DIVERSITY OF ORGAN SYSTEM OF INVERTEBRATES

SEMESTER: I
UNIT: III

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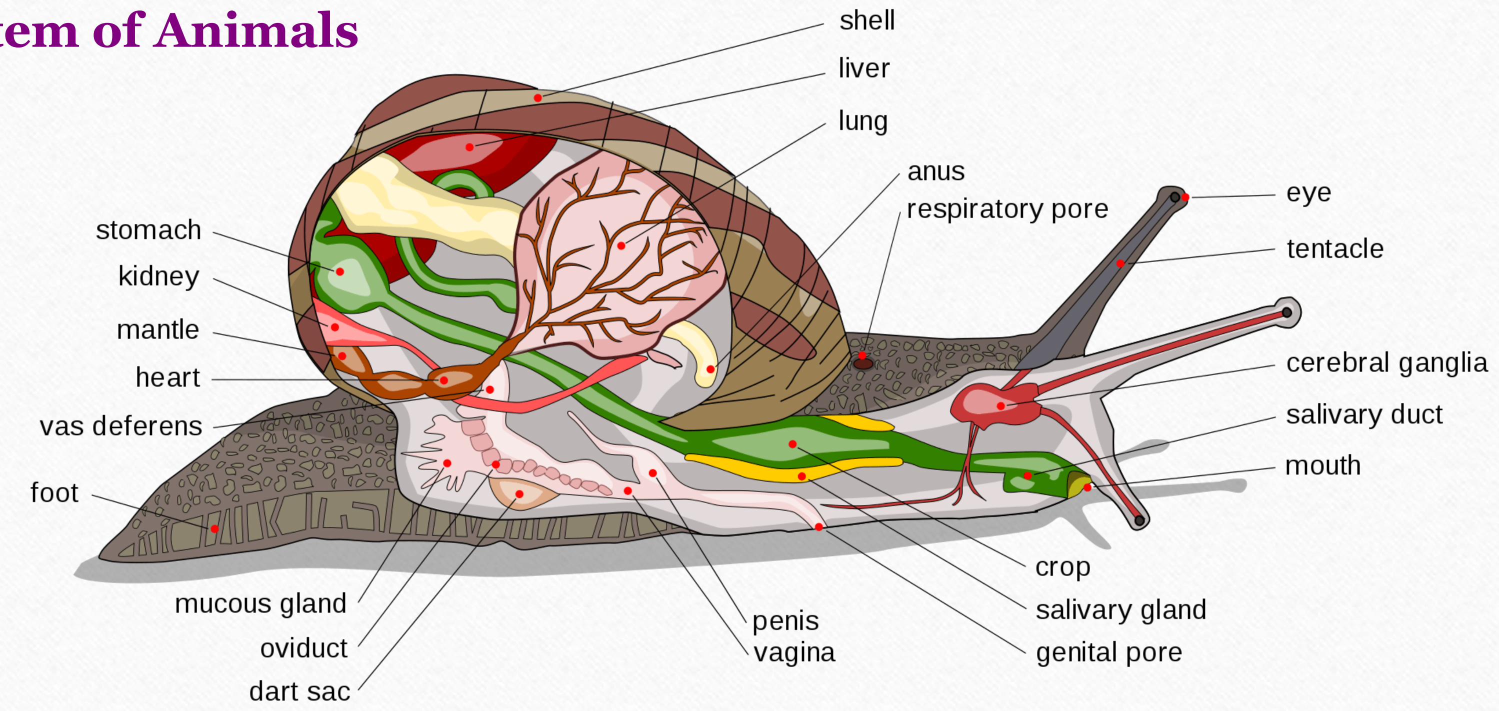
UNIT-III

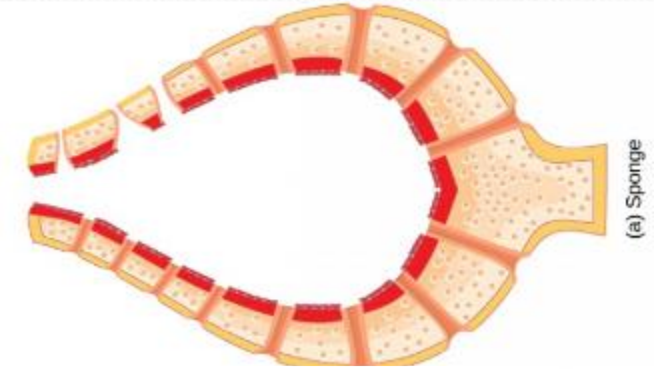
DIVERSITY OF ORGAN SYSTEM OF INVERTEBRATES

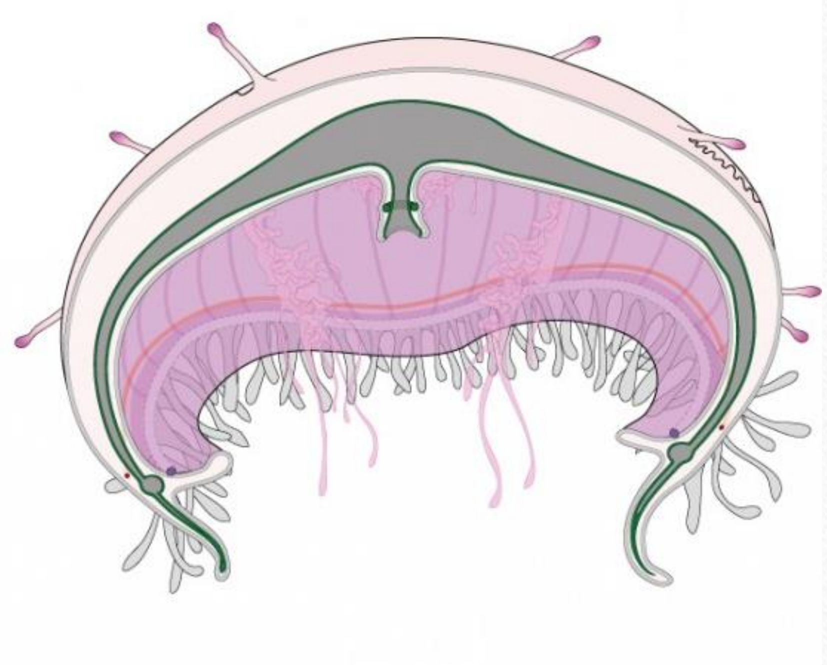
Diversity of organ system of invertebrates: Overview of the circulatory systems, Respiratory systems, Excretory systems, Nervous and sensory system and Reproductive system of Animals



OVERVIEW OF CIRCULATORY SYSTEMS

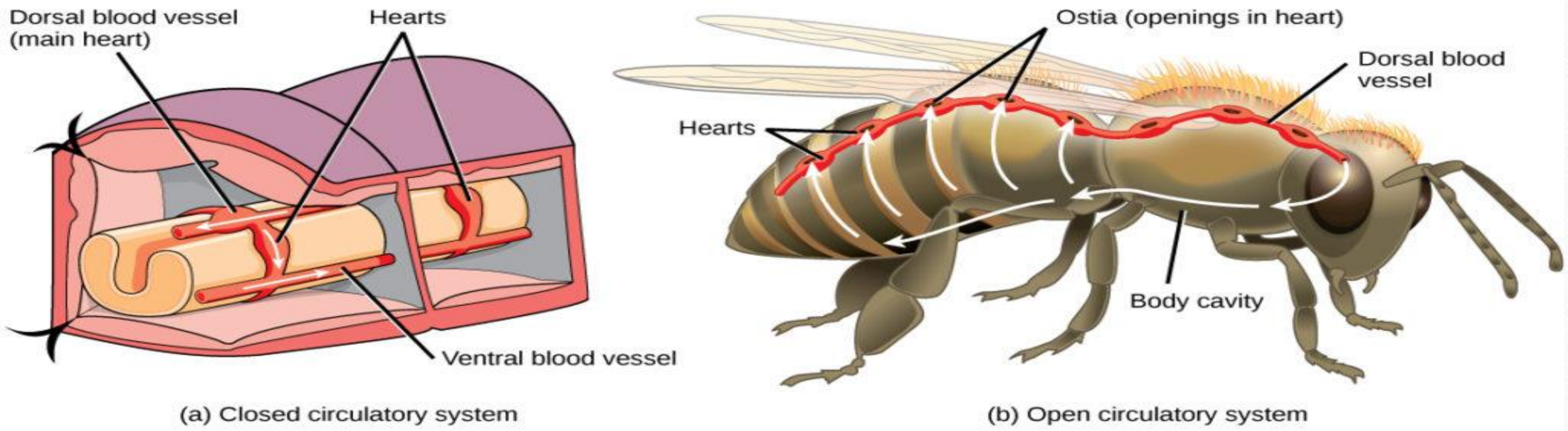
The circulatory system varies from simple systems in invertebrates to more complex systems in vertebrates. The simplest animals, such as the sponges (Porifera) and rotifers (Rotifera), do not need a circulatory system because diffusion allows adequate exchange of water, nutrients, and waste, as well as dissolved gases. Organisms that are more complex but still only have two layers of cells in their body plan, such as jellies (Cnidaria) and comb jellies (Ctenophora) also use diffusion through their epidermis and internally through the gastrovascular compartment. Both their internal and external tissues are bathed in an aqueous environment and exchange fluids by diffusion on both sides. Exchange of fluids is assisted by the pulsing of the jellyfish body.





(b) Jellyfish

For more complex organisms, diffusion is not efficient for cycling gases, nutrients, and waste effectively through the body; therefore, more complex circulatory systems evolved. Most arthropods and many mollusks have open circulatory systems. In an open system, an elongated beating heart pushes the hemolymph through the body and muscle contractions help to move fluids. The larger more complex crustaceans, including lobsters, have developed arterial-like vessels to push blood through their bodies, and the most active mollusks, such as squids, have evolved a closed circulatory system and are able to move rapidly to catch prey.



Open circulatory systems

Open circulatory systems are systems where blood, rather than being sealed tight in arteries and veins, suffuses the body and may be directly open to the environment at places such as the digestive tract. Open circulatory systems use hemolymph instead of blood. This "hemolymph" performs the functions of blood, lymph, and intestinal fluid – which are three different, highly specialized fluids in animals with closed circulatory systems. Instead of a complex and closed system of veins and arteries, organisms with open circulatory systems have a "hemocoel." This is a central body cavity found inside most invertebrate animals where both digestive and circulatory functions are performed. This hemocoel may have "arteries" through which the blood can reach tissues – but these arteries are not closed and do not circulate blood as quickly as closed, muscle-assisted arteries. Within the hemocoel, hemolymph directly absorbs nutrients from food and oxygen from the lungs or breathing pores. It also contains immune cells – but hemolymph does not have red blood cells like our own. Instead of using hemoglobin to carry oxygen, organisms with open circulatory systems use blue or yellow-green pigments to carry oxygen throughout the body.

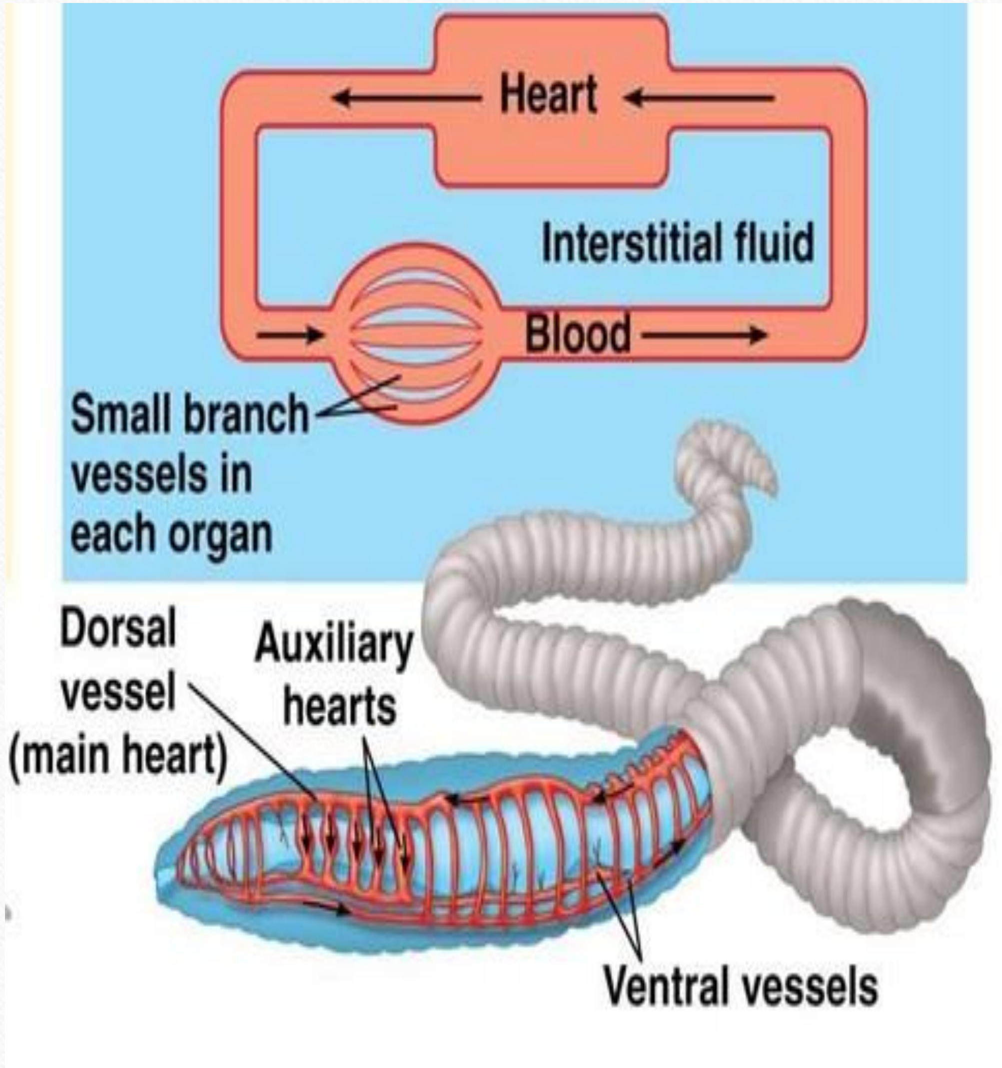
Function of open circulatory systems

In all animals, circulatory systems perform several vital functions. The circulatory system can be thought of as a river connecting the specialized cells of the body, which allows them to perform the trade and communication upon which their survival depends. There are a few vital functions that all circulatory systems must serve. These include:

- Transporting the oxygen that is necessary for cellular respiration
- Transporting nutrients from food, which are necessary for cellular respiration and other functions
- Transporting waste products of cellular respiration and other functions, which could otherwise build up to toxic levels within the body
- Transporting any necessary messages between cells, such as hormones signaling hunger, thirst, oxygen deprivation, or other bodily needs.
- Transporting immune cells which can fight infection to any area of the body where they might be needed.

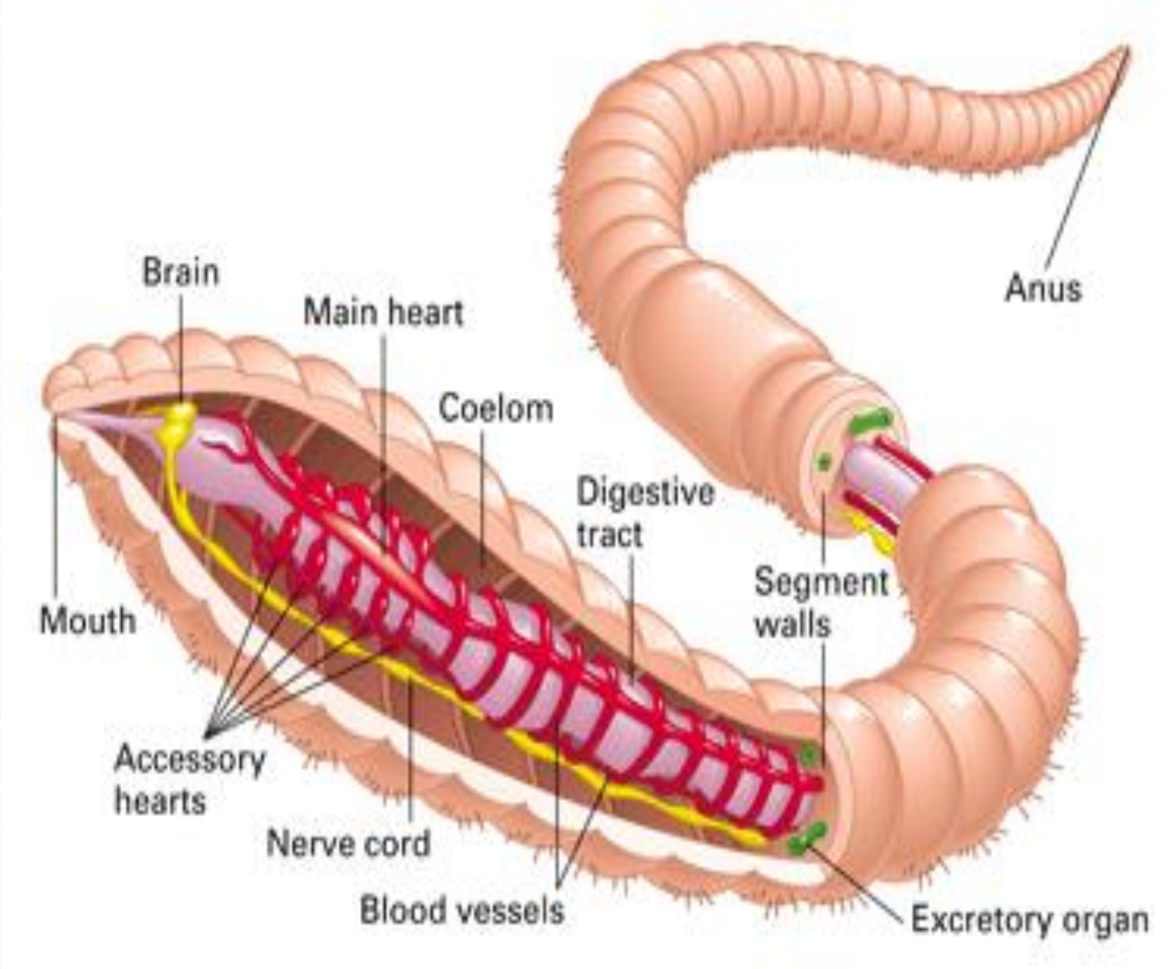
Closed circulatory systems

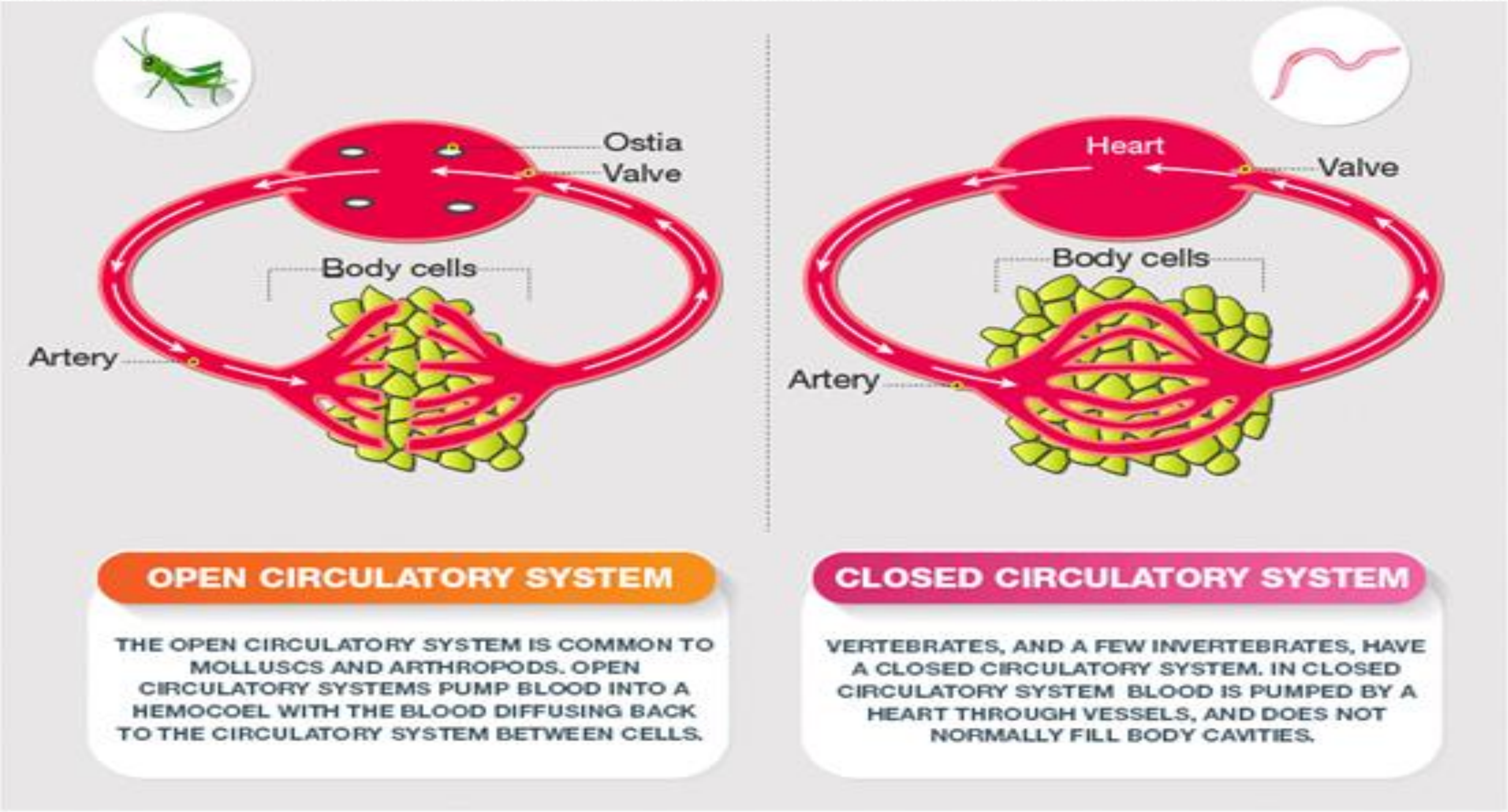
In a closed circulatory system, the blood stays within blood vessels. In this way, blood is kept separate from body tissues. This system has a heart that pumps blood through a continuous circulation pattern. As such, the blood tends to be pumped at a higher pressure. In closed circulatory systems, the heart pumps blood through vessels that are separate from the interstitial fluid of the body. Most vertebrates and some invertebrates, like this annelid earthworm, have a closed circulatory system.



