VIVEKANANDA COLLEGE

THAKURPUKUR
KOLKATA–700063
NAAC ACCREDITED 'A' GRADE

Topic: ECHINODERMATA
Course Title: NON-CHORDATES II – COELOMATES
Paper: CC3 (ZOOA-CC2-3-TH)
Unit: 2
Semester: 2ND
Name of the Teacher: **Dr. Shaoli Majumder**
Name of the Department: **Zoology**

Echinodermata

Dr. Shaoli Majumder

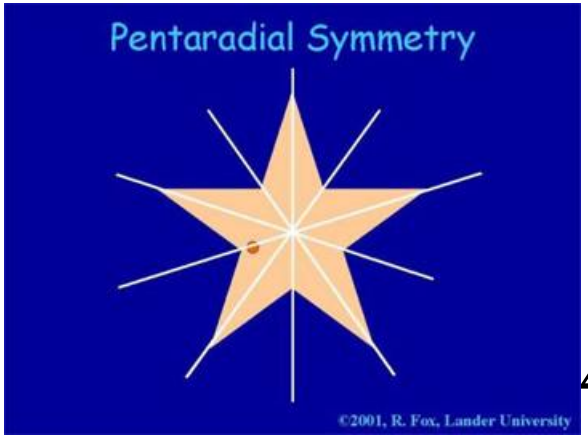
- **Echinodermata means “spiny skin”**
- **Beginning of Deuterostomia**
  - **Anus forms from or near blastopore**
  - **Mouth forms secondarily**
- **Echinoderms usually inhabit shallow coastal waters and ocean trenches (bottom of deep seas, bottom of coastal shores**
- **6500 living species & 20000 fossil members**

CHARACTERISTICS

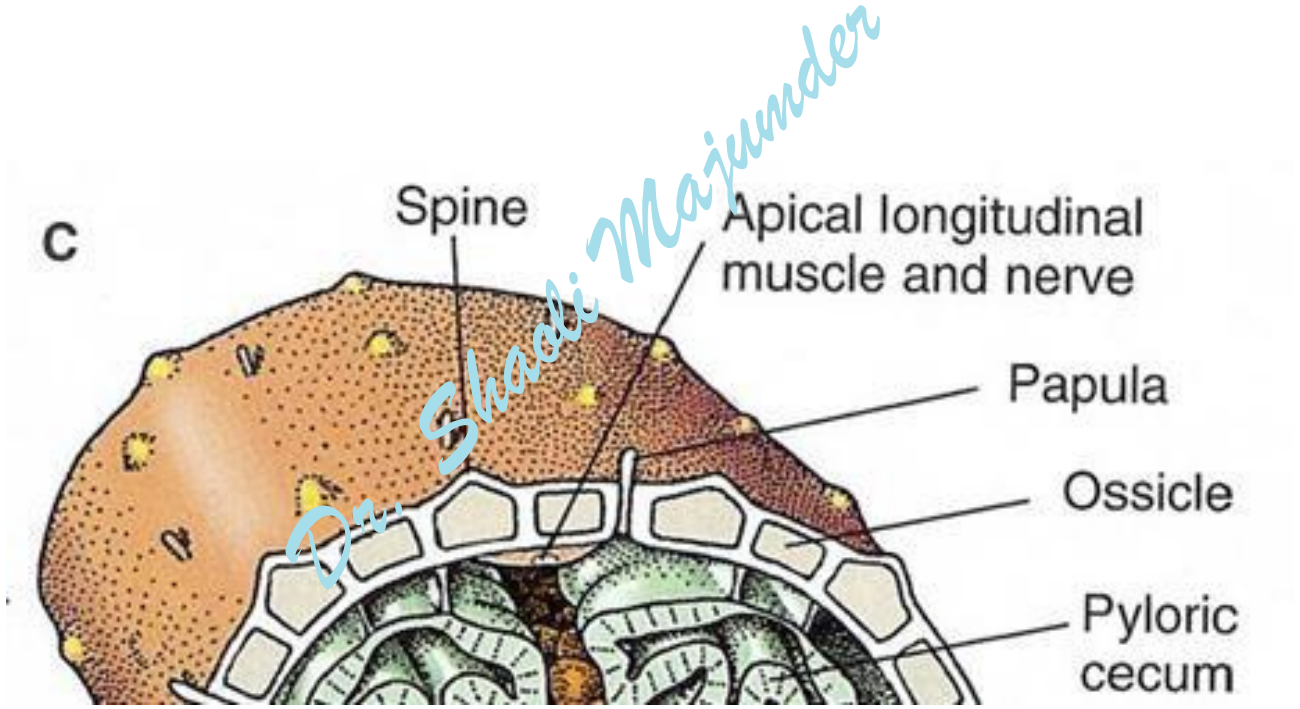
- Body unsegmented, Head absent
- Body divided into oral and aboral surface
- Parts arranged in fives, or multiples of fives, around an oral aboral axis- pentaradial symmetry .

  Radial symmetry is secondary; free-swimming bilaterally symmetrical larvae undergo metamorphosis to become bottom-dwelling radially symmetrical adults.

