

(a) 1st annule of 10th segment

(b) 1st annule of 11th segment

(c) 2nd annule of 10th segment

(d) 2nd annule of 11th segment

9. The posterior sucker of Hirudinaria is formed by the union of:

(a) 1 segment

(b) 7 segments

(b) 6-22 segment

(d) 33 segments

10. The number of segments in Hirudinaria is:

(a) 109

(c) 26

(b) 33

(d) numerous

11. Anterior sucker of Hirudinaria is formed by the union of:

(a) 1 segment

(c) 7 segments

(b) 3 segments

(d) prostomium and 3 segments

12. In Hirudinaria space between body wall and alimentary canal is filled not the:

(a) botryoidal tissue

(b) connective tissue

(c) haemocoelomic fluid

13. Chitogenous glands are found in:

(a) clitellar region forming wall of cocoon

(b) prostomium

(c) suckers

(d) epidermis

14. The detailed study about Hirudinaria made by:

(a) K. N. Behl

(b) SN. Dash

(c) M. L. Bhatia

(d) none

15. Hirudinaria is:

(a) herbivorous

(b) carnivorous

(c) omnivorous

(d) sangivorous

16. A temporary clitellum is form in Hirudinaria on segments:

(a) 7th 8th 9th

(b) 9th to 11th

(c) 11th to 13th

(d) none

17. Number of annular recepter in each annulus

(a) 18

(b) 18 on dorsal and 18 on ventral

(c) 9

18. Hirudinaria contains:

(a) slime gland (b) sucker gland

(c) cliteller gland (d) all above

19. Velum present in:

(a) *Pheritema*

(c) *Ascaris*

(b) *Hirudinaria*

(d) all

20. In *Hirudinaria* there is no special organs far:

(a) digestion

(b) excretion

(c) respiration

(d) reproduction

21. Number of testes in Hirudinaria are:

(a) 10 pairs

(b) 11 pairs

(c) 12 pairs

(d) 13 pairs

Answers

➤➤Fill in the blanks

1. botryoidal tissue, 2. hirudin, 3 of a layer of hammer-shaped cells, 4. botryoidal tissue, 5. botryoidal tissue, 6. 17 pairs, 7. (a) second and third segments, (b) 11 segments

➤➤True and false questions

1. false. 2. true.

➤➤Multiple choice questions

1. (b)

2. (d)

3. (b)

4. (d)

5. (c)

6. (b)

7. (b)

8 (d)

9. (b)

10. (b)

11. (d)

12. (a)

13. (a)

14. (c)

15. (d)

16. (b)

17. (b)

18. (d)

19. (b)

20. (c)

21. (b).