Function of closed circulatory systems

A closed circulatory system is comprised of the heart that pumps blood into the vessels to reach the tissues and organs. The exchange of gases in the bloodstream occurs between smaller vessels (capillaries) and tissues. Since blood circulates only inside blood vessels it can do it with more pressure reaching farther distances between the organs where hematosis happens and the peripheral tissues. Earthworms' blood vessels run throughout their segments, carrying vital oxygen and nutrients to all their organs




Ostia
Valve
Body cells
Artery
Heart
Valve
Body cells
Artery
OPEN CIRCULATORY SYSTEM
THE OPEN CIRCULATORY SYSTEM IS COMMON TO MOLLUSCS AND ARTHROPODS. OPEN CIRCULATORY SYSTEMS PUMP BLOOD INTO A HEMOCOEL WITH THE BLOOD DIFFUSING BACK TO THE CIRCULATORY SYSTEM BETWEEN CELLS.
CLOSED CIRCULATORY SYSTEM
VERTEBRATES, AND A FEW INVERTEBRATES, HAVE A CLOSED CIRCULATORY SYSTEM. IN CLOSED CIRCULATORY SYSTEM BLOOD IS PUMPED BY A HEART THROUGH VESSELS, AND DOES NOT NORMALLY FILL BODY CAVITIES.

OVERVIEW OF RESPIRATORY SYSTEMS

The respiration involves the exchange of gases between the body and environment. The animals take oxygen from m the surroundings and gives off carbon dioxide to the environment. The oxygen is chemically utilized to oxidize food stuffs to produce energy. The energy is utilized by the living organisms. Animals may have skin, lungs, gills, etc. as the devices of respiration. Physiologically animals get oxygen from water, from air or living in water but breathe air. In aquatic arthropods, gills, book gills, epipodites, tracheal gills, blood gills, rectal gills, etc. are found ass respiratory organs.

GILLS

The gills (originated as out pushing of body wall) are well developed in crustaceans and typically associated with appendages. The organization of gills includes the following:

Origin of gills

These are outgrowths of thoracic limbs in arthropods and in isopods, 2^{nd} and 5^{th} pleopods are modified as gills.

Shape of gills

It is typically crescent-shaped containing a rod and blade like gill filaments. One end of filament connected with rod and blood vessel enters into it through this region. The other end of filament is free. The decapods contain all the types of gill with great variation.

Number of gills

Gills are absent in Lucifer (Shrimps) but Penacid, Homarus, Peacarb has 24, 20 and 6 gills respectively.

Size of gills

The anterior gills are small and the size increases towards the posterior end.

Types of gills

On the basis of position

Dendrobranchiate gills: It contains a central axis and two steroids of main branches with a number of sub-branches or dendrites. e.g., Penaeus.

Phyllobranchiate (=lamellar) gills: It have a central axis and two series of leaf like flattened gill plates arranged in the form of leaves of a book. e.g., Palaemon (Prawn).

Trichobranchiate (=filamettous) gills: It contains a central axis and several series of filamentous branches. e.g., Cray fish (Astacus).

On the basis of origin of attachment

Pleurobranch or aide gills: It is attached to lateral wall of segment above the origin of thoracic appandages.

Podobrach or foot gills: It is attached to coxa of the appendages and represents a modification of a part of an epipodite.

Arthrobranch or joint gill: It is attached to arthrodial membrane.

Modifications of gills: Broad epipodites of thoracic appendages work as gills in phyllocardia and cumacea. In Palianus (Decapoda), gills are flattened. Gills are plate like in amphipoda. Leaf like pleopods work as gills in Phyllopoda. In Euphausiacea, tufted podobranchs are not covered by carapace. The gills are a row of small branchial lamellae on each side of cyprididae. Abdominal gills are present in stomatopoda and isopoda.

Tracheal gills

A series of simple and divided external process attached to abdominal segments. These are richly supplied with trachea and tracheoles. e.g., Aquatic larvae of many insects. In Culex, four leaves like tracheal gills are present surrounding the anus. It probably takes oxygen dissolve in water. Naiad of mayfly and damselfly bears 7 pairs and 3 pairs of tracheal gills.

Blood gills

The tracheas are replaced by branching of blood vessels. e.g., Trichopterous and tripulid larvae.

Rectal gills

The inner surface of rectum bears gills. e.g., Nymphs of several insects.

Book gills

These are formed by evagination of posterior border of opisthosoma from 9th to 13th segments. Each gill contains nearly 100-200 lamellae as delicate leaves of a book. The lamellae are actual surface for gaseous exchange. The movement of gill lamellae maintains the circulation of water around the gills where gaseous exchange takes place.

AERIAL RESPIRATORY ORGANS (TRACHEA AND LUNGS) IN ARTHROPODS

The respiration involves the exchange of gases between the body and environment. The animals take oxygen from m the surroundings and gives off carbon dioxide to the environment. The oxygen is chemically utilized to oxidize food stuffs to produce energy. The energy is utilized by the living organisms. Animals may have skin, lungs, gills, etc. as the devices of respiration. Physiologically animals get oxygen from water, from air or living in water but breathe air. In arthropods, aerial respiration occurs through trachea, lungs, book lungs, spiracular gills, tracheal gills and modification of trachea.

Types of trachea

(a) On the basis of appearance:

1. Ventilation trachea: This is oval in section, collapses after exhaustion of air and

2. Diffused trachea: They are rigid and do not collapse after exhaustion.

(b) In larval stages:

1. Polypneustic: It has eight or more functional spiracles. It is subdivided into:

I. Holopneustic: Two thoracic and eight adnominal open spiracles present. E.g., Cockroach, most adults.

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II. Peripneustic: One thoracic and eight adnominal open spiracles present.

III. Hemipneustic: One thoracic and seven adnominal open spiracles present. E.g., beetles and butterfly.

2. Oligopneustic: It one or two functional spiracles. It is subdivided into:

I. Amphipneustic: One pair of thoracic and one pair of posterior abdominal spiracles.

II. Metapneustic: One pair of posterior abdominal spiracles.

III. Propneustic: One pair of thoracic spiracles.

3. Apeustic: Functional spiracles absent. e.g., Collmebole. Parasitic larvae, Hymenoptera, endoparasite insects

Number of spiracles

1. In certain insects, spiracles are absent but they are present during larval stages.

2. Queen of termite has only six abdominal spiracles.

Lungs

The upper part of gill chamber is separated from the rest and forms a closed chamber within which vascular tuft project is known as lung. E.g., Birgus.

Book lungs

These are modified abdominal appendages and originate from evaginations of episthosoma as blind sacs. It is dividing into ventral (=atrial) chamber and dorsal or posterior (=pulmonary) chamber. The atrial chamber opens to the exterior through stigmata and pulmonary chamber receives the pulmonary vein. The pulmonary chamber contains 150 lammellae in vertical folds. The lamellae are highly vascular, parallel arranged as leaves of a book and bear air spaces filled with air. The respiratory movement is regulated by atrial muscles. It is best seen in scorpionids.

Plastron respiration

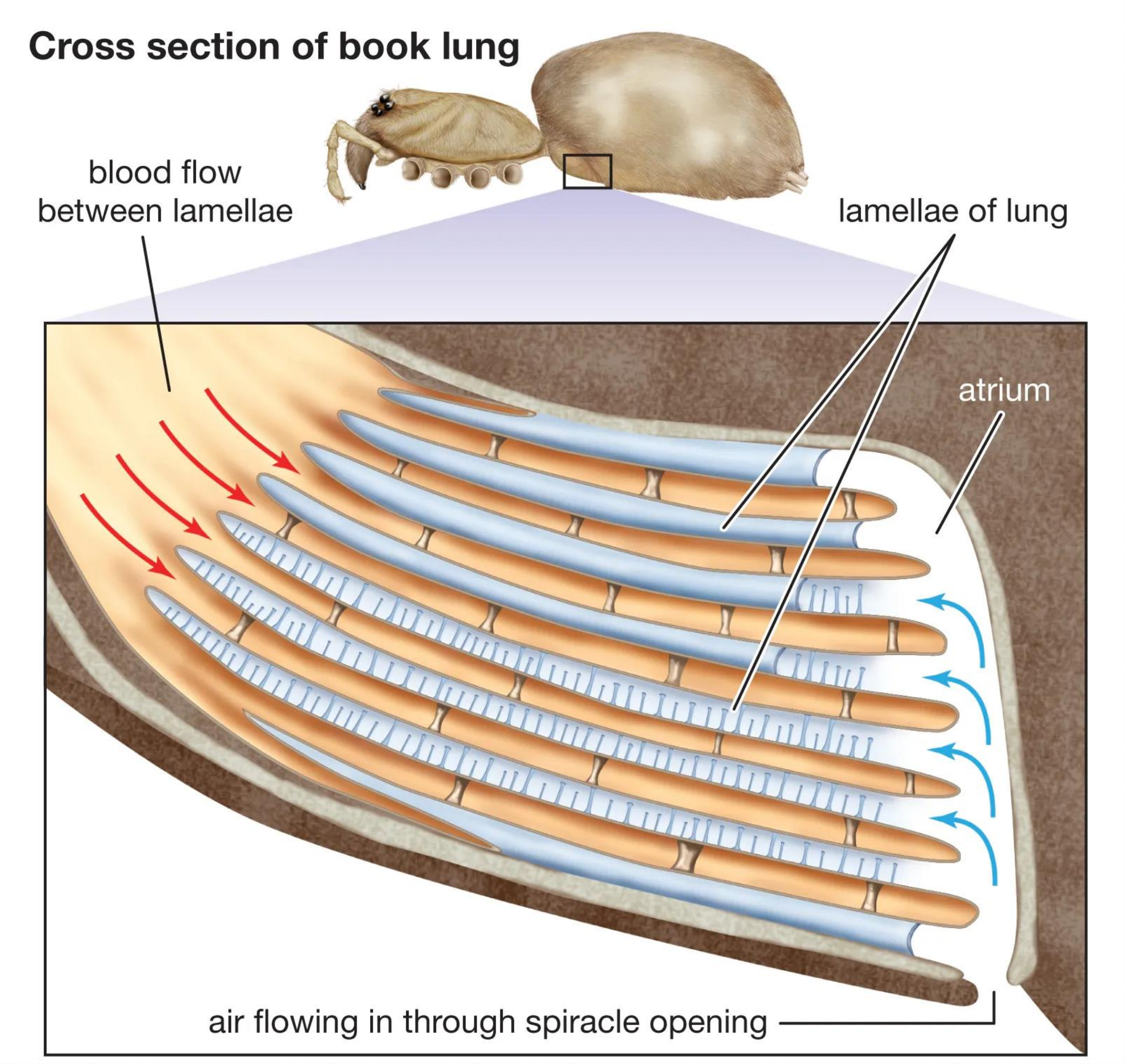
In aquatic insects, the angle of contact between water surface and particular body region is known as hydrofuge. The air film is held so firmly by a region of hydrofuge hair which cannot be replaced by water. This very thin, firmly held layer of air is known as plastron. Functionally, it resembles a tracheal gill more than an air store. It is seen in riffle, beetle, Coxelmis, Eimis.

Spiracular gills

These are filamentous outgrowth of ectoderm, covered with a thin cuticle. It can resist high pressure. E.g., larvae of Teicheomyza, pupa of Simuliura and psephenoids etc.

Anal respiration

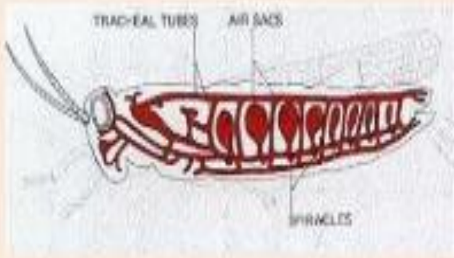
Rhythmic contraction of intestine takes in and expels out water. It is common in Cyclops



Respiratory organs of invertebrates

Trachea

- This respiratory organ is a hallmark of insects.
- It is made up of a system of branching tubes that deliver oxygen to, and remove carbon dioxide from, the tissues,
- The smallest tubes, tracheoles, penetrate cells and diffuse water, oxygen, and carbon dioxide.
- Tracheae are a system of tiny tubes that permit passage of gases into the interior of the body.
- Tracheal systems are highly efficient for these small, terrestrial animals.
- The pores to the outside, called spiracles, are typically paired structures, two in the thorax and eight in the abdomen. Periodic opening and closing of the spiracles prevents water loss by evaporation,



Gills

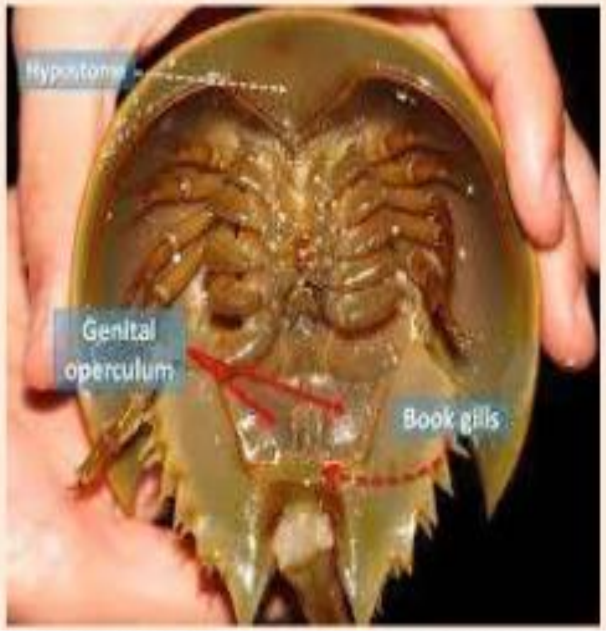
- Many invertebrates use gills as a major means of gas exchange
- Gills are branching organs located on the side of heads that have small blood vessels called capillaries. As the organism opens its mouth, water runs over the gills, and blood in the capillaries picks up oxygen that's dissolved in the water.
- Gills consist of plate-like structures called filaments that are covered by an array of lamellae enclosing a capillary blood network
- Oxygen-rich water passes through the narrow channels formed by the lamellar layers, where oxygen diffuses into the capillaries. The densely packed lamellar structure is advantageous because it provides a large surface area for oxygen transfer.

Book lung

- It is a form of respiratory organ found in certain air-breathing arthropods (scorpions and some spiders).
- Each book lung consists of a series of thin plates that are highly vascular (i.e., richly supplied with blood) and are arranged in relation to each other like the pages of a book.
- These plates extend into an internal pouch formed by the external skeleton that opens to the exterior by a small slit. This provides an extensive surface for the exchange of oxygen and carbon dioxide with the surrounding air. There are four pairs in scorpions and up to two in spiders.

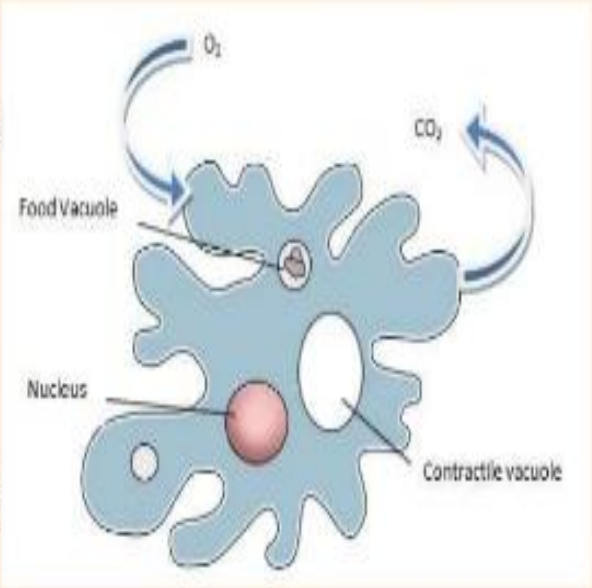
Book gills

- It is believed that book lungs evolved from book gills. Although they have a similar book-like structure,
- book gills are external, while book lungs are internal. Both are considered appendages because book lungs develop from limb buds before the buds flatten into segmented lamellae.
- Book gills are still present in the marine arthropod *Limulus* (horseshoe crabs) which have five pairs of them,
- the flap in front of them being the genital operculum which lacks gills.



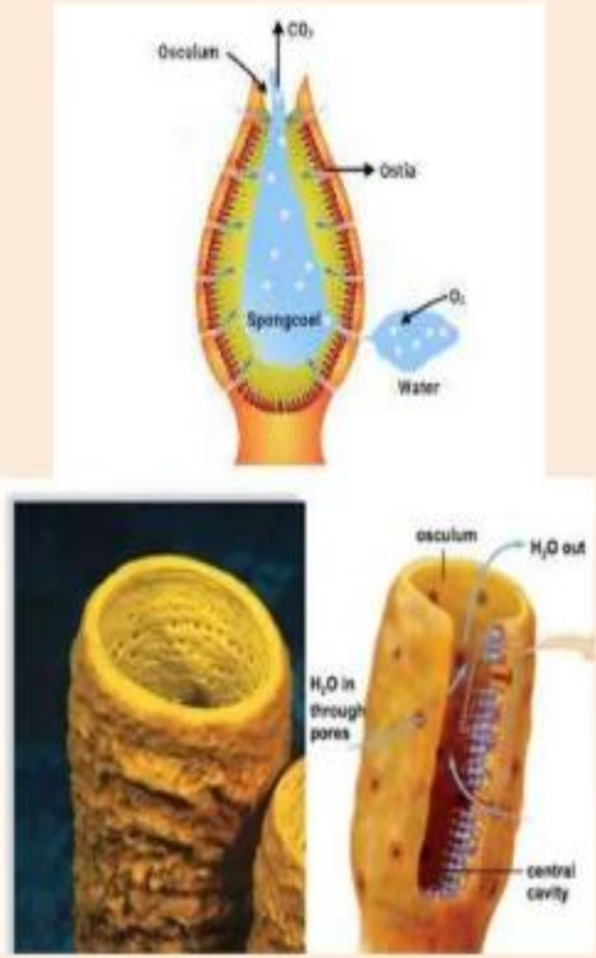
PROTOZOA

- Single-celled organisms, such as bacteria and protozoa, are in constant contact with their externa environment. Gas exchange occurs by diffusion across their membranes. The respiratory gases may diffuse in and diffuses out trough the general body surface, there are no special organ for respiration.



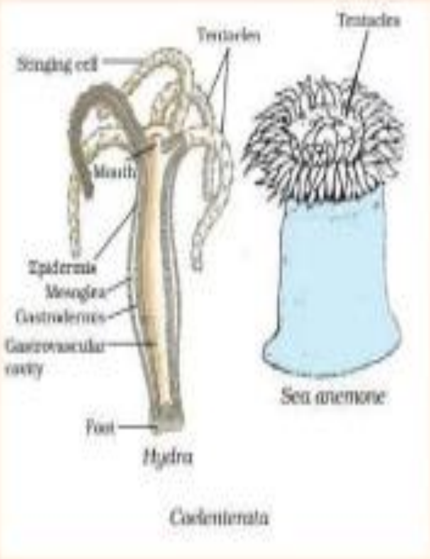
PORIFERA

- In sponges, the special respiratory organs are absent
- Gaseous exchange occurs by simple diffusion between the cells of sponges and the current of water
- Oxygen dissolved in water is taken in by diffusion through the general body surface and carbon di oxide is given out
- Amoebocytes distributes oxygen with in the mesenchyme and carry away carbon di oxide



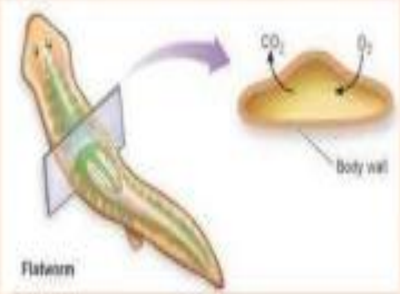
COELENTERATES

- In coelenterates, the special respiratory organs are absent
- Their body cells are ore or less directly exposed to the environment, both cell layers absorb oxygen from and expel carbon dioxide into the surrounding water.
- the oxygen is absorbed into their first layer of skin, called the ectoderm.
- Then, it goes through to the second layer, called the endoderm. The oxygen molecules are used and excess oxygen is released as carbon dioxide.