  Some modern echiderms tend towards restoration of adult bilaterism



- **First phylum with internal skeleton -**
  dermal calcareous ossicles [$CaCO_3$, $Ca_2(PO_3)_2$]; Some with spines or spicules



- **Possess a network of canals throughout the body - WATER VASCULAR SYSTEM.**

- **These canals are connected to extensions called tube feet (=podia), located on the oral surface, that aid in movement, feeding, respiration, & excretion.**

- **hydrostatic pressure permits movement**

- **The water vascular system is important for locomotion, feeding, and gas exchange.**

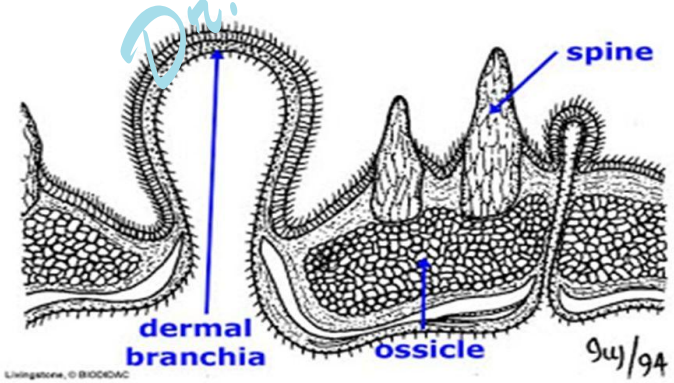
- **enables them to store water in their tube feet so they can survive while the tide is out**

Body wall

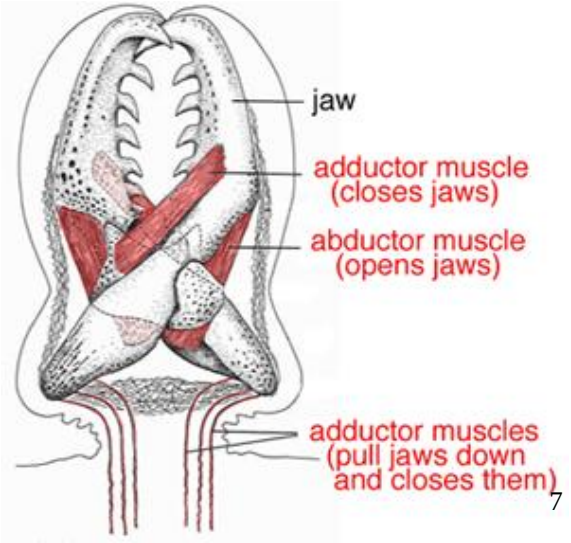
Body surface rough and populated by many fleshy, warty or spiny projections

- **Papulae [**special outpocketings of the body wall (epidermis and peritoneum) for gas exchange in asteroids]
- **Pedicellaria (**tiny forceps that protect and clean the body surface)
- **Tube feet**