ASCHELMINTHES AND PLATYHELMINTHES

- respiratory organs are absent The body walls of aschelminthes are very thin and thus it acts as their respiratory system.
- In living flatworms and roundworms, the exchange of gases takes place through general body surface
- In parasitic form, there is no exchange of gases. Endo parasites lives n almost oxygen free environment and fulfills its relatively less energy requirements by anaerobic respiration
- Flatworms are small, literally flat worms, which 'breathe' through diffusion across the outer membrane. The flat shape of these organisms increases the surface area for diffusion, ensuring that each cell within the body is close to the outer membrane surface and has access to oxygen.

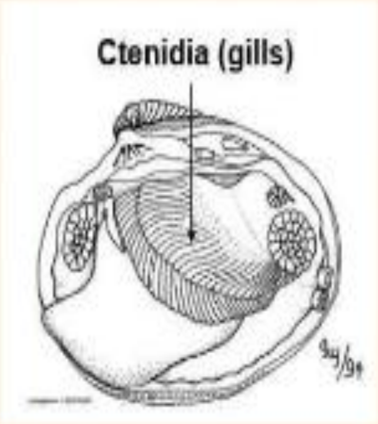


ANNELIDA

- Respiration in annelids occurs primarily through their moist skin, although certain species have evolved specialized gills or use paired projections called parapodia in gas exchange.
- In earthworms the respiration mainly occurred or performed through skin the called as cutaneous respiration
- The blood of earthworm contains a respiratory pigment – Haemoglobin in a dissolved state in its plasma
- The epidermis of the body wall acts as a permeable membranes through which the atmospheric oxygen diffuses in its capillaries and combine with haemoglobin to form oxyhaemoglobin

MOLLUSCA

- Basically all molluscs breathe by gills that are called ctenidia (comb-gills) because of their comb-like shape.
- A ctenidium is shaped like a comb or a feather, with a central part from which many filaments or plate-like structures protrude, lined up in a row
- In land snails and slugs, mantle cavity has evolved into primitive lung
- the mantle cavity forms a pulmonary chamber, the inner surface of which is highly vascularised.
- Many molluscs have a siphon which expels water and wastes



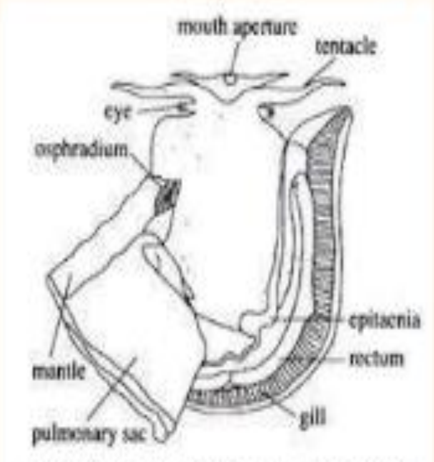


Fig. 2.61 : Respiratory organs in *Pila*. The mantle is partially displaced to show the position of gill.

ECHINODERMS

- In echinoderms (starfish, sea urchins, brittle stars), most of the respiratory exchange occurs across tube feet (a series of suction-cup extensions used for locomotion).
- Echinoderms typically breathe and respire by the simple diffusion of gases like oxygen and carbon dioxide in and out of their body cell membranes.
- However, this exchange is supplemented by extensions of the coelomic, or body-fluid, cavity into thin-walled "gills" or dermal branchiae that bring the coelomic fluid into close contact with seawater.
- Respiratory tree is the branches of cloaca just inside the anus with the help of the drawing water through the anus and then expelled

Functions of respiration

- Delivers oxygen to the cells in your body.
- Removes waste gases, including carbon dioxide, from the body when you exhale.
- Breathing – movement of air
- Sound Production
- Olfaction, or Smelling, Is a Chemical Sensation

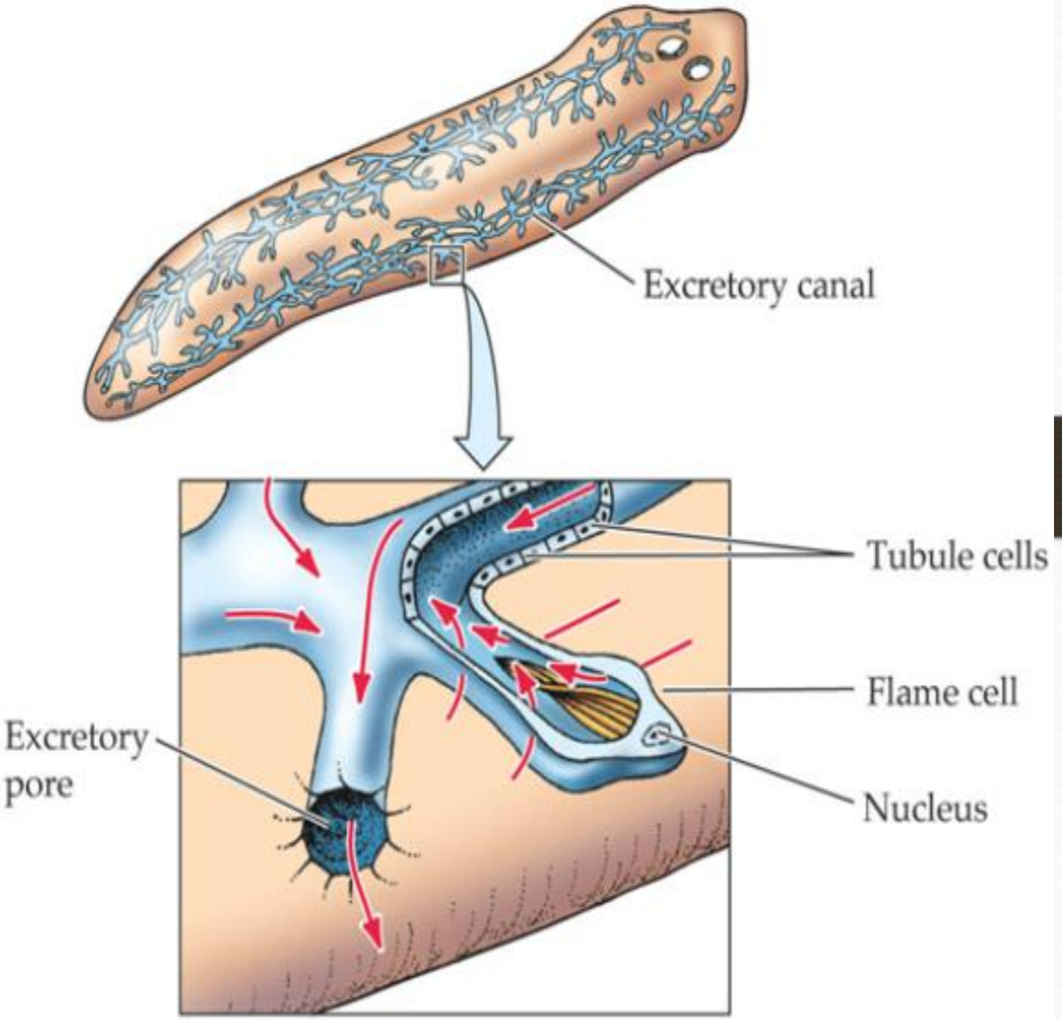
OVERVIEW OF EXCRETORY SYSTEMS

Invertebrates Excretory Systems

- Protonephridia
- Metanephridia
- Malpighian Tubules

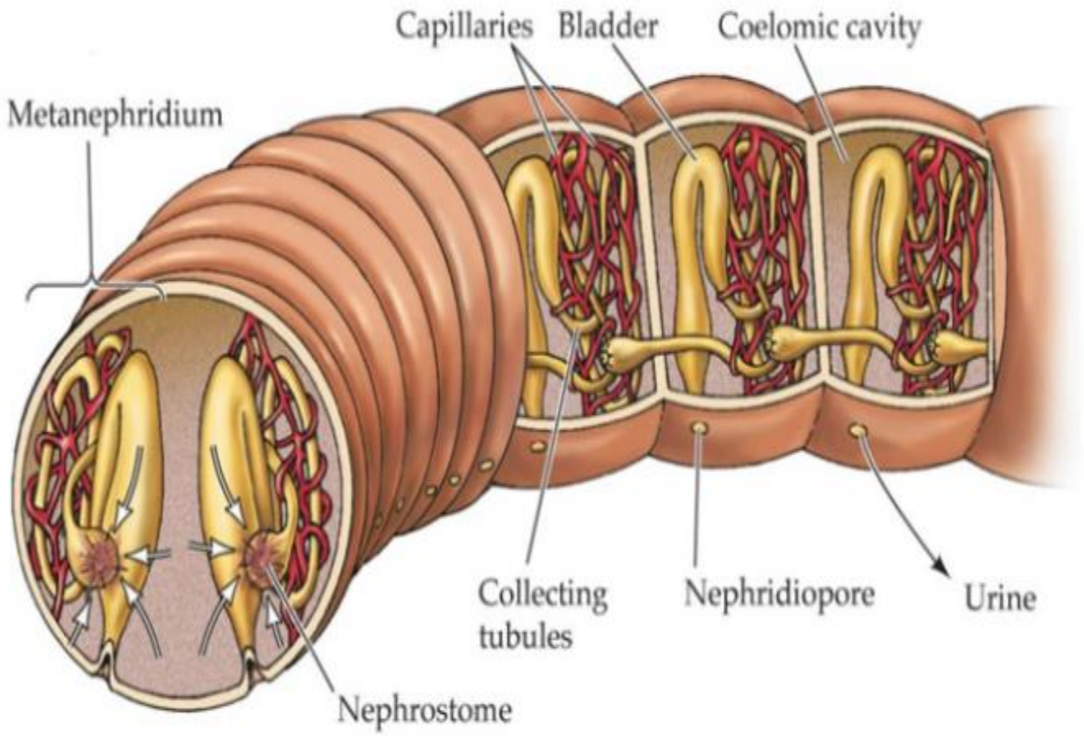
Protonephridia

- freshwater flatworms
- network of blind-ended tubes opening only to the exterior
- tubes branch through the body, ending in flame bulbs
  - tuft of cilia that beat, forcing fluids through tubes
- urine empties via a nephridiopore



Metanephridia

- most annelids
- each segment contains a pair of metanephridia
  - tubules bathed in coelomic fluid and encircled by capillaries
  - nephrostome collects fluid from coelom (ultra filtration) in the first filterate is **isosomotic**
  - transport epithelia in lumen of tubules resorb and secrete molecules
  - urine exits nephridiopore



Osmoregulation in insects

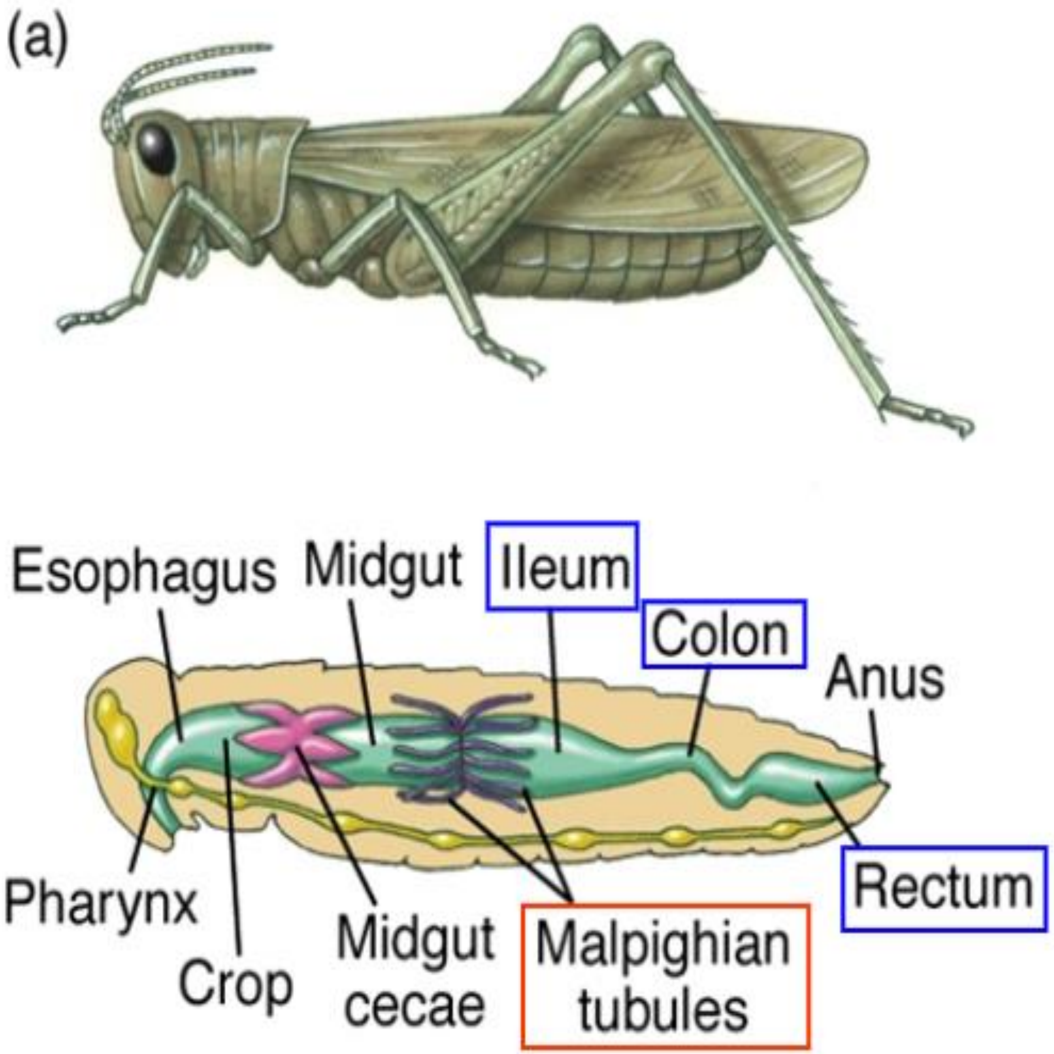
Malpighian Tubules

Osmoregulatory system of insects

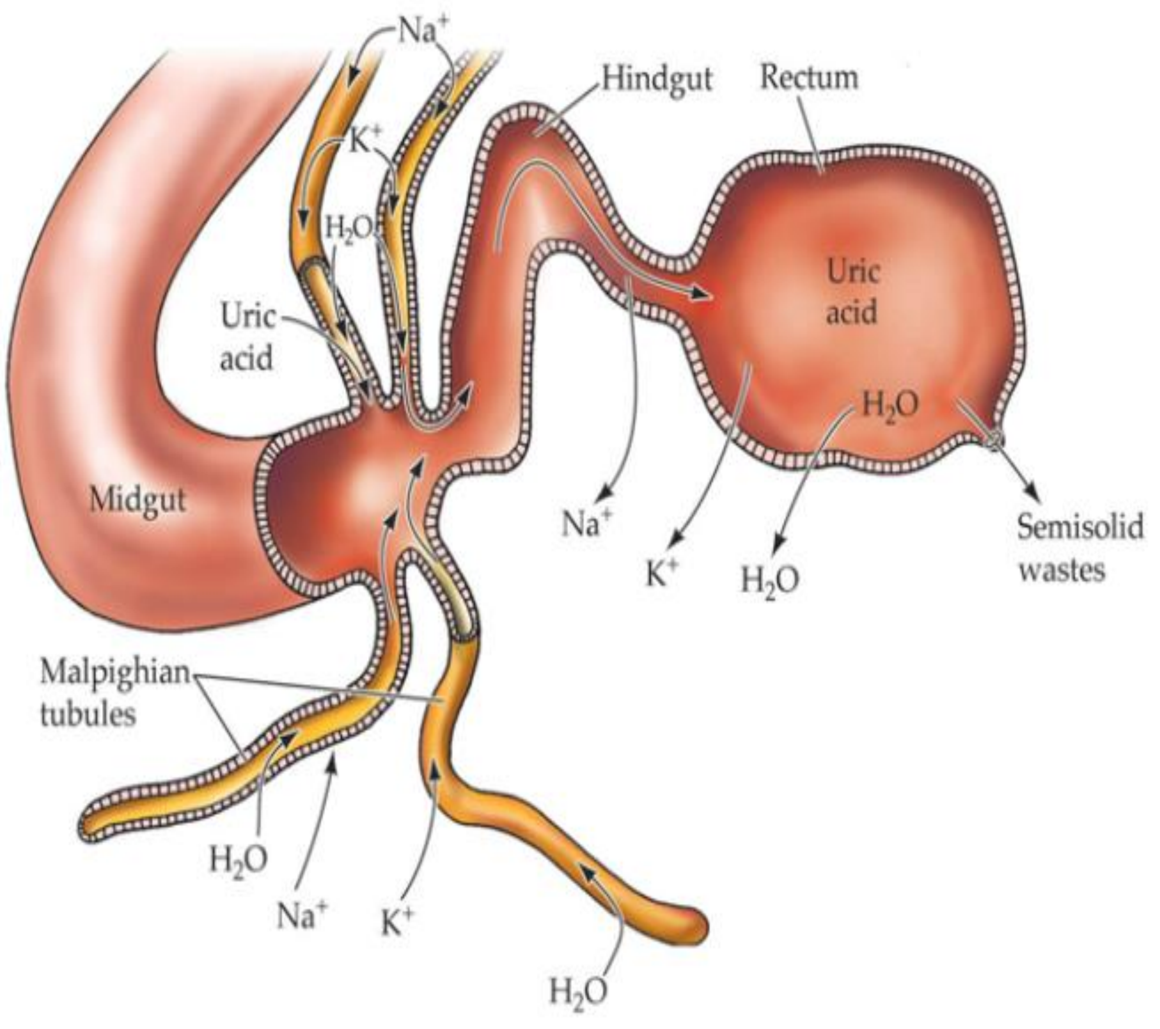
- The main organs involved in solute and water balance are:
  1) Malpighian tubules (MTs)
     - Form primary urine
  2) Lower MTs and hindgut (ileum, colon, rectum)
     - Reabsorption of water and ions

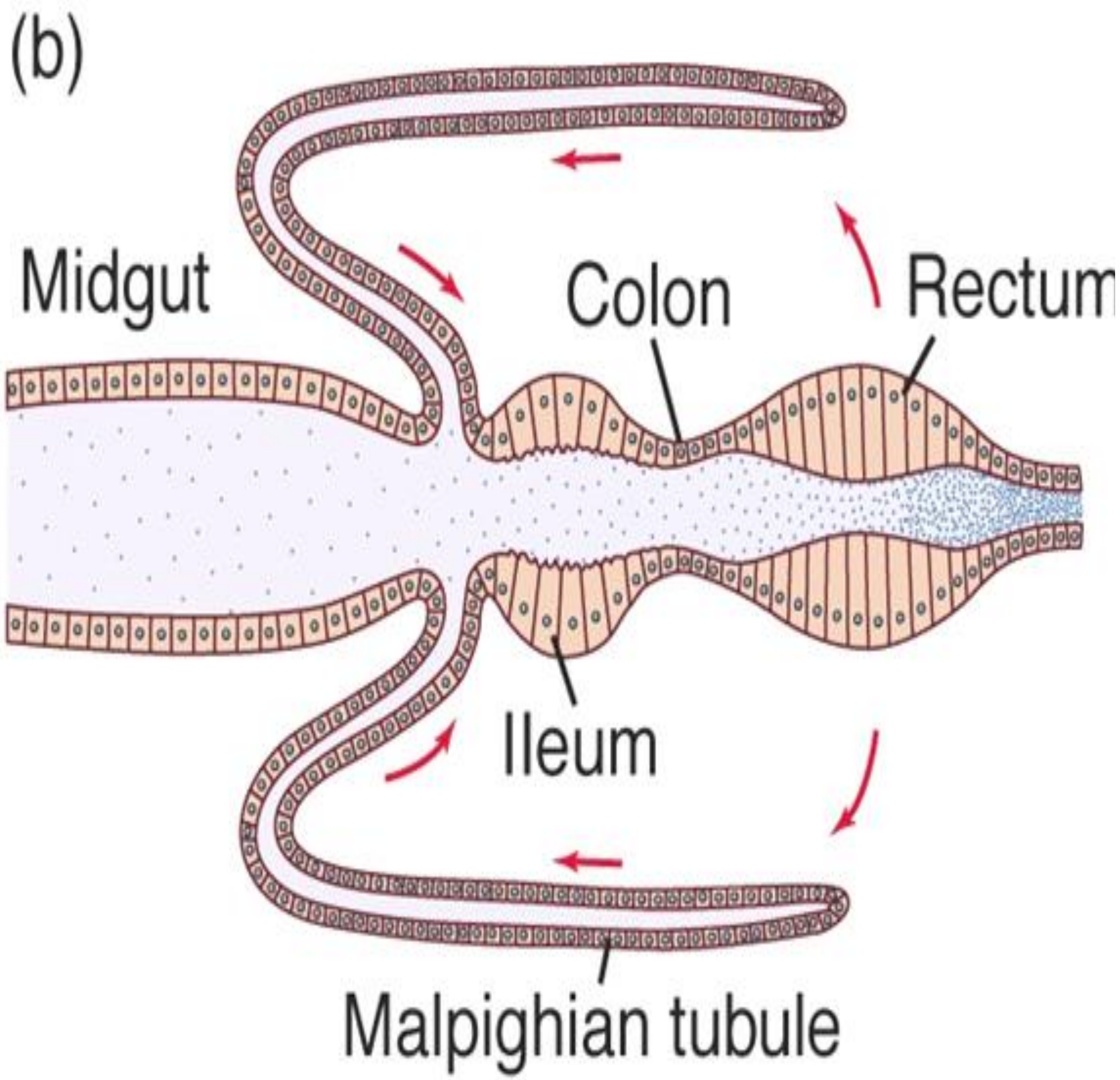
- insects and other terrestrial arthropods
- remove wastes from hemolymph and osmoregulate
- open in digestive tract, tips immersed in hemolymph
- transport epithelia line tubules
  – solutes are secreted into tubules and some are reabsorbed by the rectum
  – causes the precipitation of uric acid

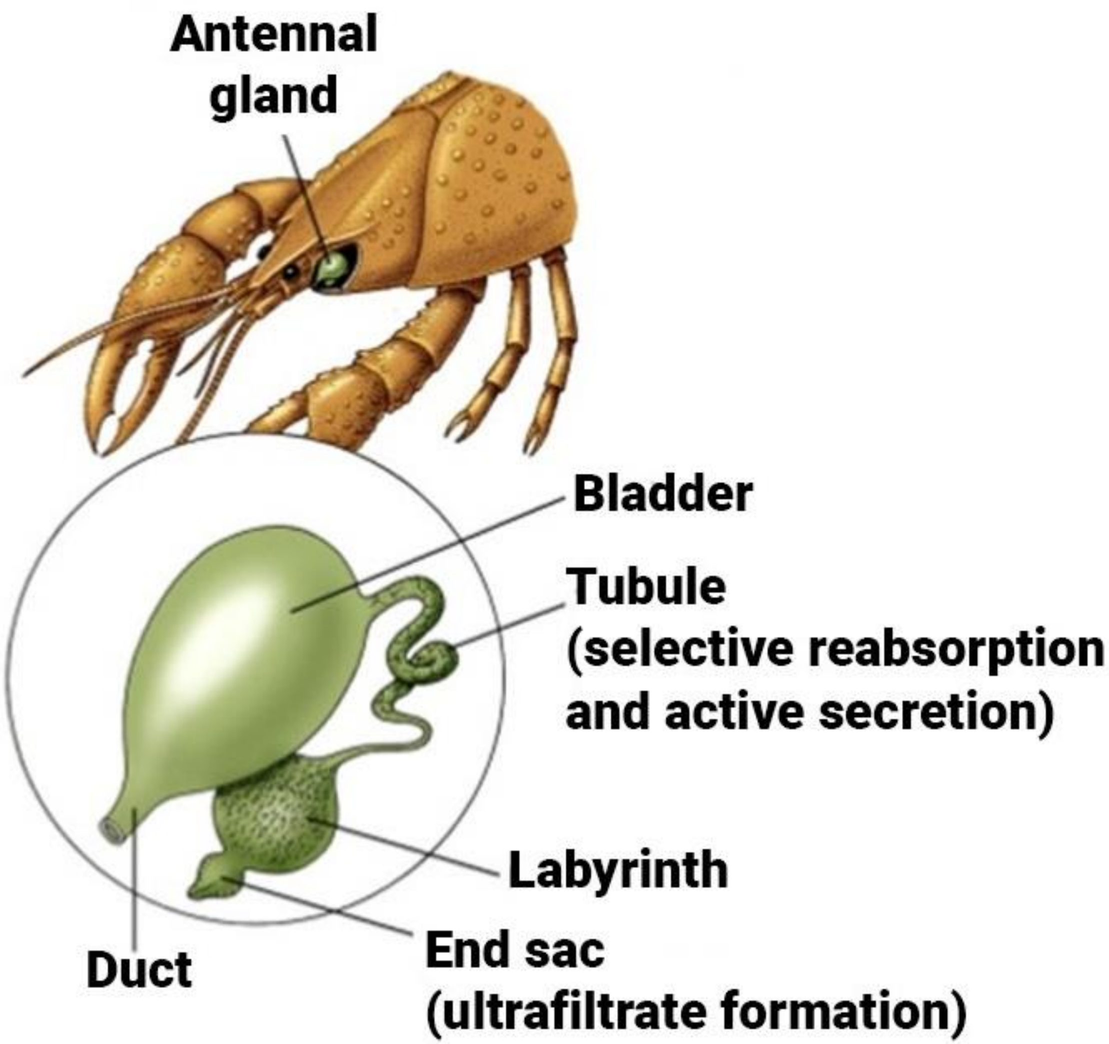
- MTs empty into the alimentary canal between the midgut and hindgut
- The number of MTs varies from 4-200 depending on the species
- 2-100 mm in length and 30-100 μm in diameter
- Walls of the MTs consist of a single layer of epithelial cells
- Process ECF at high rates to regulate composition and volume of ECF
- MTs are not innervated and fluid secretion is controlled by the action of hormones



- MTs lie free in hemocoel and are not supplied with blood vessels
- Insect circulatory system is at relatively low pressure, therefore urine is formed entirely by secretion
- NaCl and KCl are transported from the hemolymph into the lumen of the MT
- MTs secrete K^+ in herbivorous insects and Na^+ in blood-feeders
- NaCl and KCl are returned to the hemolymph across the rectal wall




(b)
Midgut
Colon
Rectum
Ileum
Malpighian tubule


Antennal gland
Bladder
Tubule (selective reabsorption and active secretion)
Labyrinth
End sac (ultrafiltrate formation)
Duct

NERVOUS AND SENSORY SYSTEMS

Invertebrate nervous systems have different degrees of centralization, cephalization, and specialization

Cnidarians have a *simple nerve net*

Flatworms, whose nervous systems are more *centralized, have small ganglia in their heads*

Arthropods and cephalopod mollusks have a *centralized brain and specialized sensory organs*

- The simplest nervous systems, found in cnidarians, are called nerve nets
  - *Nerve nets consist of individual nerve cells that form a netlike arrangement throughout the animal's body*
- In flatworms and roundworms, the *nerve cells are more concentrated, or centralized*
  - *There are a few small clumps of nerve tissue, or* ganglia, *in the head*
- In cephalopod mollusks and arthropods, *ganglia are organized into a* brain *that controls and coordinates the nervous system*
  - *This concentration of nerve tissue and organs in one end of the body is called* cephalization

- **The more complex an animal's nervous system is, the more developed its sense organs tend to be**
- **Flatworms** , for example, have ***simple eyespots*** that detect only the presence of light
- More complex animals, such as **insects** , have eyes that detect motion and color and form images
- Complex animals may have a variety of specialized sense organs that detect light, sound, chemicals, movement, and even electricity to help them discover what is happening around them

Protozoa

- Protozoans lack specialized nervous system to respond to the environment.

-Single cell function as both the receptor and the effector.

-Contain an eyespot that act as a light sensitive receptor.

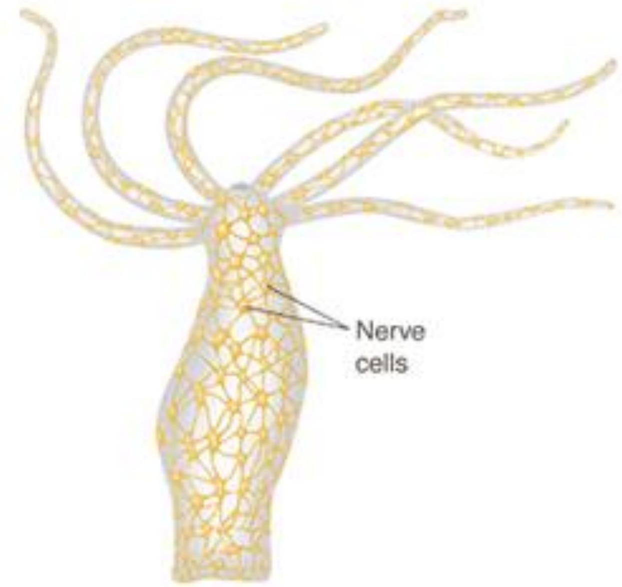
Porifera

Poriferans or the sponges are the only multicellular animals without a nervous system. They do not show any neurons or sensory cells.

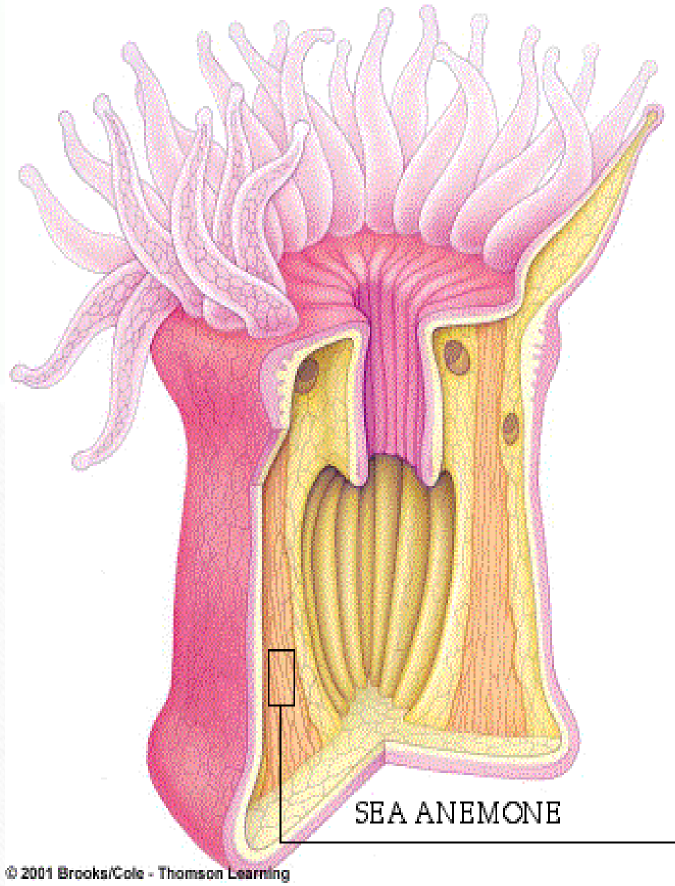
Although they lack a nervous system they are sensitive to pressure and touch that helps in their locomotion.

Cnidaria

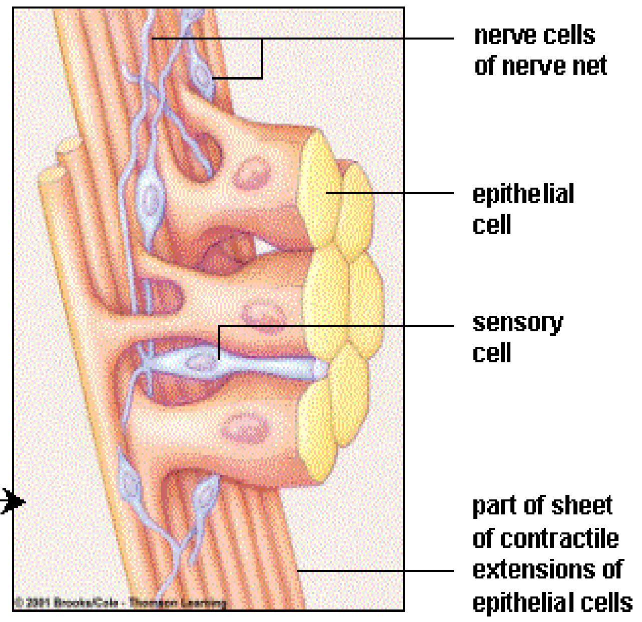
- Contains a diffuse nerve net.
- Sensory neurons, intermediate neurons and motor neurons are present
- These neurons are connected together by synapses.
- Synapses carry impulses to both directions within the nerve net.



Nerve Net

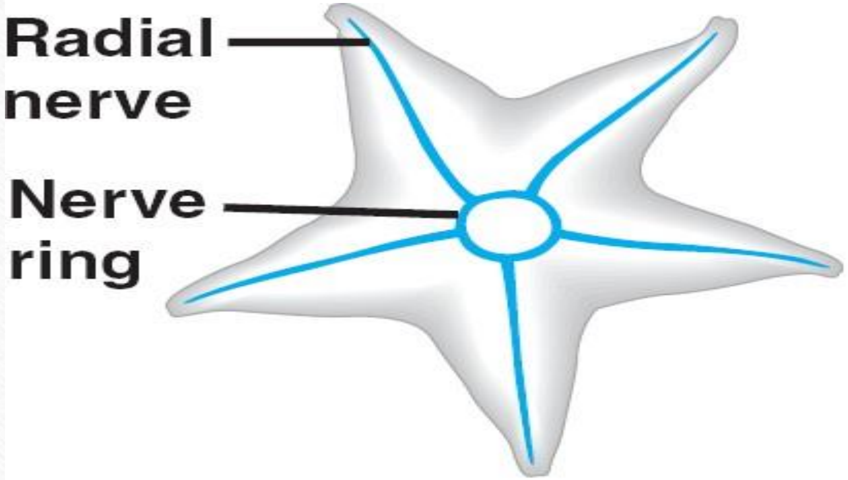


- Diffuse mesh of nerve cells that take part in simple reflex pathways
- Nerve cells interact with sensory and contractile cells



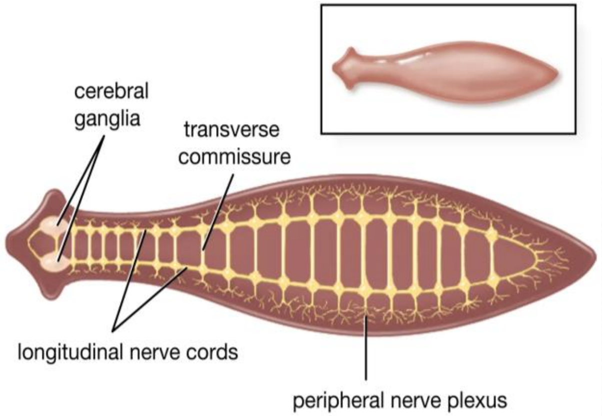
Echinodermata

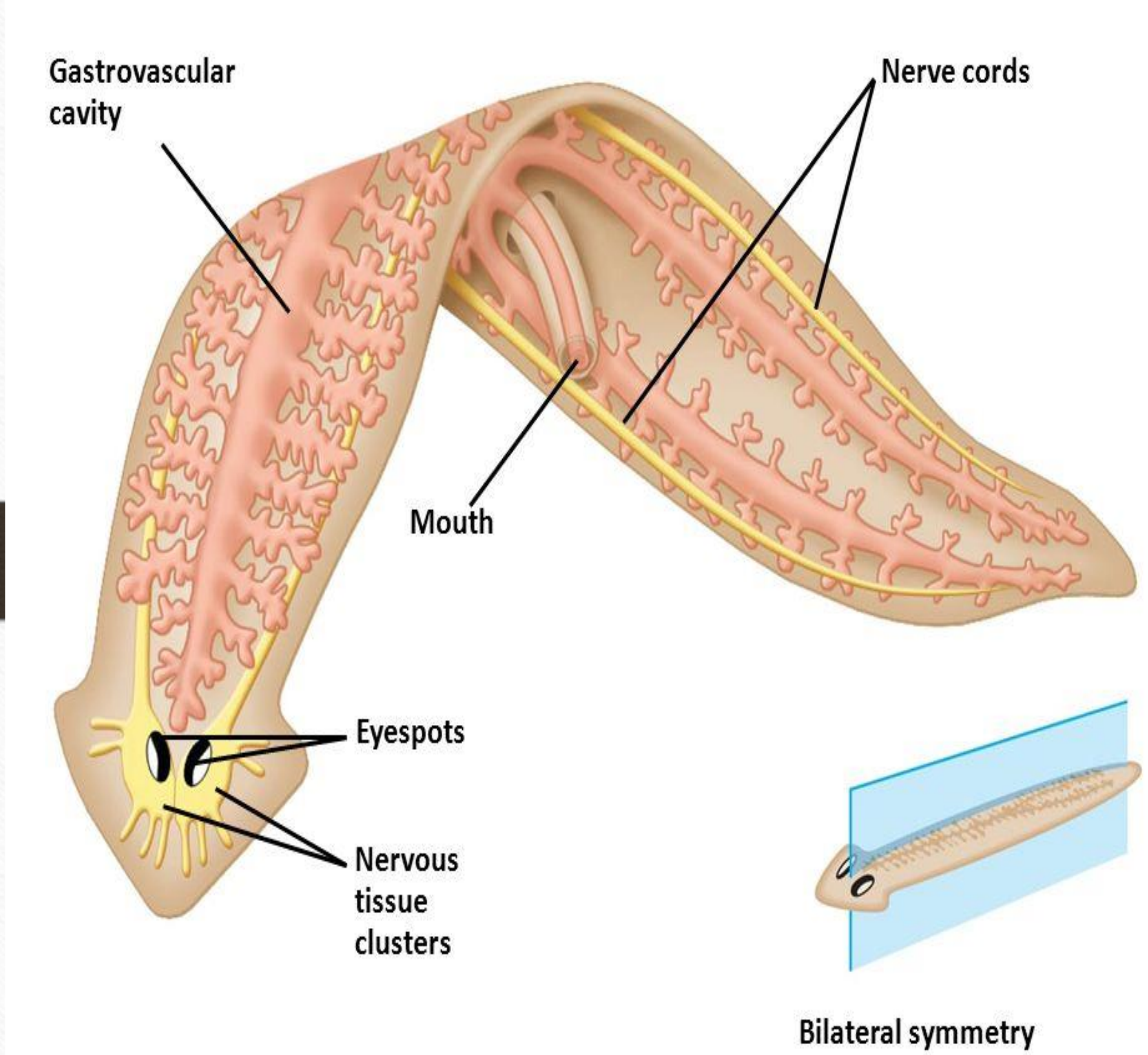
- Echinoderms show ganglia along the radial nerves.
- They include the cell bodies of almost all motor neurons and intermediate neurons.
- A central nerve ring surrounds the gut connecting the radial nerves.
- Some shows Ocelli to sense light.
- Sensory neurons lie within the ectoderm, and send axons to the radial nerves.



Platyhelminthes

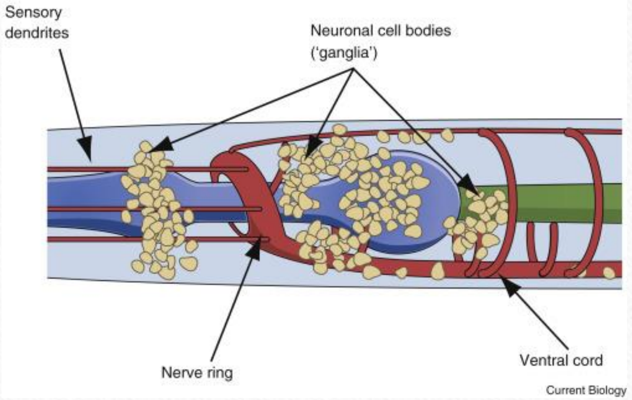
- Bilateral symmetry and cephalization have led to the nervous system.
- Shows the primitive arrangement of the central nervous system.
- Nervous system resembles a ladder.
- Two long nerves are connected to the cerebral ganglia located in the head region.
- Short, smaller nerves are connected to the nerve cord.
- Auricles can be found at the sides of the head.
- These contain sensory receptors.
- Eyespots are also present.

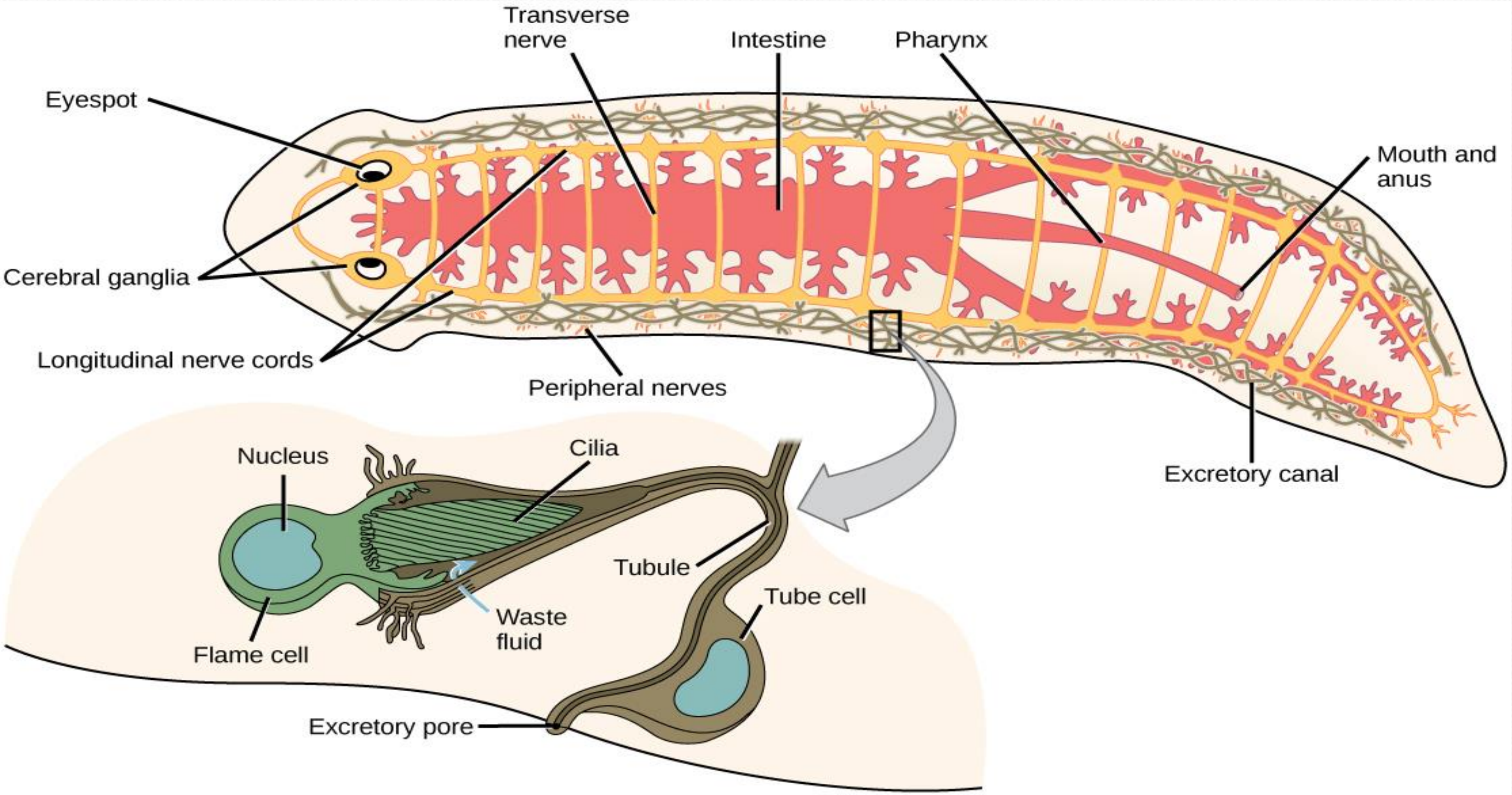




Nematoda

- At the anterior end cerebral ganglion is present composed of dense circular nerve ring surrounding the pharynx.
- Arising from the nerve ring four nerves run along the length of the body as one dorsal, one ventral and two lateral nerves.
- Each nerve is located within a cord of connective tissue lying beneath the cuticle and between muscle cells.
- Dorsal nerve trunk is motor, lateral trunks are sensory and ventral nerve function as both.