Dermal Branchiae or Papulae



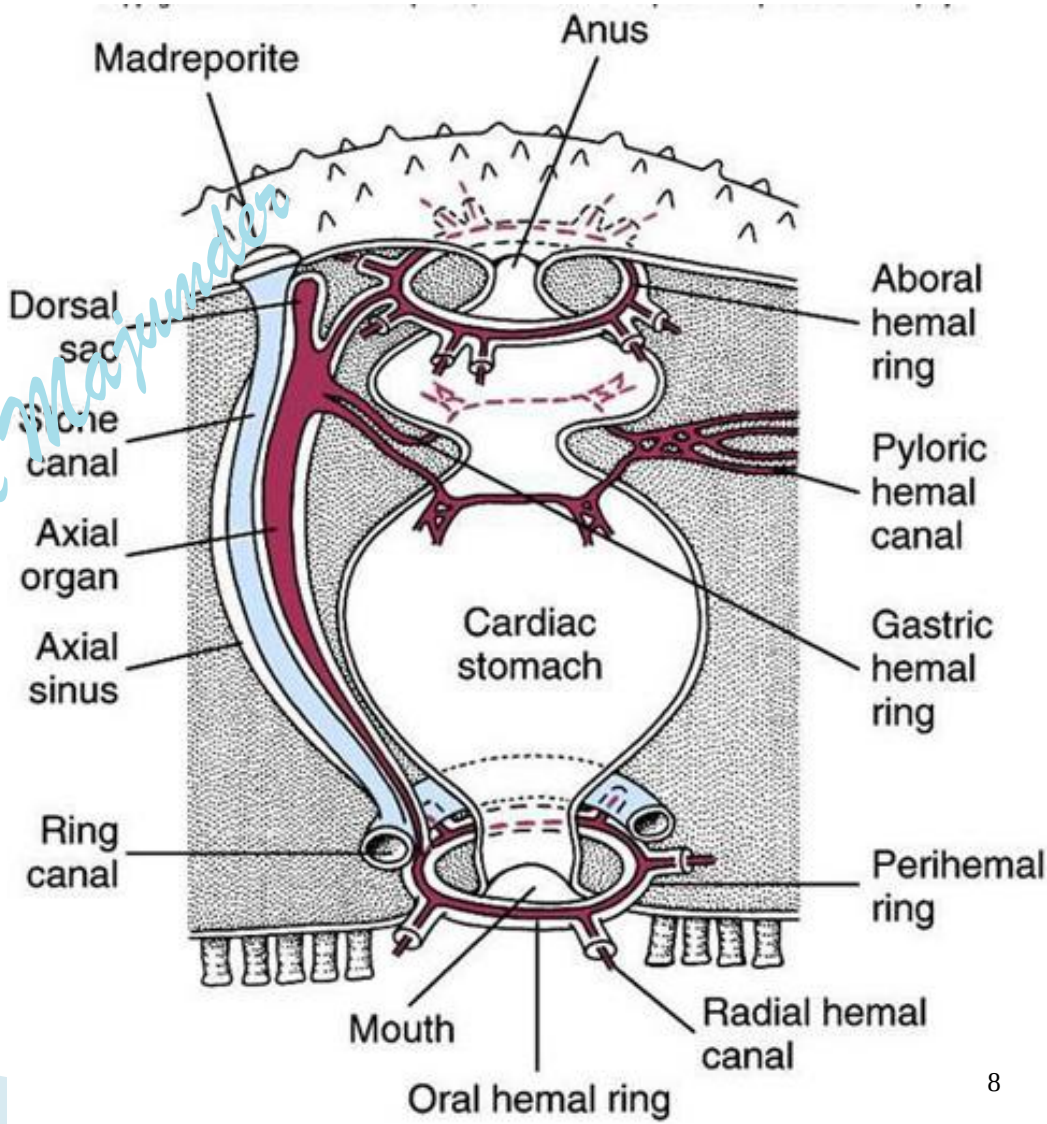
Pedicellaria



Body cavity

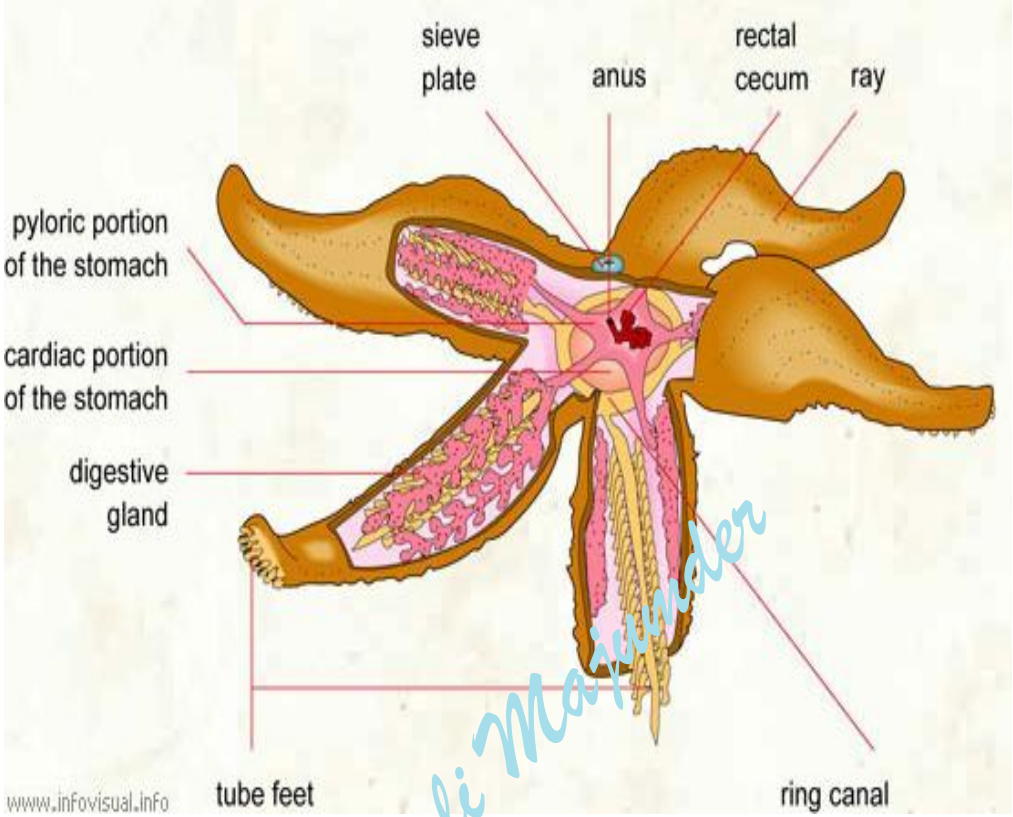
Coelom comprises of 4 systems of internal tubes, sinuses and cavities

- **Perivisceral**
- **Ambulacral**
- **Hemal**
- **Perihemal**



Digestive System

- Digestive system complete
- Mouth leads to a 2-part stomach: a large cardiac stomach and a smaller pyloric stomach
- The pyloric stomach connects with digestive glands (=pyloric cecae) that runs into each arm
- A short intestine extends from from the pyloric stomach to an anus on the aboral surface
- Associated with the Intestine are rectal cecae that pump the fecal wastes out of the anus