Transverse nerve
Intestine
Pharynx
Eyespot
Mouth and anus
Cerebral ganglia
Longitudinal nerve cords
Peripheral nerves
Excretory canal
Nucleus
Cilia
Tubule
Tube cell
Waste fluid
Flame cell
Excretory pore

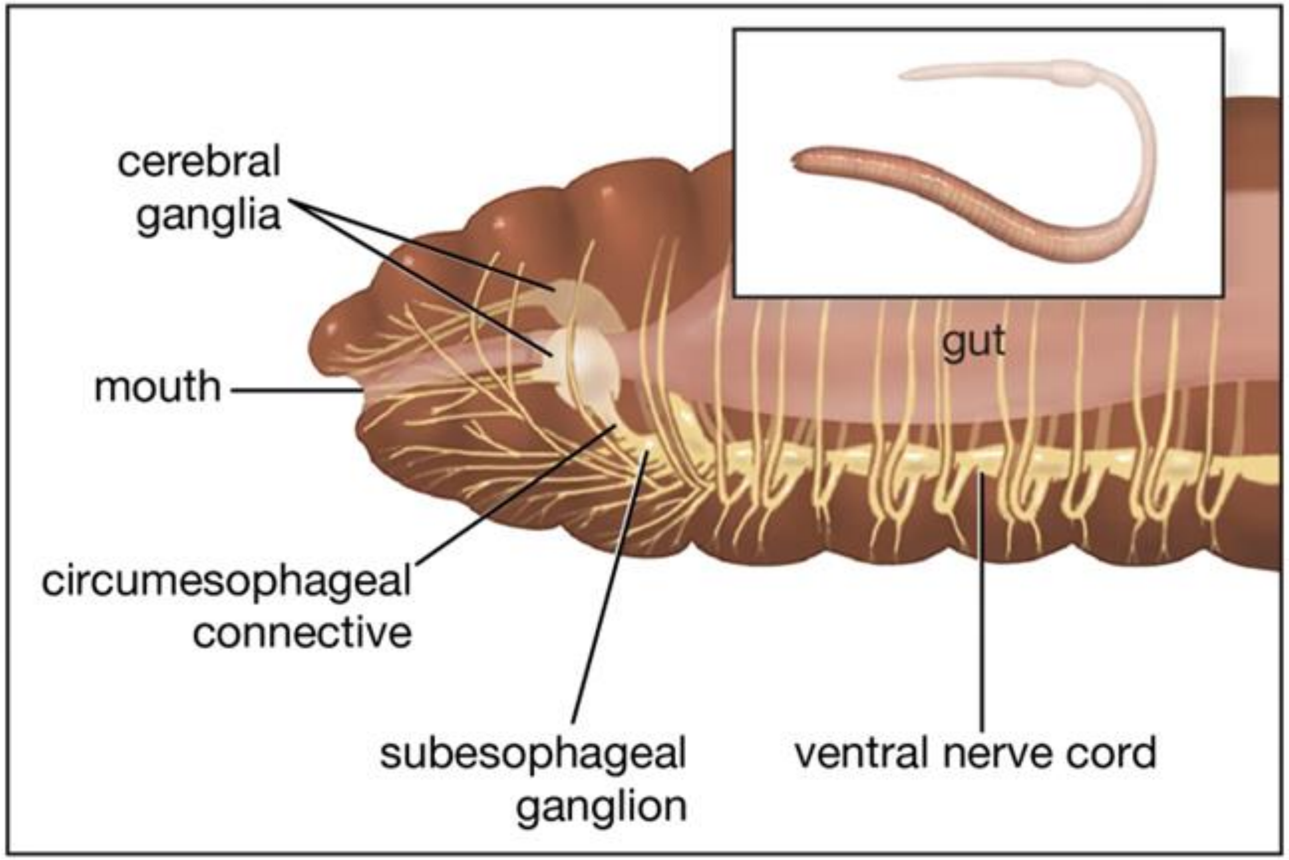
Annelida

- Nervous system is segmented.
- Pair of cerebral ganglia (supra-pharyngeal) situated above and in front the pharynx.
- Two lateral nerves (circum or pharyngeal connectives) form a ring around the pharynx connecting the ganglia.
- A pair of mid ventrally placed nerves that connected to the anterior nerve ring, run throughout the length of the body. These nerves have a ganglion in each of the body segment from which nerves are given out to various organs.
- Most annelids have giant axons.
- Some annelids have ocelli or simple eyes.

Annelids have well developed sensory receptors.

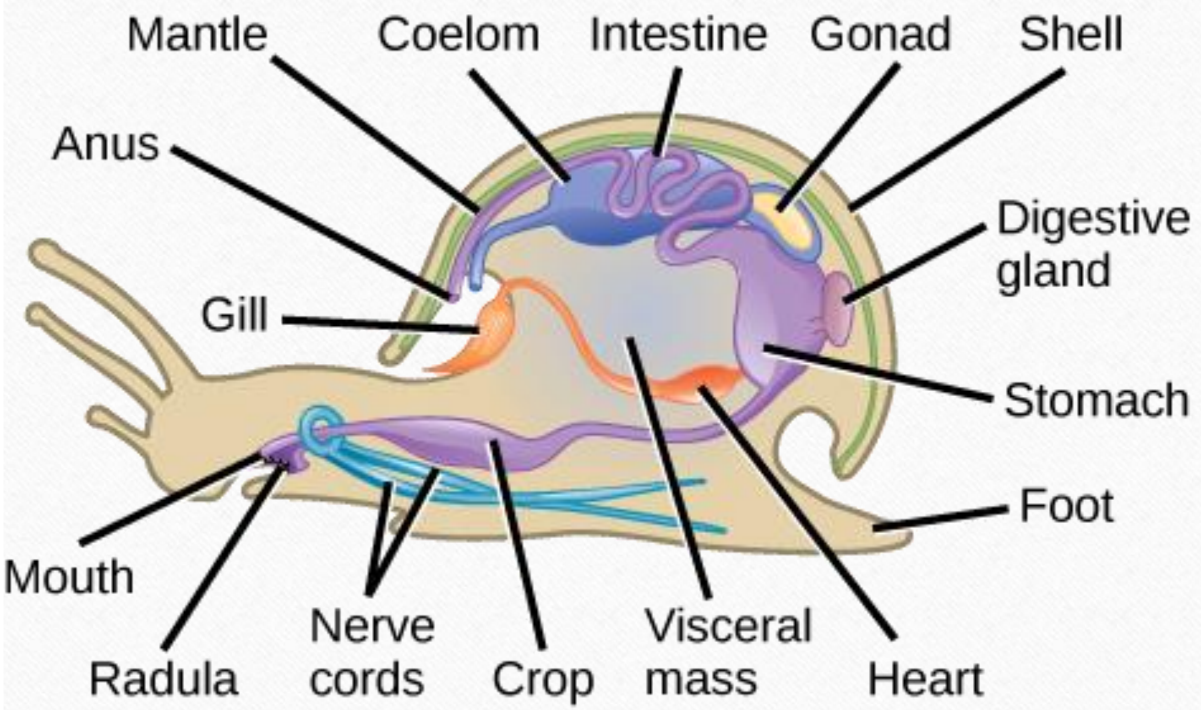
Polychaetes have a variety of tactile, photoreceptors, and chemoreceptor distributed over the body surface; most burrowing and tube - dwelling forms have statocysts and georeceptors that enable them to orient themselves in the subrate

Nervous system of the annelid (earthworm)



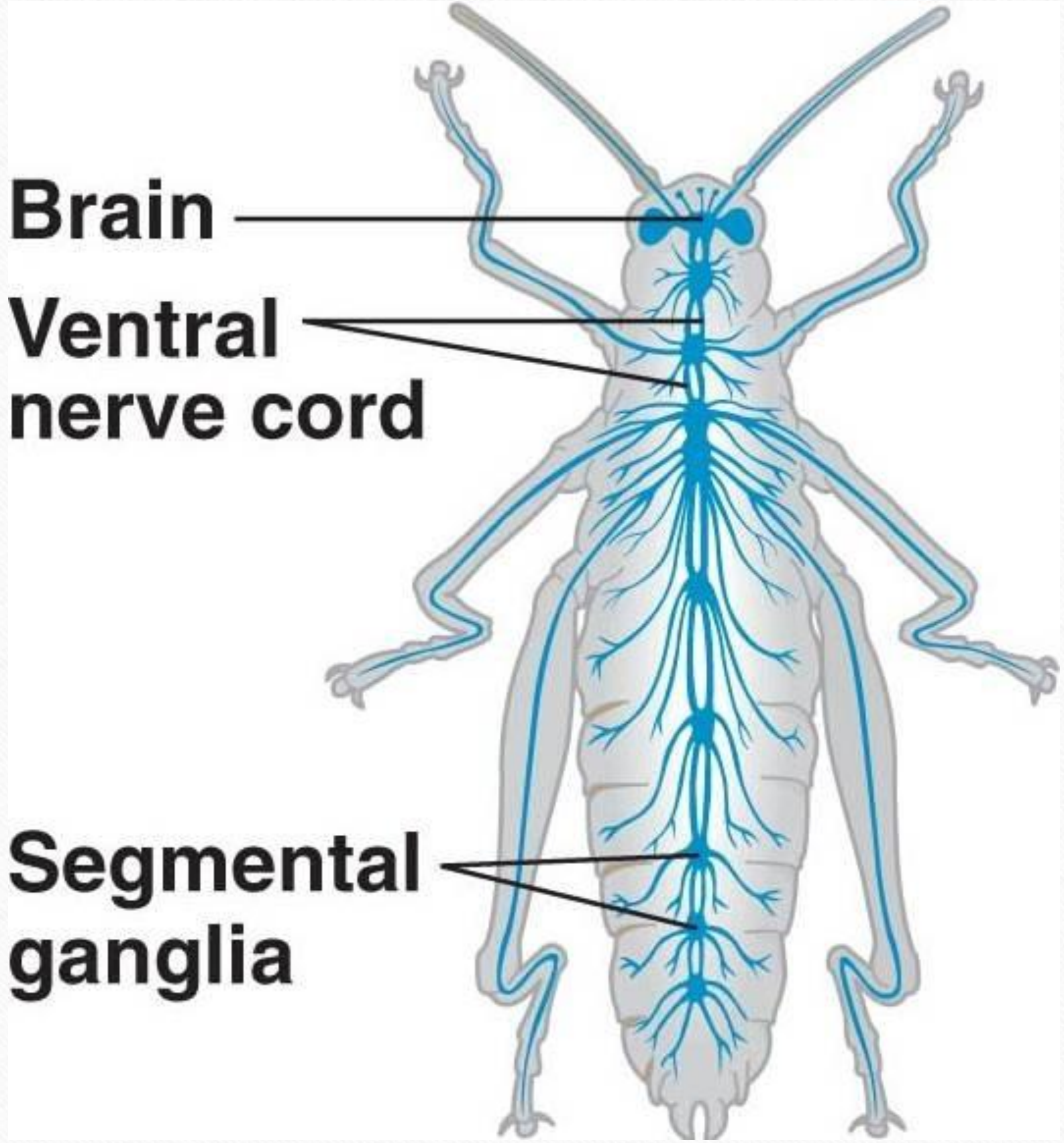
Mollusca

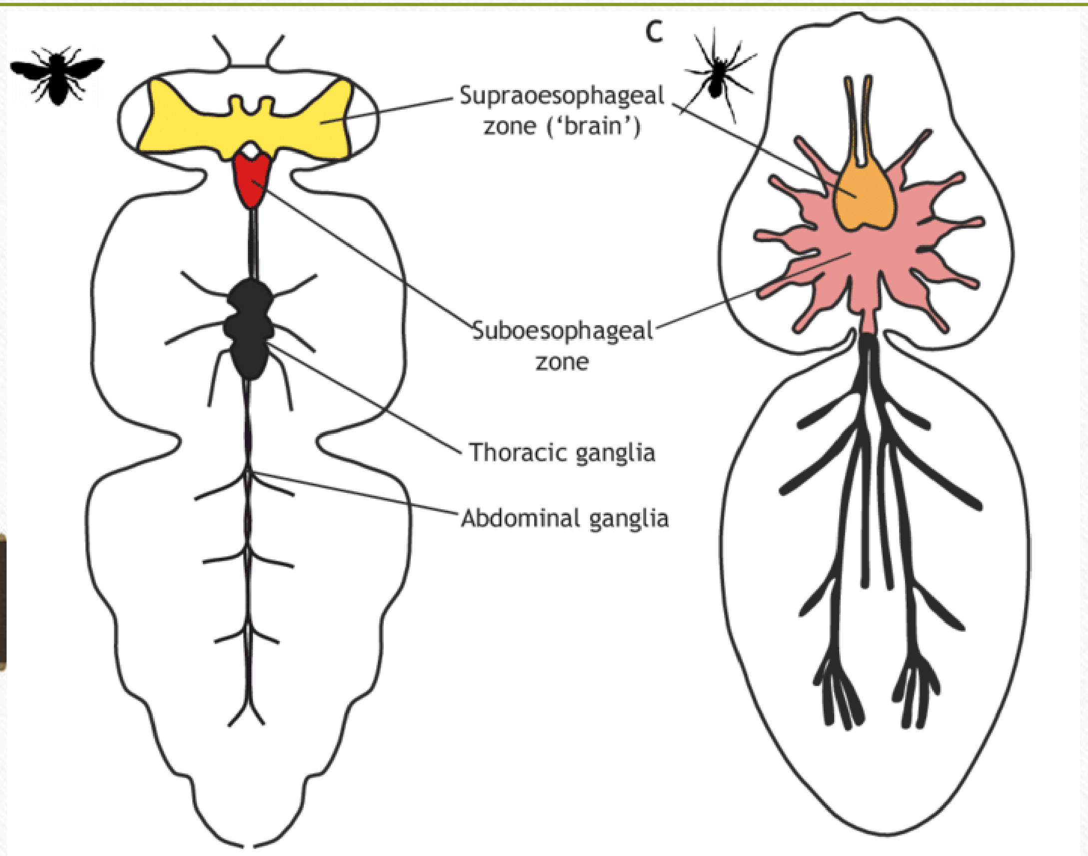
- Shows great range of nervous systems.
- Typical nervous system of Mollusks is composed of three pairs of ganglia connected with one another by bundles of nerve fibers but distributed in a characteristically scattered manner.
- One pair of ganglia above the oesophagus is called as "supra-oesophageal" or "cerebral" ganglion.
- A pair of ganglia below the oesophagus is called as "infra-oesophageal" or "pedal" ganglion.
- The other pair of ganglia is called as "branchial" or "parieto-splanchnic" ganglion.
- In higher Molluscs, the cerebral and pedal ganglia are fused forming an oesophageal ring.
- Several ganglia are present that are connected with long nerves.

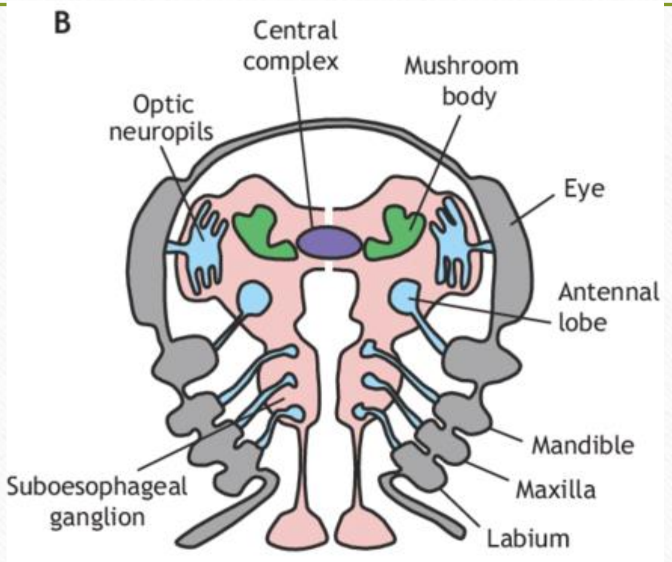


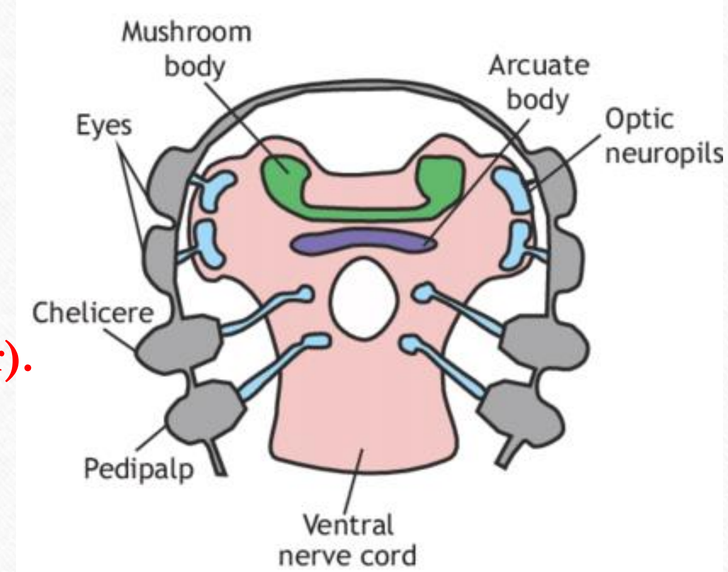
Arthropoda

- Similar to annelid nervous system but more advanced in structure.
- Central nervous system is present.
- Supra-oesophageal or cerebral ganglion is located in the head segment. This serves as the brain.
- Most arthropods show well developed sensory organs such as compound eyes and antennae.
- Compound eyes contain 'Ommatidia' that samples a small part of the visual field.



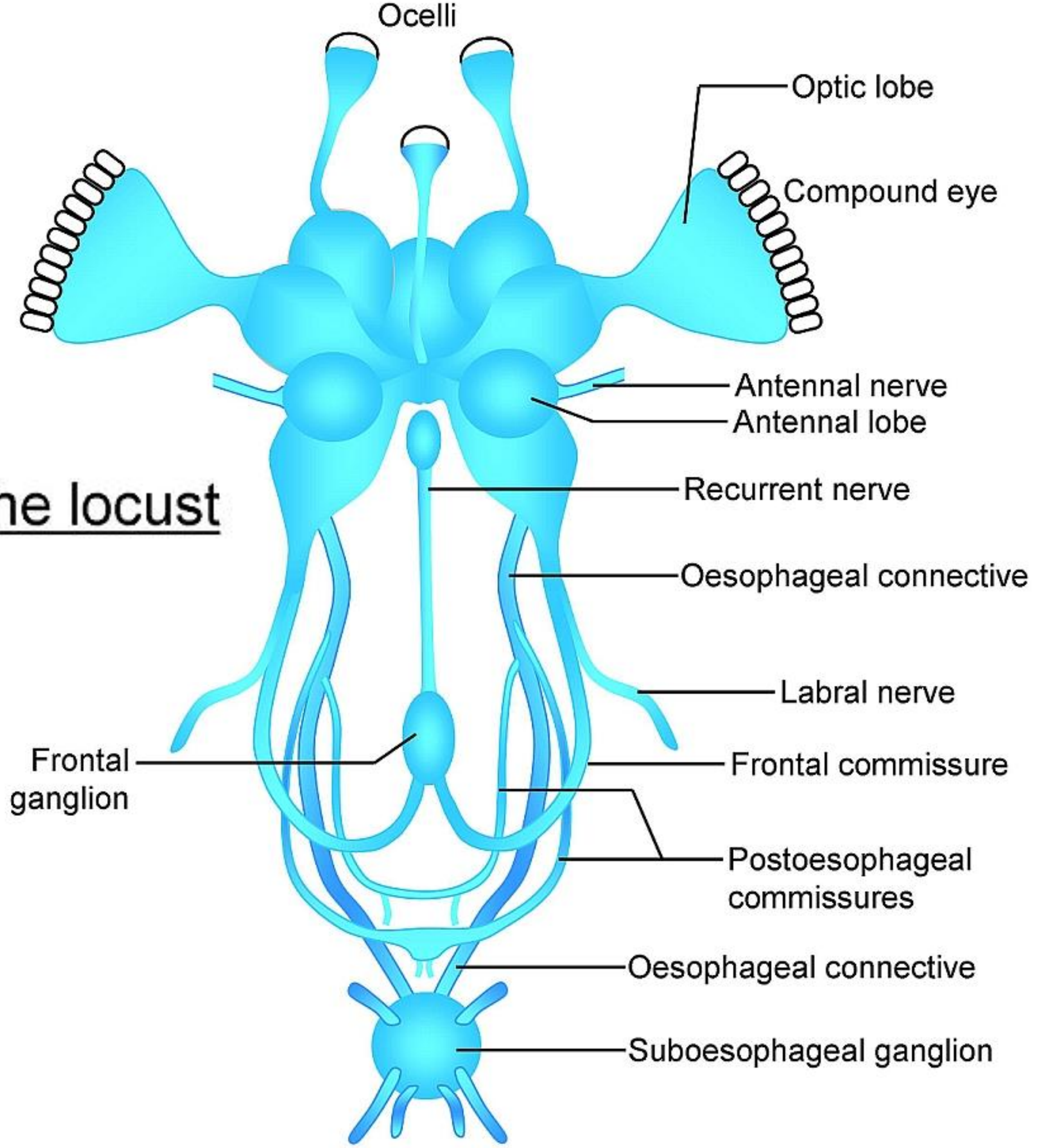






Arthropod central nervous system.
Dorsal view of a simplified insect central nervous system (top is anterior). Closeup of head region with schematic representation of the brain and head sensory organs of insects. Nerve tissue in pink, sensory nerves in blue.