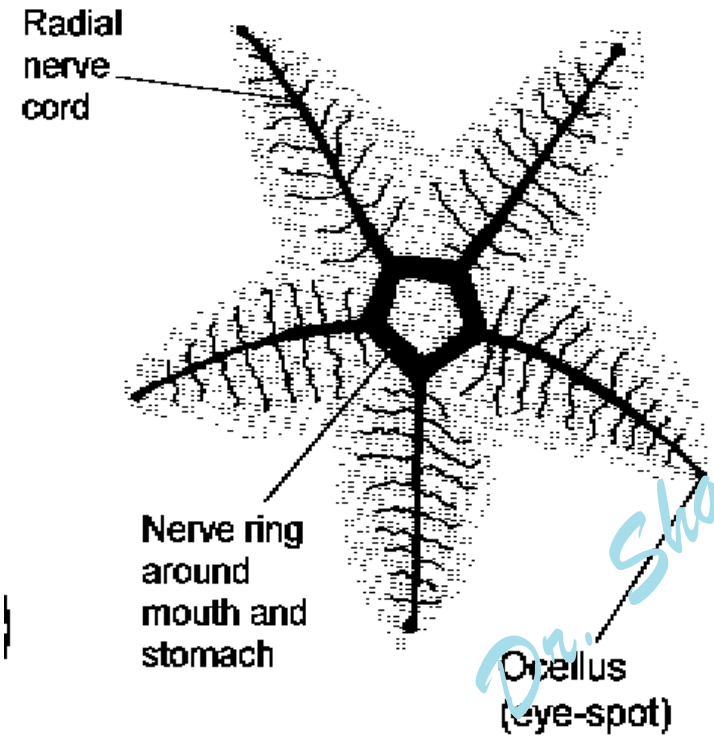


- **Feeding**
  - **some species feed on animal remains on the ocean floor**
  - **some filter plankton through their mouth pore**
  - **some scrape food off rocks**
  - **others are predaceous on mollusks, arthropods**

Reproduction:

- dioecious –two sexes are indistinguishable externally
- can reproduce sexually and asexually.
- gametes shed into the water; fertilization is external
- gamete release by one individual is accomplished by the release of spawning pheromones, which induce other sea stars in the area to spawn, increasing the likelihood of fertilization

Nervous System:



- Have a nervous system but no head or brain
- nerve ring encircles the mouth
- radial nerves extend into each arm (these coordinate the functions of the tube feet)
- other nervous elements are in the form of a nerve net associated with the body wall

Locomotion

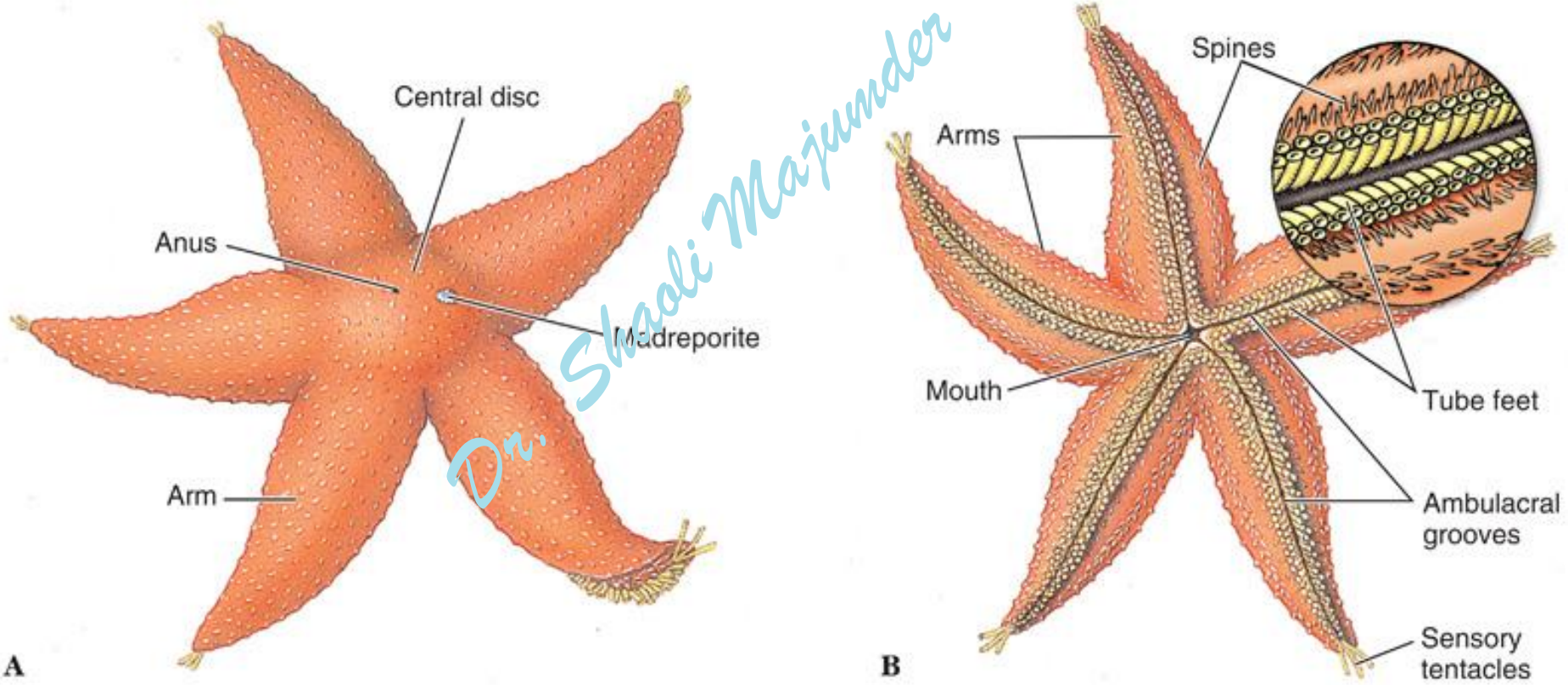
Locomotion by tube feet, and/or arms

Other systems

Do not have circulatory, respiratory or excretory systems.