Anterior (frontal) view of the brain of the locust



SENSORY SYSTEMS

Invertebrate sensory receptors are

- (a)baroreceptors
- (b) chemoreceptors
- (c) georeceptors
- (d) thermoreceptors
- (e) phonoreceptom
- (f) photoreceptors
- (g) proprloceptors
- (h) tactile receptors
- (i) hygroreceptom

Baroreceptors

Zoologists, although have not identified any specific baroreceptors in invertebrates, yet responses to pressure changes have been identified in ocean dwelling copepod crustanceans, ctenophores, jelly fish medusae, and squids.

Chemoreceptors

Chemoreceptors respond to chemicals. This is the oldest and most universal sense in the animal kingdom. Protozoa avoid strong acids, alkali, and salt. Specific chemicals attract predatory ciliates to their prey. Chemoreceptors of many aquatic invertebrates are located in pits or depressions. In arthropods, the chemoreceptors called sensilla are usually on the antennae, mouthparts, and legs. Invertebrates with their specific chemoreceptors can detect humidity, access pH, track their prey, recognize food, and locate mate. For example, male silkworm (Bombyx mod) can detect one bombykol molecule.

Goereceptors

Georeceptom respond to the force of gravity enabling animal to perceive its orientation relative to "up" and "down". Most georeceptors are statocysts. An invertebrate statocyst consists of a fluid filled chamber lined with cilia-bearing sensory epithelium; within the chamber is a solid granule called statolith. Any movement of the animal's body changes the position of the statolith and moves the fluid which alters the sensory epithelium. Statocysts are found in gastropods, cephalopods, crustaceans, nemertines, polychaetes, and scyphozoans. In addition to statocysts, a number of aquatic insects detect gravity from air bubbles trapped in certain tracheal tubes. These air bubbles, like a carpenter's level, move according to their orientation to gravity, and stimulate sensory bristles that line the tubes.

Thermoreceptors

Thermoreceptors respond to temperature changes. Although specific receptor structures have not been identified, somehow, a heat sensing mechanism draws leeches and ticks to warm blooded hosts, Paramecium, for example, collects in areas where water temperature is moderate, and avoid temperature extremes. Insects, some crustaceans, and the horseshoe crab (Limulus) can also sense thermal variations.

Phonoreceptors

Phonoreceptors, demonstrated only in insects, arachnids, and centipedes, respond to sound. Crickets, grasshoppers, and cicadas possess phonoreceptors called tympanic or tympanal organs. Most animals possess phonoreceptors called slit sense organs in their cuticle, centipedes have organs of Tomosvary, both poorly understood.

Photoreceptors

Photoreceptors are sensitive to light. All photoreceptors possess photosensitive pigments, such as carotenoids, rhodopsin, which absorb photons of light and produce a generator potential. Among invertebrates, four kinds of photoreceptors are identified: stigma, ocelli, compound eyes and complex camera eyes. Stigma is a mass of bright red photoreceptor granules which are carotenoid pigments which in Euglena perhaps serves as a shield. The actual photoreceptor is the swelling at the base of flagellum. °coitus is Si,t7rnulticellular, small cup lined with light sensitive receptors and backed by light absorbing pigment. The fight sensitive cells are called retinular cells that contain photoreceptor pigment which on receiving stimulus (light) produce generating potential leading to action potential. The animal only gets information about light, but image is not formed.

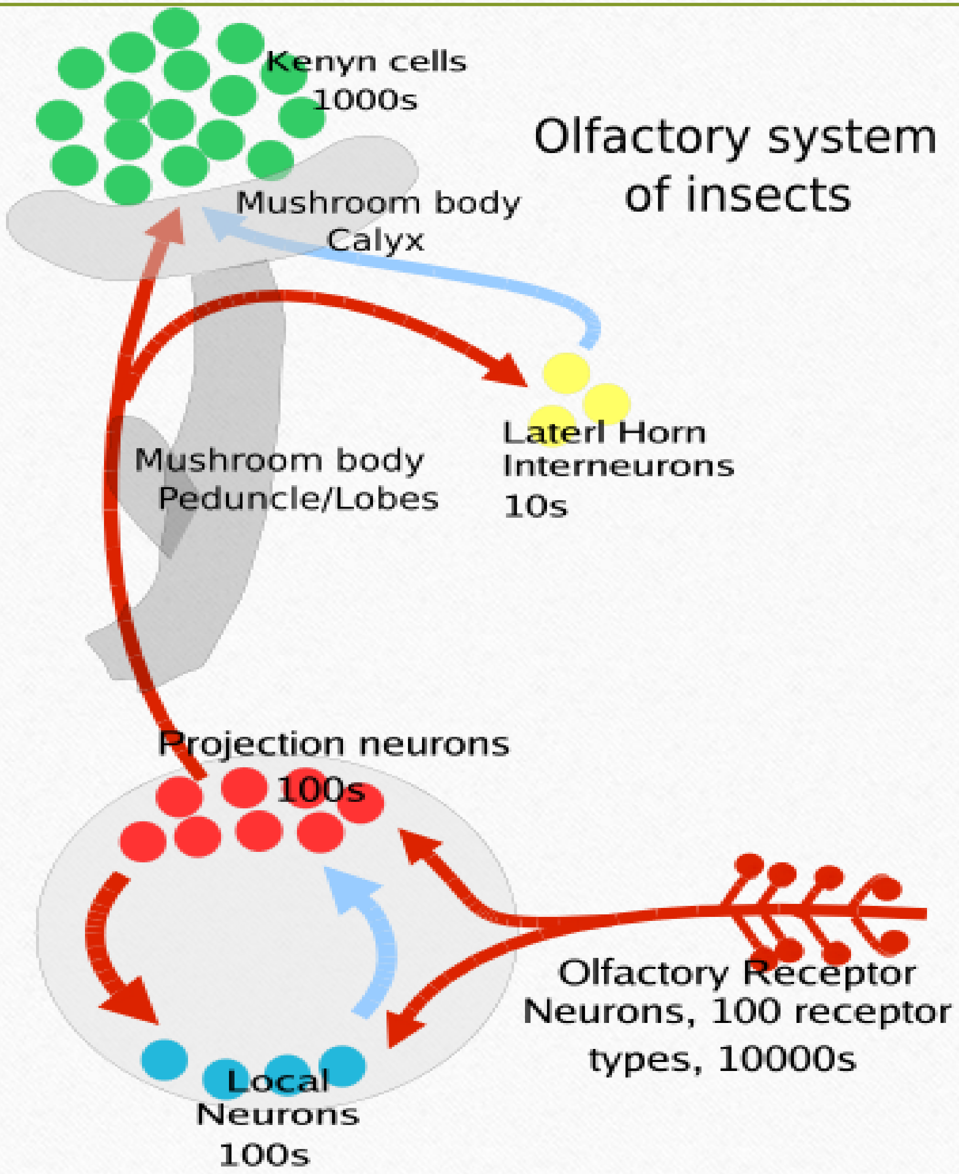
Ocelli commonly occur in phyla Annelida, Mollusca, and Arthropoda. (Earthworm (Lumbricus) has simple unicellular photoreceptor cells scattered over the epidermis). Compound eyes, although occur in some annelids and bivalve molluscs; they are best developed in arthropods. Each eye consists of a few to many distinct units called ommatidia (ommato, eye + ium, little), each oriented in a slightly different direction from the others due to eye's convex shape. The visual field of eye is very wide. Compound eyes are very effective in detecting movements and forming image and can detect colour. Colour vision is particularly important in active, day-flying, nectar feeding insects, such as honeybee. Complex camera eyes, such as of squids and octopuses are; best image forming eyes among the invertebrates, largest among animal's, exceeding 38 cm in diameter in giant squid.

Proprioceptors

Proprioceptors, commonly called as "stretch receptors" are internal sense organs that respond to mechanically induced changes caused by stretching, compression, bending, or tension. Proprioceptors have been studied thoroughly in arthropods, where they are associated with appendage joints and body extensor muscles.

Tactile receptors

Tactile receptors are touch receptors derived generally, from modifications of epithelial cells associated with sensory neurons. Examples include various bristles, spines, setae, and tubercles. For example web-building spiders have tactile receptors that can sense vibrations of the web threads when an entangled prey tries to escape from the web.



Photoreceptors

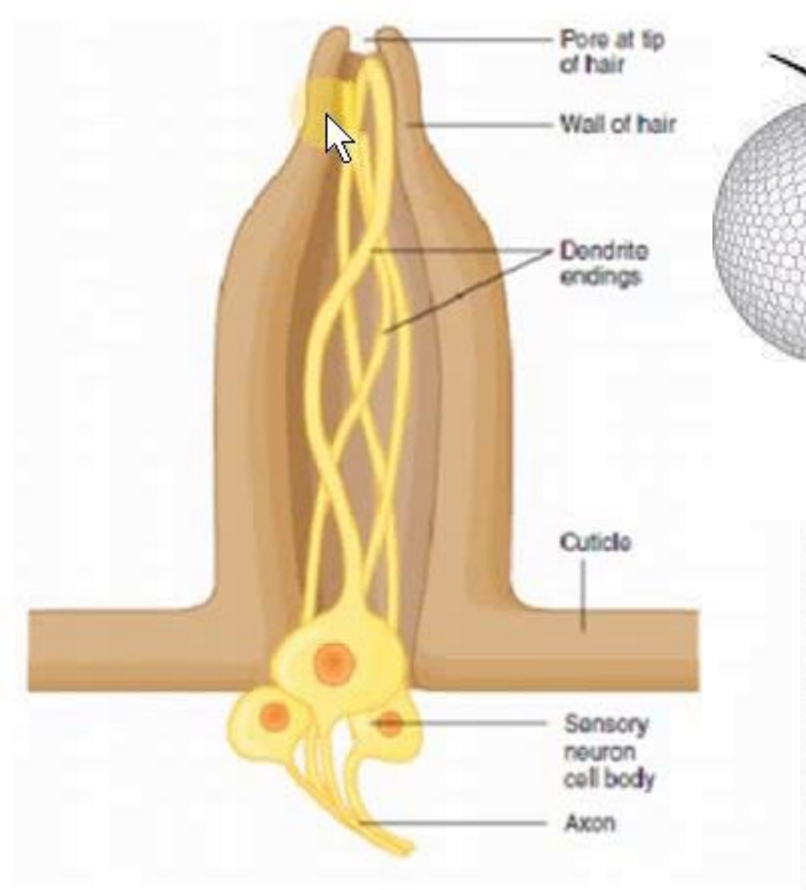
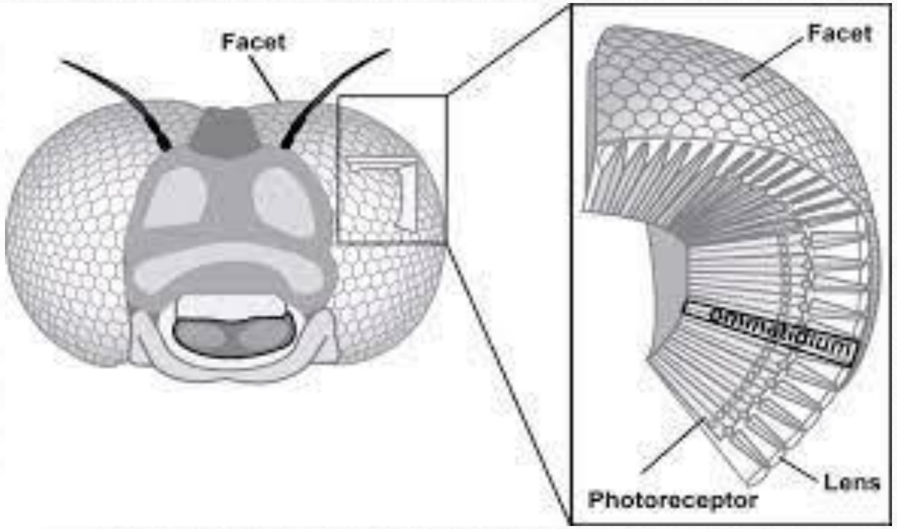
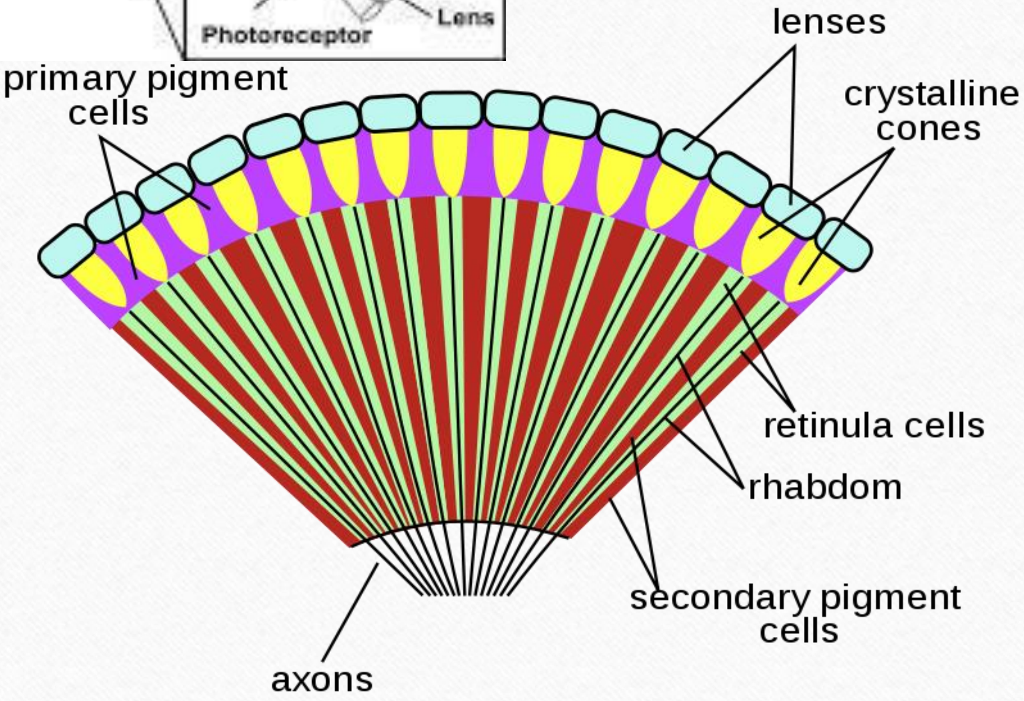
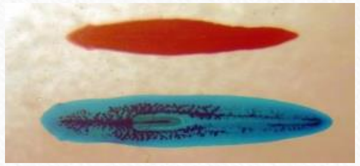


Fig: 1.Chemoreceptor of invertebrates

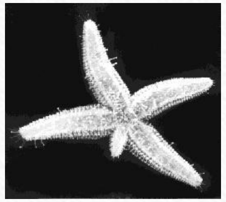




REPRODUCTIVE SYSTEMS

Type of Invertebrate	Major Characteristics	Examples	Type of Reproduction
Porifera 	-Simplest animals -can regenerate body parts -has no symmetry	Sponges	Sexual or Asexual
Cnidaria 	-2 basic body shapes; medusa (Ex. Jellyfish) & polyp (ex: Hydra) -Have tentacles -have stinging cells called nematocyst	Jellyfish Hydra	Sexual or Asexual
Platyhelminthes 	-Can regenerate -most are parasites -have flat ribbon like bodies -Bilateral symmetry	Planaria **Flukes** Flatworms	Sexual or Asexual

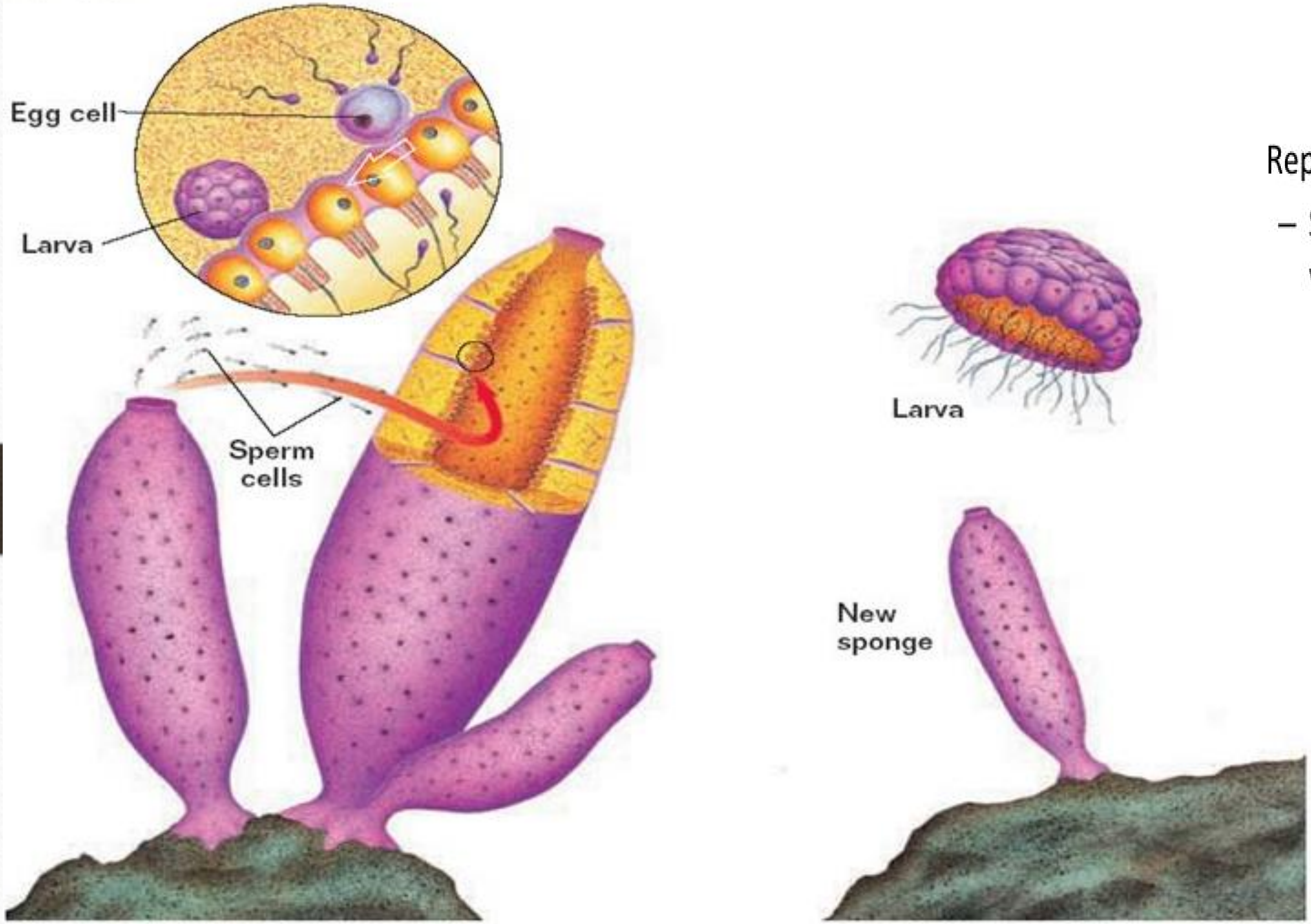
Nematoda 	-round, tubular bodies -Most are parasites -have both a mouth and anus -Bilateral symmetry	Roundworms Pinworms Hook Worms	Sexual
Mollusca 	-Broad Muscular foot -Layer of tissue called mantle -Have hard shells and soft bodies -Live on land and in the water Group includes: gastropods bivalves & cephalopods	Snails Slugs Clams Oysters Squids Octopuses	Sexual
Annelida 	-Segmented worms -Body divided into segments(sections) -Live in water or underground -have a nervous and circulatory system	Segmented worms Earthworm Bristle Worms Leeches	Sexual(majority) Asexual

Echinodermata 	Endoskeleton covered with spines	Starfish Sea Urchins Sand Dollar	Asexual

Reproduction - most sponges are monoecious - both sexes occur in same individual; do not usually self fertilize because eggs and sperm ready at different times.