Respiration by dermal branches, tube feet, or respiratory tree

External Anatomy



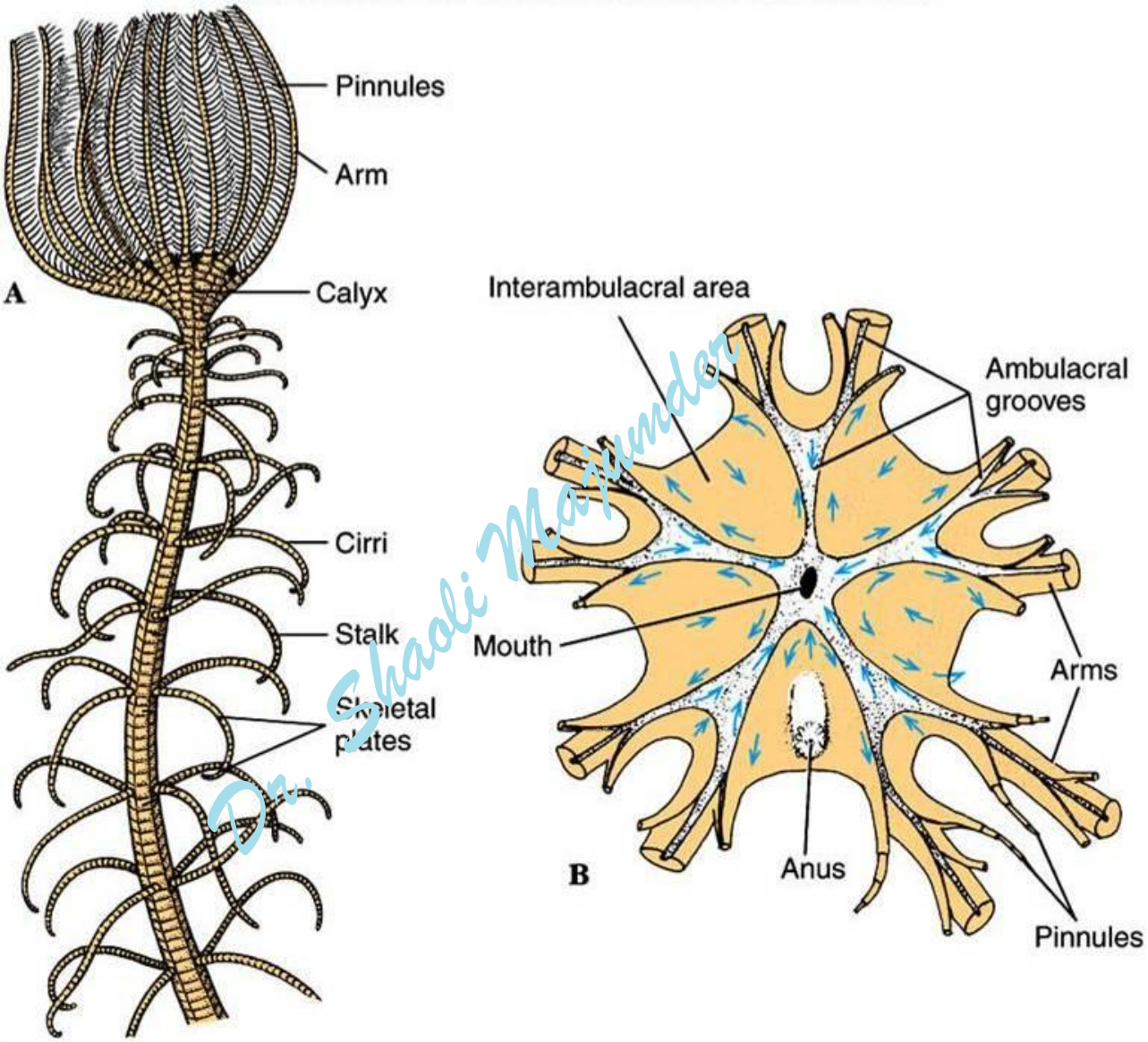
Classification

Taxonomists have divided 6,000 species of echinoderms into 3 subphylums which are further grouped into five classes:

- **CRINOZOA - Crinoidea**
- **ASTEROZOA - Asteroidea**
  Ophiuroidea
- **ECHINOZOA - Echinoidea**
  Holothuroidea

Crinoidea ("lilylike")

- most primitive of living echinoderms
- Crinoidea are sessile -have long stalks that attach to rocks or to the ocean floor (feather stars eventually detach themselves)
- from a small cup or calyx, protrudes five flexable arms (rays) with branches (pinnules) very much like pine needles
- Sticky tube feet that are at the end of each arm; catch food and serve as a respiratory surface.
- Madriporite absent.
- Ex: Sea lilies, Feather stars