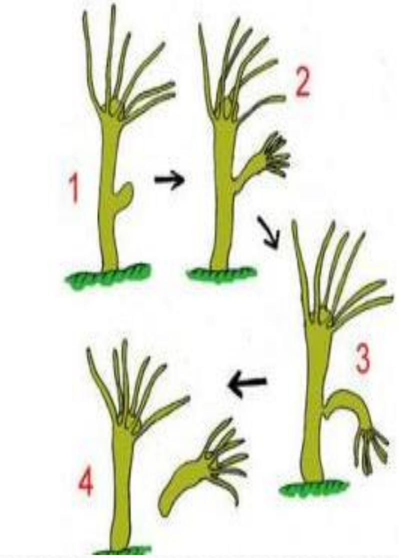
- 1. certain choanocytes lose collars and flagella and undergo meiosis to form flagellated sperm
  2. other choanocytes may undergo meiosis and form eggs. Eggs retained in mesohyl of parent
- 3. sperm cells exit one sponge by osculum and enter another with incurrent water. they are trapped by choanocytes and put in vacuoles.
- 4.sperm lose collar and flagella, become ameboid and transfer sperm to eggs
- 5. early development occurs in mesohyl, then a flagellated larva forms. Larva breaks free, free-swims for up to 2 days before settling to substrate and develops into adult form

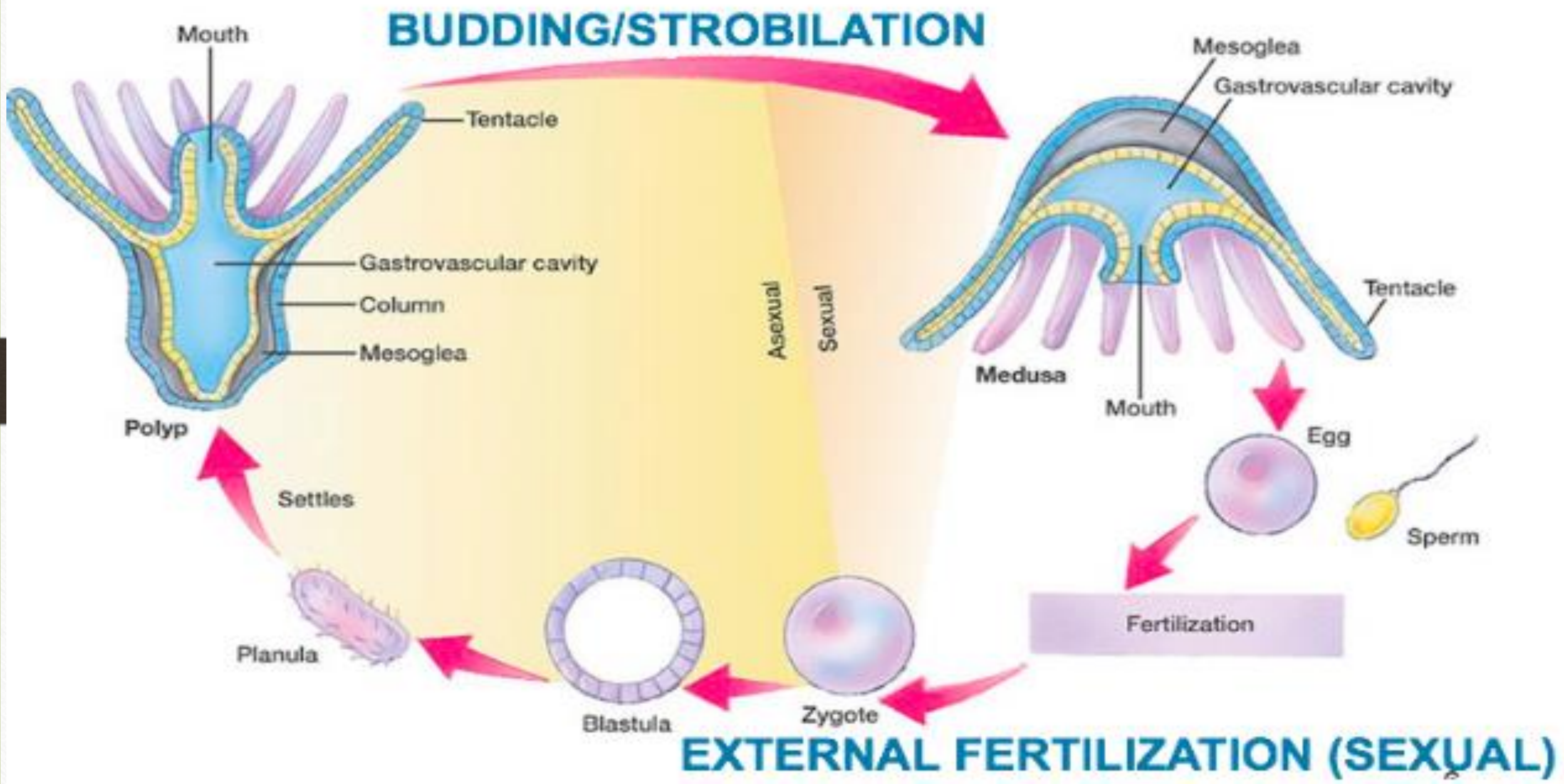
Phylum Cnidaria



Reproduction:

- Sexual reproduction occurs through external fertilization when the sperm is united with an egg outside of the body
  - Asexual reproduction can occur through budding and fission.




BUDDING/STROBILATION
Mouth
Tentacle
Gastrovascular cavity
Column
Mesoglea
Polyp
Settles
Planula
Blastula
Zygote
Asexual
Sexual
Mesoglea
Gastrovascular cavity
Tentacle
Medusa
Mouth
Egg
Sperm
Fertilization
EXTERNAL FERTILIZATION (SEXUAL)

PLATYHELMINTHES

Asexual Reproduction

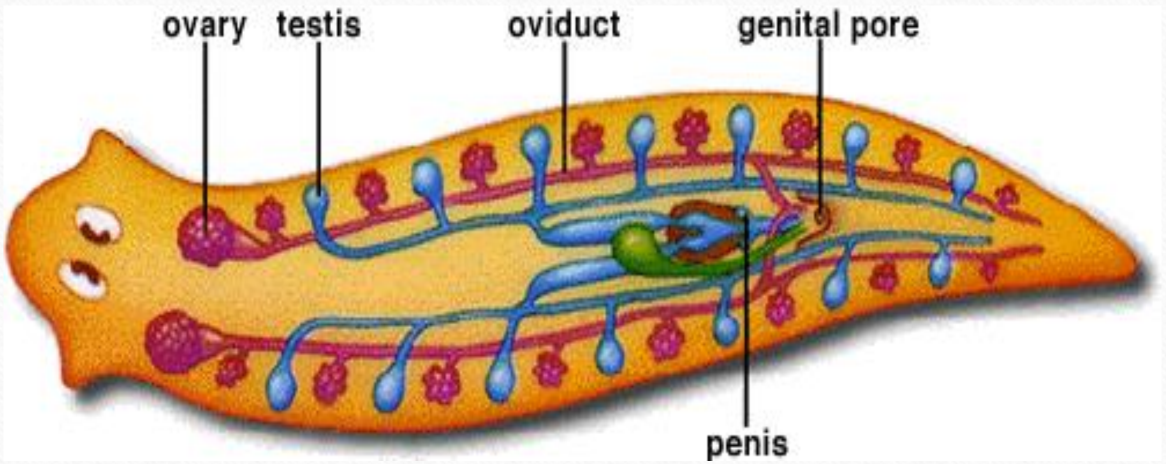
- They reproduce asexually by **transverse fission** (split into two) and have great regenerative capabilities. This means that if a part of their body is cut into half, they are able to grow the lost body part within a period of time.

Sexual Reproduction

- Most Turbellarians are **hermaphroditic**, meaning that they contain the male and the female sex organs. However, they are unable to self-fertilize and thus need the sperm of other turbellarians to fertilize the egg.

The MALE Reproductive System

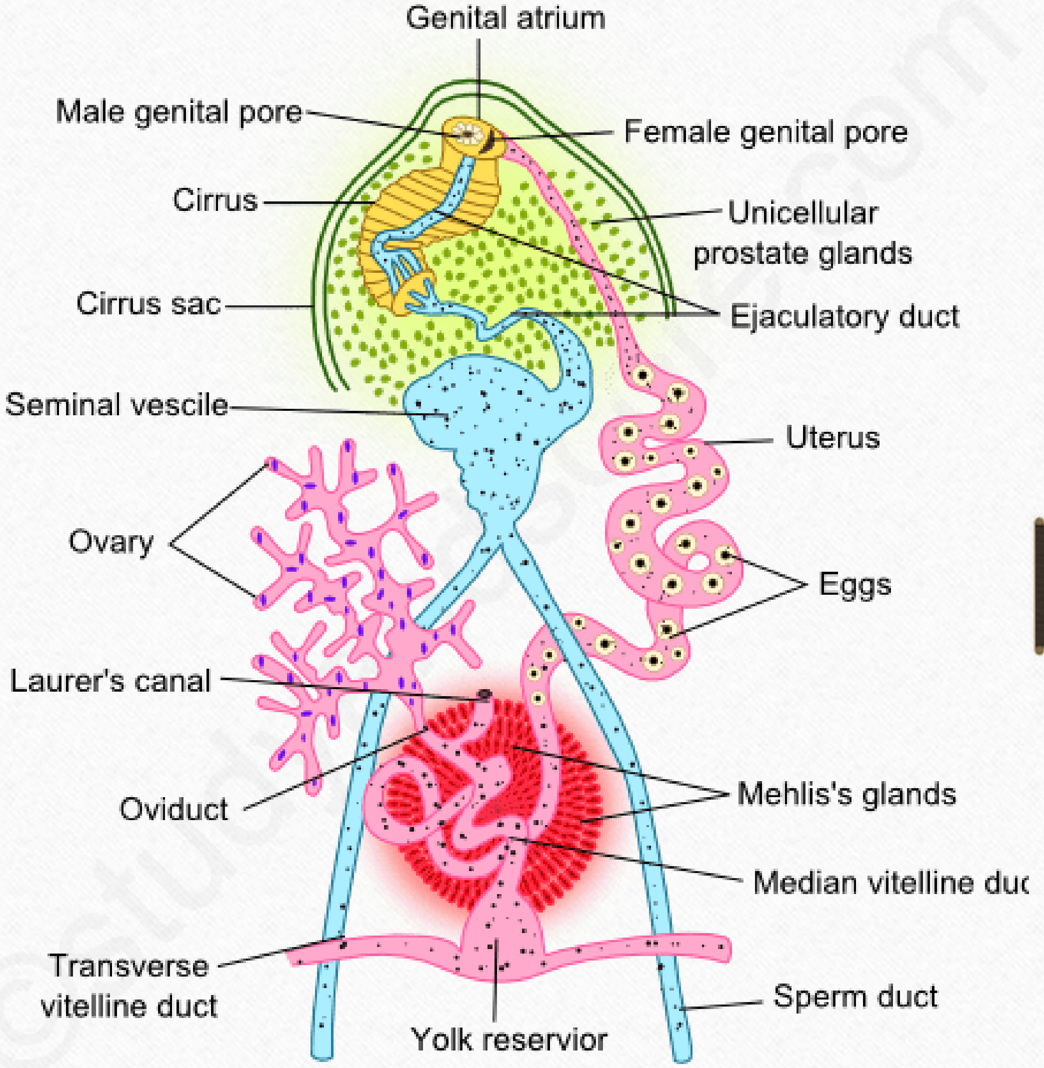
- Several hundred small **spherical testes** along both sides of the body, each connected by,
- a minute **ductus eferens** to,
- A **larger ductus deferens**: the 2 ducts enter
- **Median seminal vesicle** for sperm storage, connects to,
- Muscular **penis** opening into.
- **Genital atrium**, just within the genital pore



The FEMALE Reproductive System

- 2 **rounded ovaries**, connecting to,
- **Two oviducts**
- Along each duct are: **many yolk** or **vitelline glands**, which supply yolk cells when eggs are produced
- the 2 oviducts join the **median vagina** opening into,
- The **genital atrium**, to the vagina is connected
- A **bulbous copulatory sac** that receives sperm at mating
- Soon the sperm move to the **seminal receptacles** which are slight enlargement between the ovaries and oviducts.

- **Cross-fertilization-** exchange of sex products between separate individual
- **Internal fertilization-** direct transfer of sperm from male to female organ
- Development is direct



FASCIOLA-MALE AND FEMALE REPRODUCTIVE SYSTEM

NEMATODES

- Nematodes are dioecious
- Both sexes look alike
- Reproductive system is tubular
- Males v/s Females
  - **Males are slightly shorter**
  - **Tail end curved ventrally**
  - **Possess secondary sexual organs**
    - Spicules
    - Gubernaculum
    - Bursa

Ovary
Germinal zone: Production of oogonia
Growth zone: Oogonia increase in size

Oviduct
A narrow passage for oogonia

Spermatheca
Store sperms; oogonia get fertilized when pass through

Uterus
Columellar glandular cells – deposit egg shell around fertilized egg

Vagina
Expulsion of egg

Vulva
Slit-like on ventral side; help in egg laying and copulation

Testis
Production of spermatogonia

Seminal vesicle
Storage of sperms till mating

Vas Deferens
Passage for sperms, merges with intestine to form cloaca

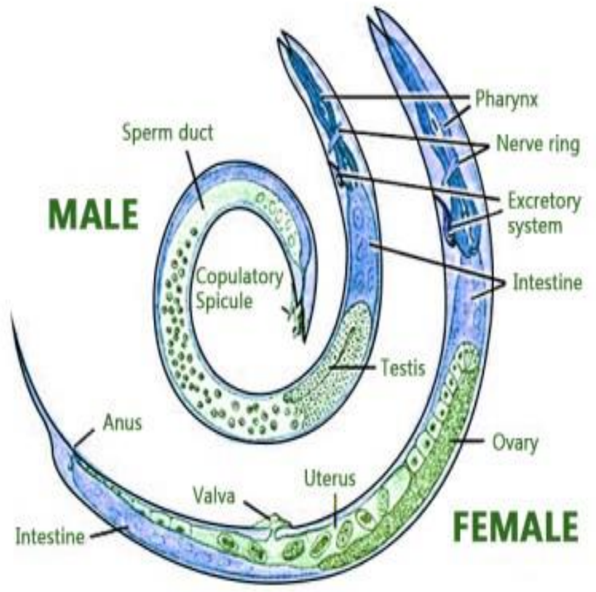
Cloaca
Common tube for digestive and reproductive systems

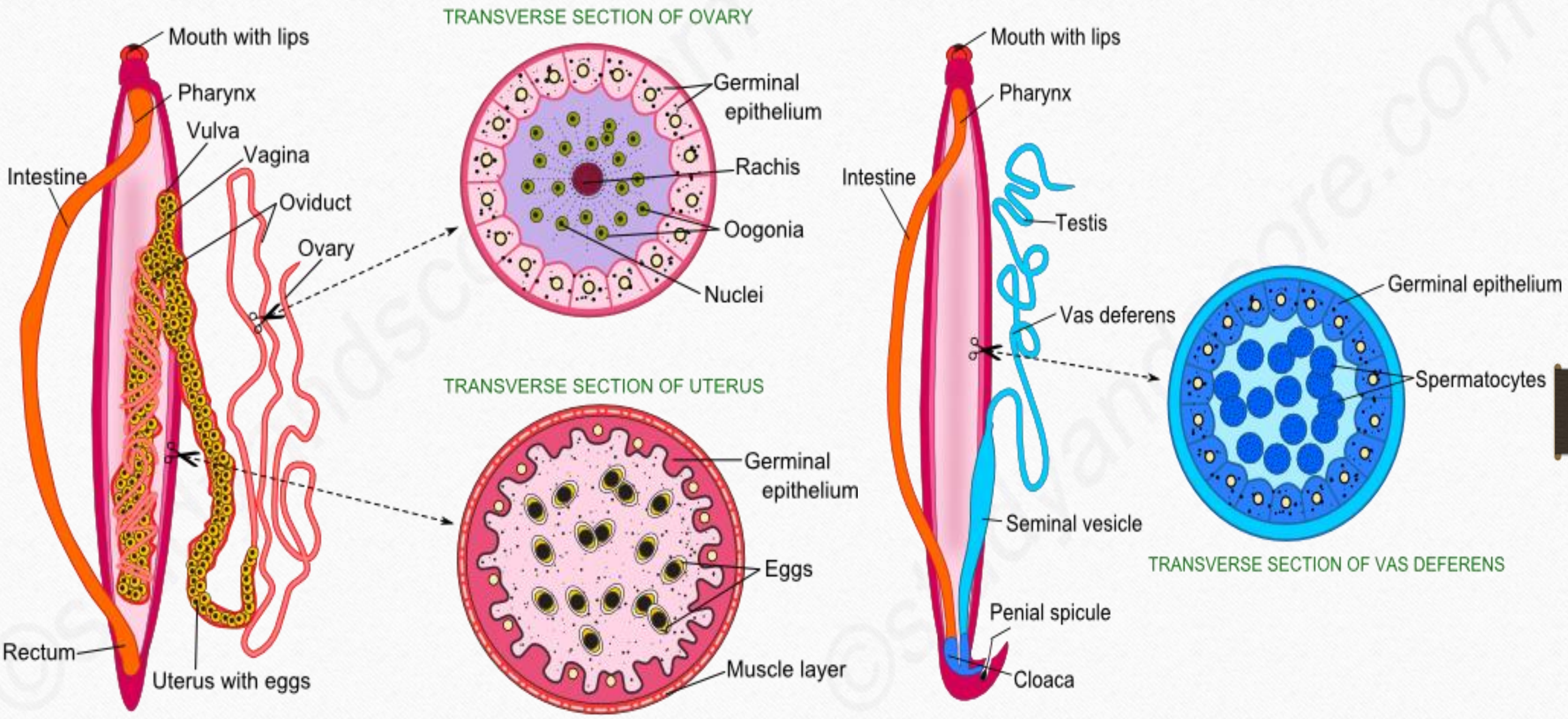
Cloacal aperture
Common opening for both systems

Spicules
Sclerotized, a pair, movable, mating organ

Gubernaculum
Plate-like, not movable, guides the movement of spicules

Bursa
External cuticular extensions on lateral side, a pair, leptoderan or peloderan, hold female during mating





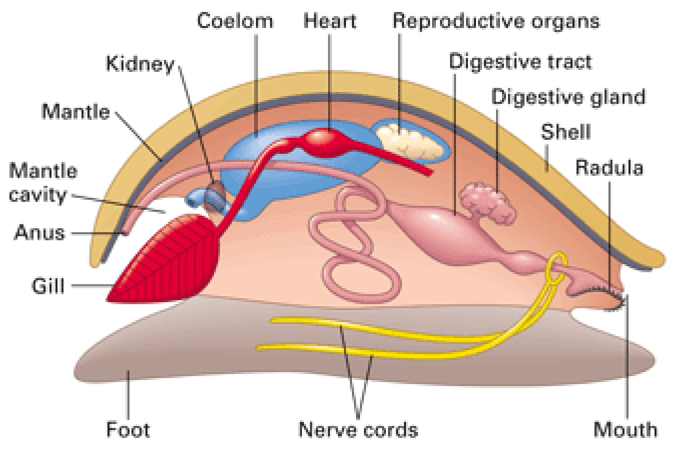
ASCARIS - FEMALE REPRODUCTIVE SYSTEM

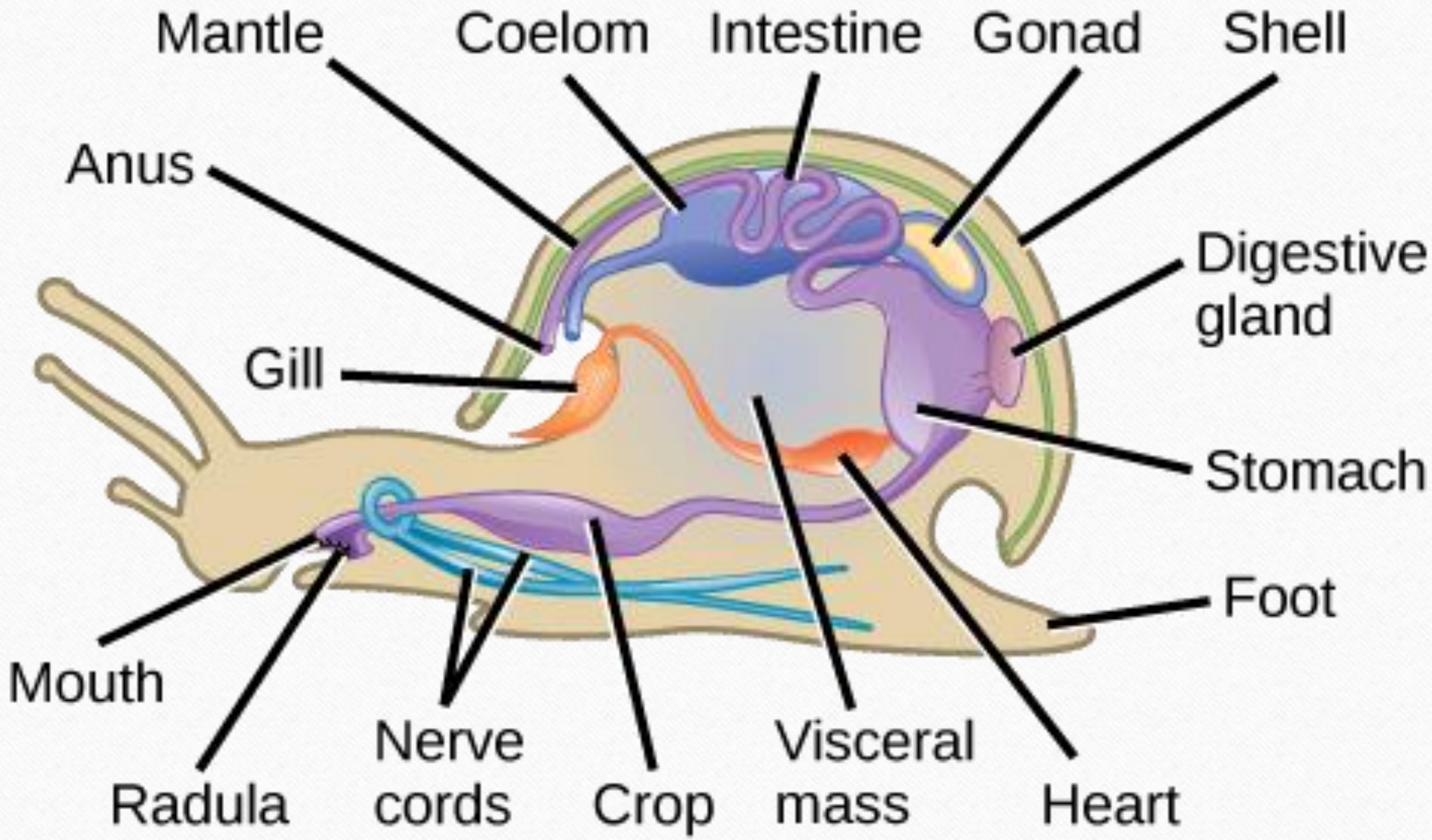
ASCARIS - MALE REPRODUCTIVE SYSTEM

Molluscan reproduction

Mollusks are primarily of separate sexes, and the reproductive organs (gonads) are simple. Reproduction via an unfertilized gamete (parthenogenesis) is also found among gastropods of the subclass Prosobranchia. Most reproduction, however, is by sexual means. Eggs and sperm are released into the water by members of some (primitive) species, and fertilization occurs there. In prosobranch gastropods, water currents may cause a simple internal fertilization within the mantle cavity, or males may fertilize eggs internally using a muscular penis. Both male and female reproductive organs may be present in one individual (hermaphroditism) in some species, and various groups exhibit different adaptations to this body form. For example, in hermaphroditic bivalves and prosobranch gastropods, male and female gonads are functional at separate times and in rhythmic and consecutive patterns (successive hermaphroditism). Conversely, male and female gonads are functional at the same time (simultaneous hermaphroditism) in solenogasters and many other gastropods.