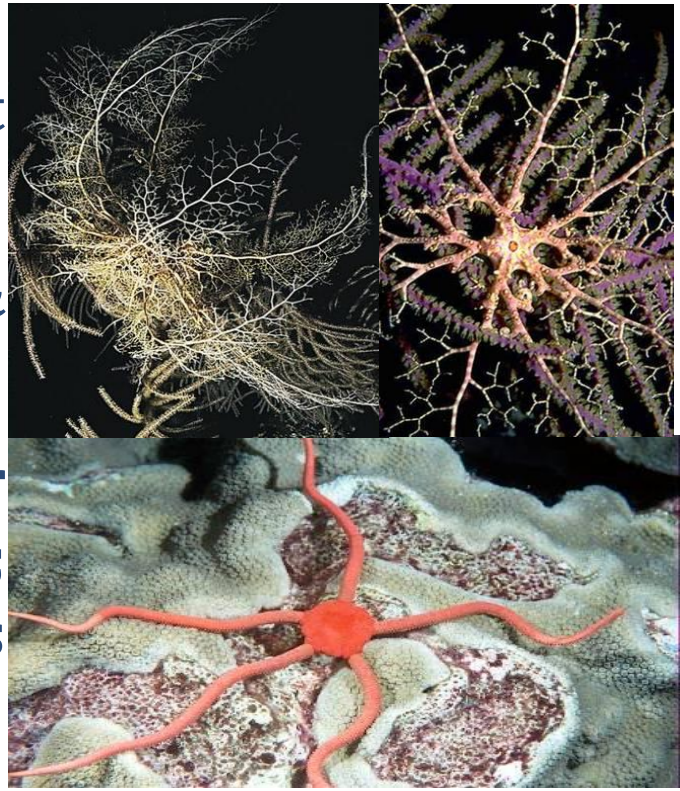


Asteroidea ("star-like")

- found all over coastal shores around the world
- Typically have 5 arms which are not sharply set off from the cetral dosc.
- Mouth is located in the center of oral surface which is directed downward
- Anus & madreporite are present on the aboral surface
- Regeneration
- carnivorous, they eat mostly shellfish, snails and barnacles.
- Ex. Starfish

Class Ophiuroidea ("snakelike")

- largest echinoderm class; primarily reside under stones & in crevices and holes of coral reefs
- Reduced central disc; Arm sharply set off from the central disc
- have thin brittle arms that break off & regenerate themselves quickly
- feed by raking food off the ocean floor with their arms and bottom of tube feet; also trap food with mucous strands between their spines.
- have an anus, but it is almost nonfunctional; undigested food is expelled back through the mouth
- Reduced tube feet

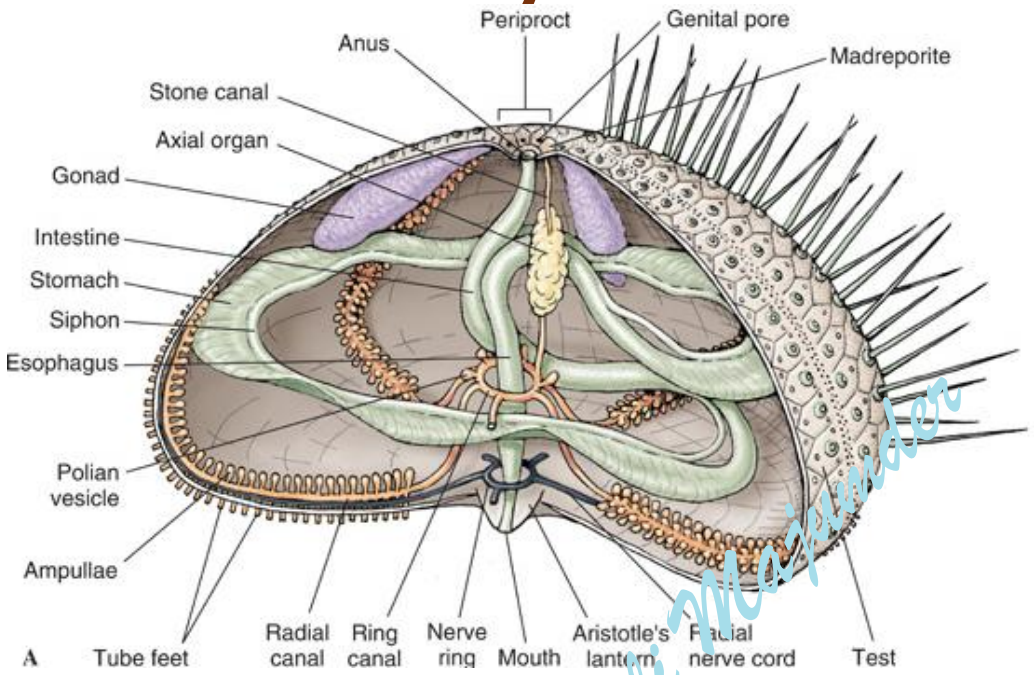


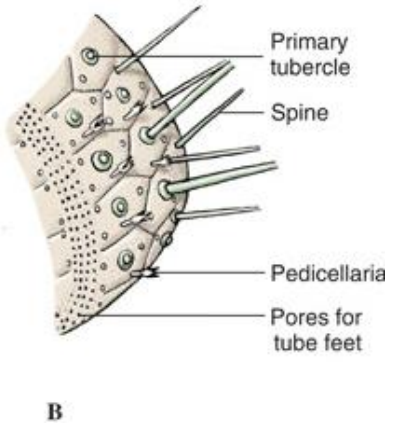
Ex: basket stars & brittle stars

Echinoidea ("hedgehoglike")