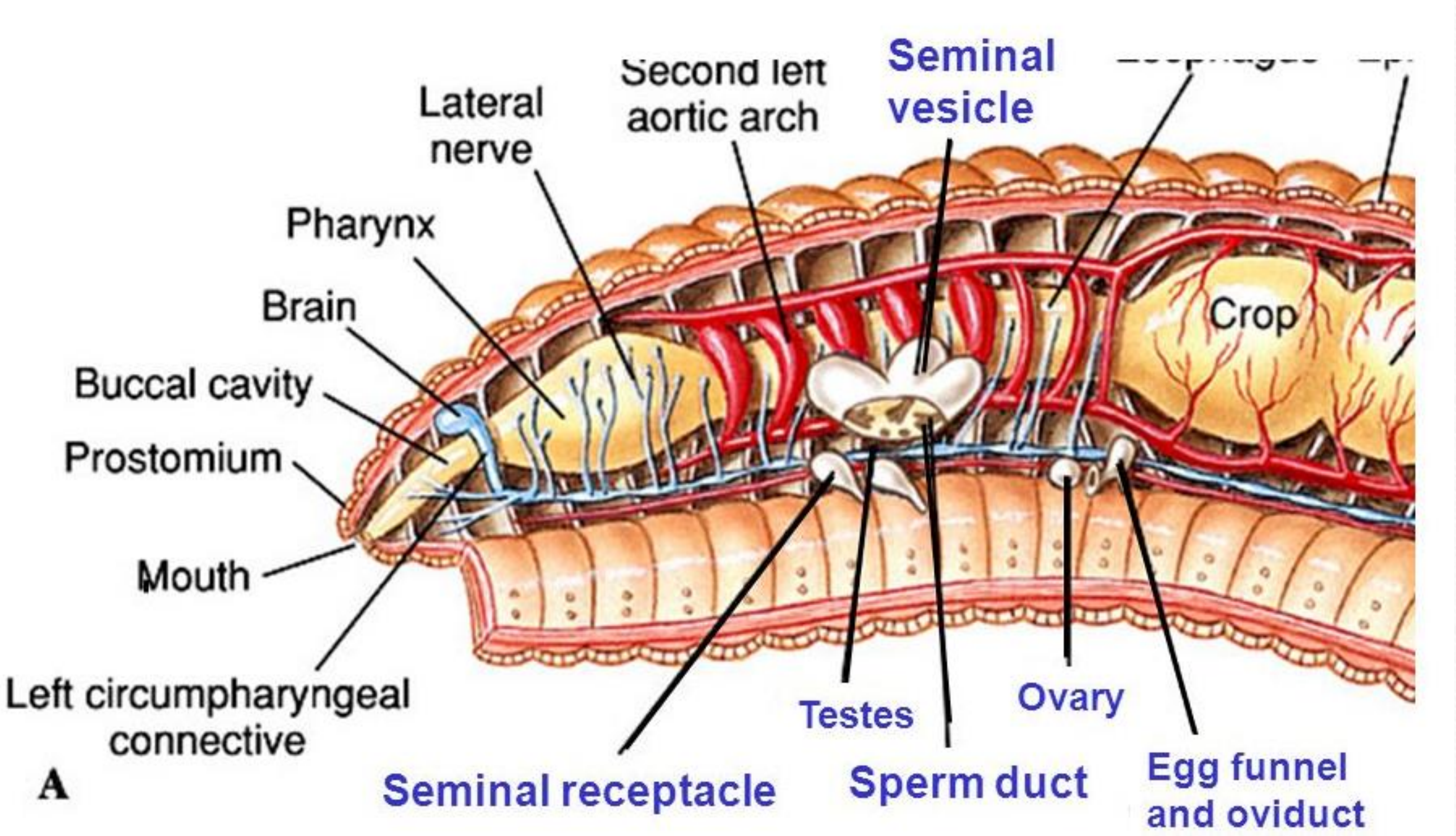
Fertilization by transfer of capsules containing sperm (spermatophores) typically occurs in cephalopods and some gastropods. In cephalopods, transfer of spermatophores is usually combined with copulation by a modified arm, or hectocotylus. Copulation in solenogasters, often by means of a special genital cone, may be supported by copulatory stylets. Various penis formations, in part with copulatory stylets, or darts, are widely found in gastropods. Eggs are deposited singly or in groups, generally on some hard surface and often within jelly masses or leathery capsules. Squids of the suborder Oegopsida and some gastropods have eggs that are suspended in the water. Fertilized eggs commonly undergo spiral cleavage, as in annelids and a number of other "protostome" phyla. The eggs of cephalopods, on the other hand, possess a large amount of yolk, which displaces the dividing cells and causes a characteristic type of development.

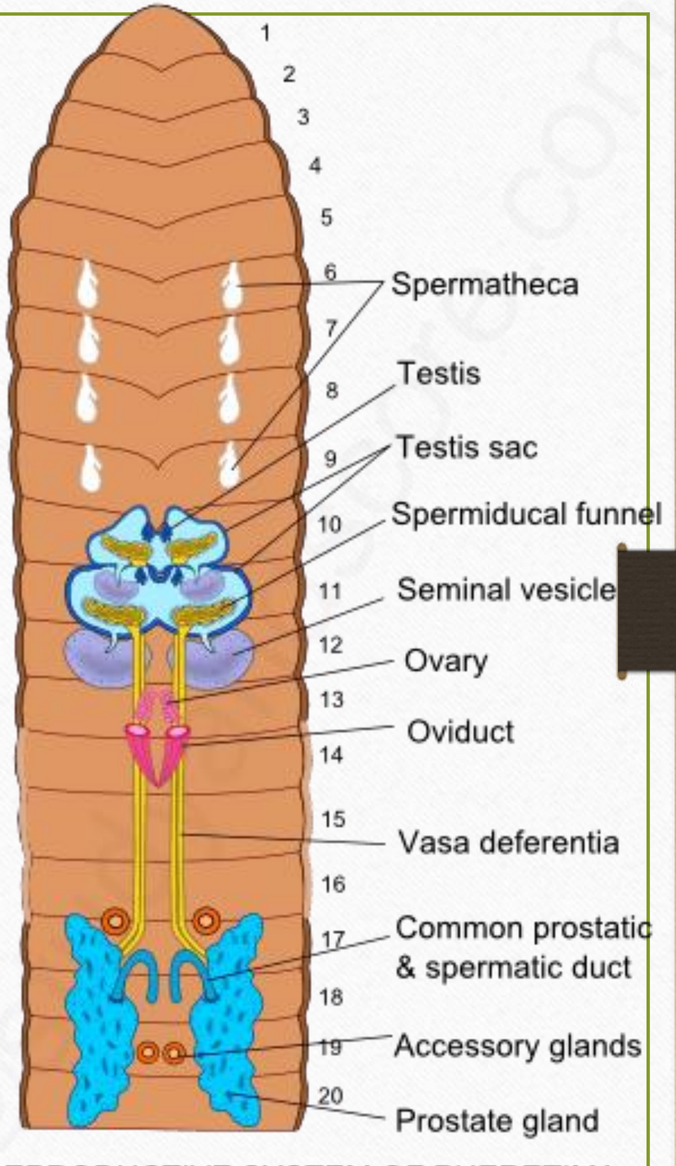



Mantle
Coelom
Intestine
Gonad
Shell
Anus
Digestive gland
Gill
Stomach
Foot
Mouth
Radula
Nerve cords
Crop
Visceral mass
Heart

Annelida

Asexual reproduction may occur by budding or fission. Sexual reproduction varies by species. In some species, the same individual produces both sperm and eggs. But worms mate to exchange sperm, rather than self-fertilizing their own eggs. In some species, the same individual produces both sperm and eggs. But worms mate to exchange sperm, rather than self-fertilizing their own eggs. Fertilized eggs are deposited in a mucous cocoon. Offspring emerge from the cocoon looking like small adults. They grow to adult size without going through a larval stage. In polychaete species, there are separate sexes. Adult worms go through a major transformation to develop reproductive organs. This occurs in many adults at once. Then they all swim to the surface and release their gametes in the water, where fertilization takes place. Offspring go through a larval stage before developing into adults.





REPRODUCTIVE SYSTEM OF PHERETIMA

Echinoderm

- Echinoderms usually have separate sexes but external fertilization. They are broadcast spawners, releasing large numbers of gametes (eggs from females, sperm from males), only a few of which will ever become adults. A female can release a hundred million eggs at once.
- Sperm and eggs are made in the gonads and released into the water. The fertilized eggs become free-swimming bilaterally symmetrical larvae (called bipinnaria) which eventually metamorphose into pentaradial adults.
- Some echinoderms have incredible regenerative abilities. An injured sea star can regrow its whole body from a single arm as long as it also contains a part of its central disc. However, they don't reproduce this way deliberately.

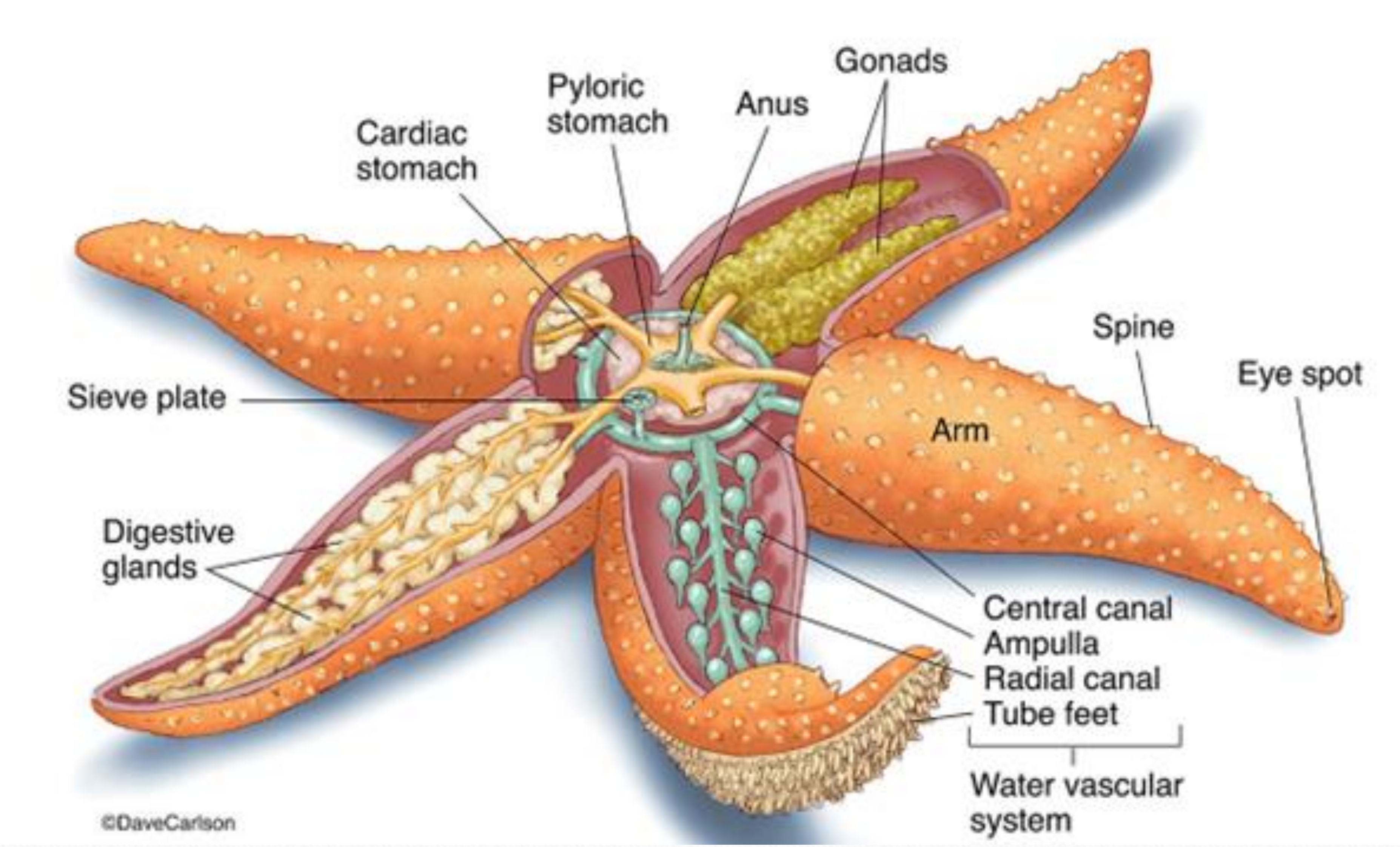
Sea star regenerating from a single arm

Asexual reproduction

Asexual reproduction in echinoderms usually involves the division of the body into two or more parts (fragmentation) and the regeneration of missing body parts. Fragmentation is a common method of reproduction used by some species of asteroids, ophiuroids, and holothurians, and in some of these species sexual reproduction is not known to occur. Successful fragmentation and regeneration require a body wall that can be torn and an ability to seal resultant wounds. In some asteroids fragmentation occurs when two groups of arms pull in opposite directions, thereby tearing the animal into two pieces. Successful regeneration requires that certain body parts be present in the lost pieces; for example, many asteroids and ophiuroids can regenerate a lost portion only if some part of the disk is present. In sea cucumbers, which divide transversely, considerable reorganization of tissues occurs in both regenerating parts. The ability to regenerate, or regrow, lost or destroyed parts is well developed in echinoderms, especially sea lilies, starfishes, and brittle stars, all of which can regenerate new arms if existing ones are broken off.

Sexual reproduction

In sexual reproduction, eggs (up to several million) from females and spermatozoa from males are shed into the water (spawning), where the eggs are fertilized. Most echinoderms spawn on an annual cycle, with the spawning period normally lasting one or two months during spring or summer; several species, however, are capable of spawning throughout the year. Spawn-inducing factors are complex and may include external influences such as temperature, light, or salinity of the water. In the case of one Japanese feather star (Crinoidea), spawning is correlated with phases of the Moon and takes place during early October when the Moon is in the first or last quarter. Many echinoderms aggregate before spawning, thus increasing the probability of fertilization of eggs. Some also display a characteristic behaviour during the spawning process; some asteroids and ophiuroids raise the centre of the body off the seafloor; holothurians may raise the front end of the body and wave it about. These movements are presumably intended to prevent eggs and sperm from becoming entrapped in the sediment.


Gonads
Pyloric stomach
Anus
Cardiac stomach
Spine
Eye spot
Sieve plate
Arm
Digestive glands
Central canal
Ampulla
Radial canal
Tube feet
Water vascular system
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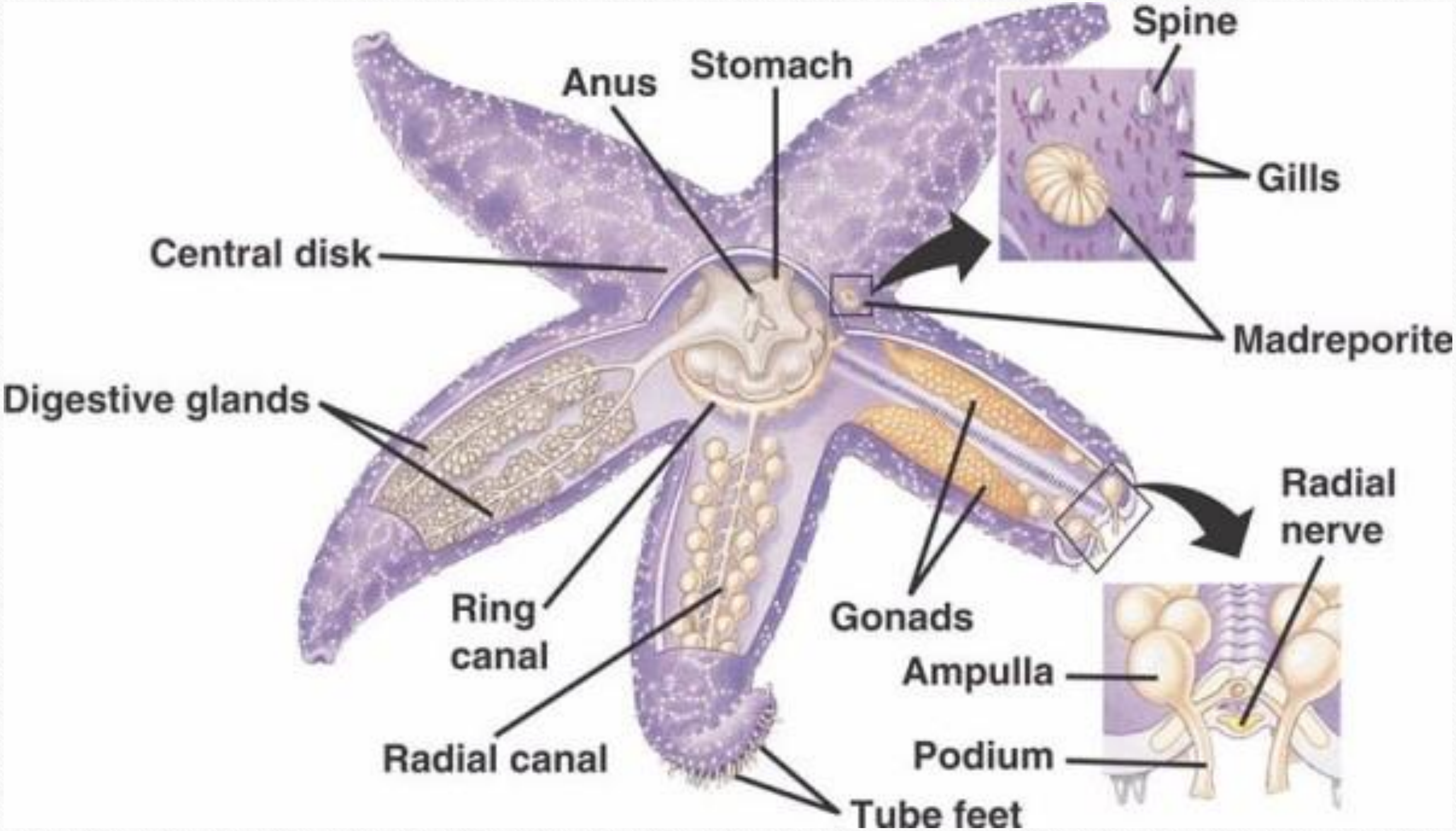

Spine
Anus
Stomach
Gills
Central disk
Madreporite
Digestive glands
Radial
nerve
Ring
canal
Gonads
Ampulla
Radial canal
Podium
Tube feet