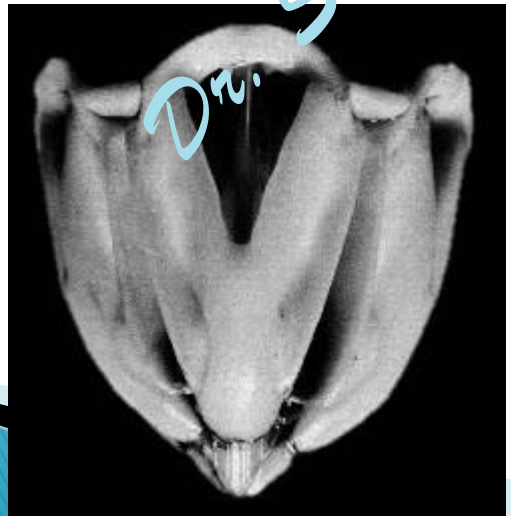
- rounded body shape
- test: rigid endoskeleton that the internal organs are compacted in
- long spines on exterior
- Aristotle's lantern: complex jaw-like structure that is used to grind their food
- In sand dollars, aboral surface exhibits flower petal-shaped grooves (petaloids) that correspond to the arms of sea stars and brittle stars
- locomotion: tube feet
- protection: barbs on their long spines that are sometimes venomous
- Ex: sand dollars & sea urchins

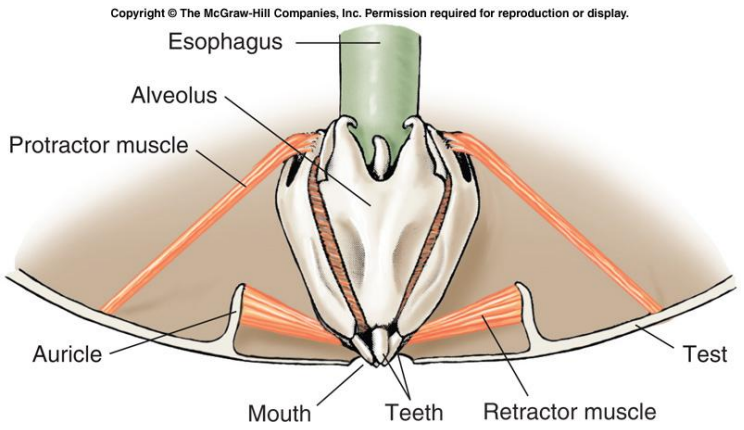
Anatomy of a Sea Urchin



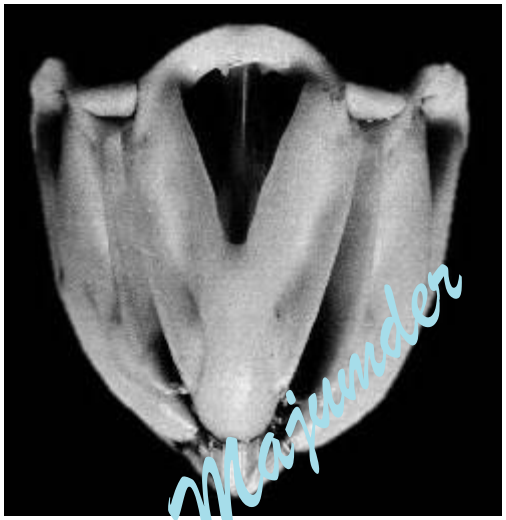


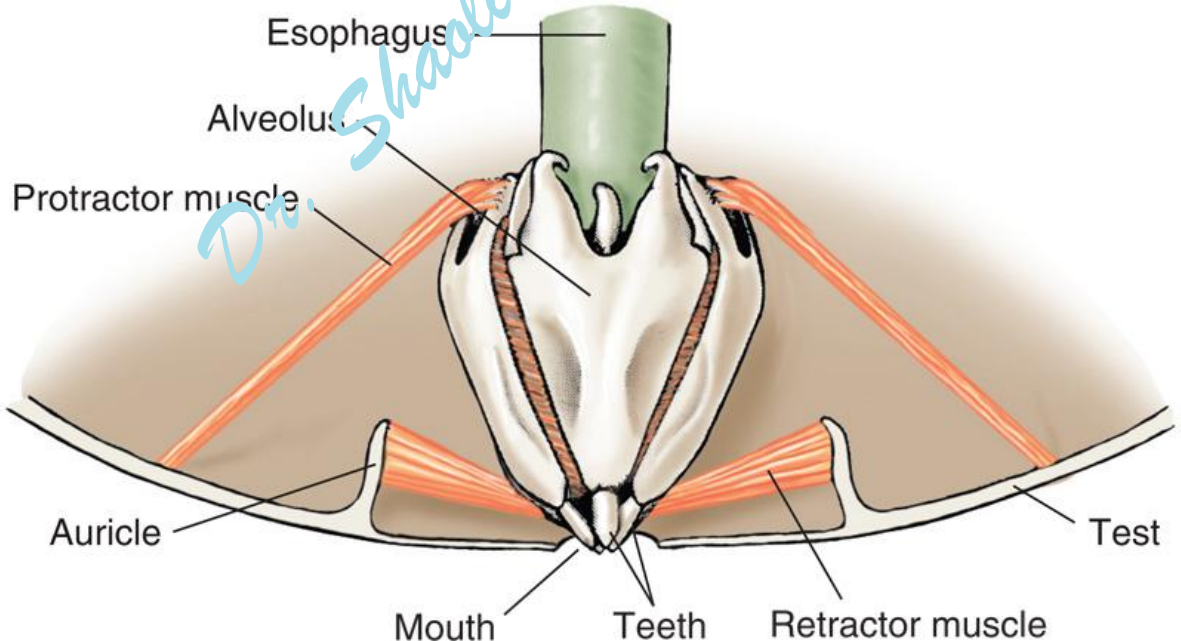
Aristotle's Lantern





Aristotle's Lantern

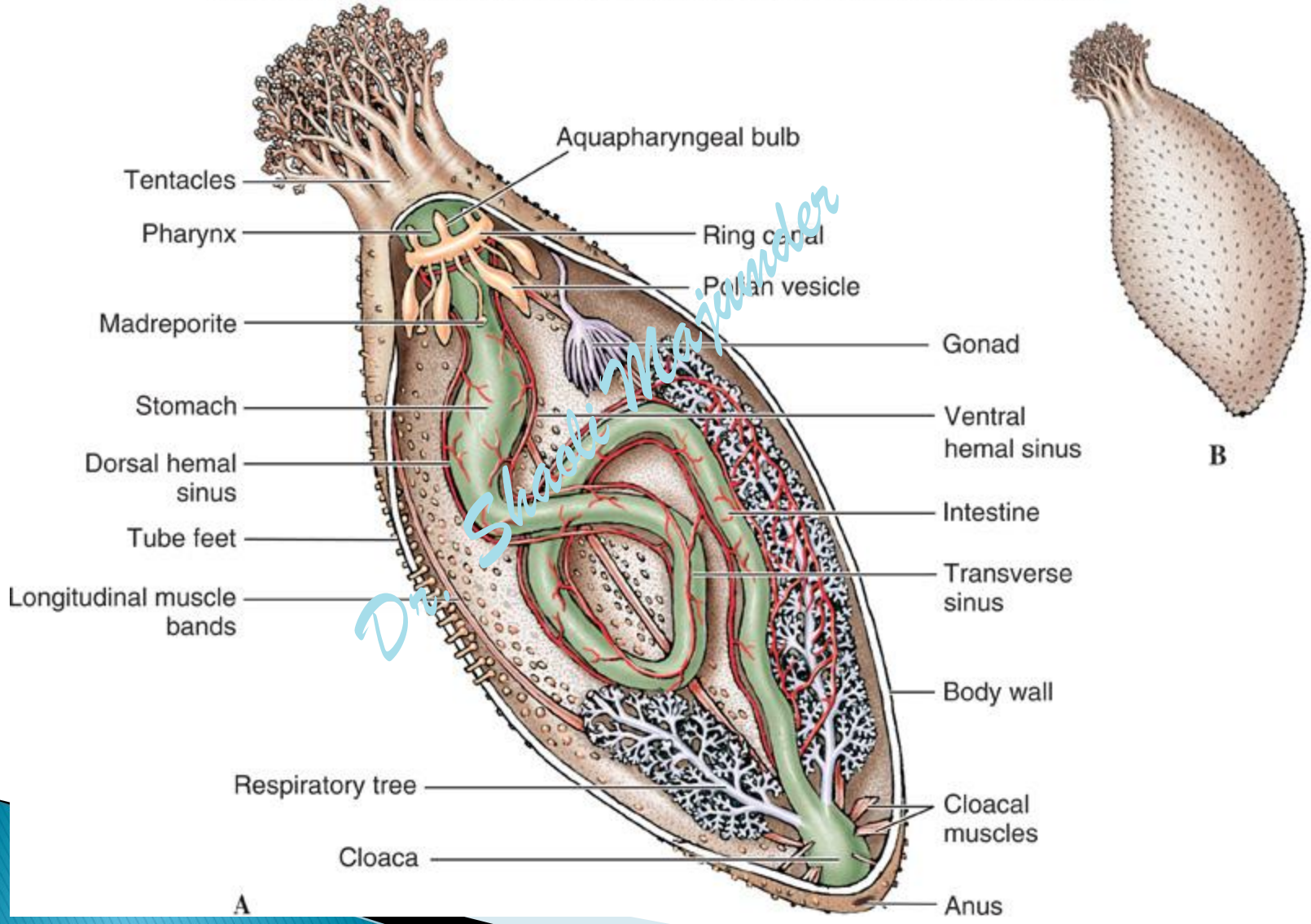




Holothuroidea

- found on the sea bottom, often partially submerged in mud or sand, or among intertidal rocks
- Body elongated along oral/ aboral axis.
- oral end has a ring of retractile tentacles that represent highly modified tube feet
- Feeding: filter feeders and have a sticky slime that covers their tentacles and lets them grab particles from the ocean floor
- Ex: sea cucumbers

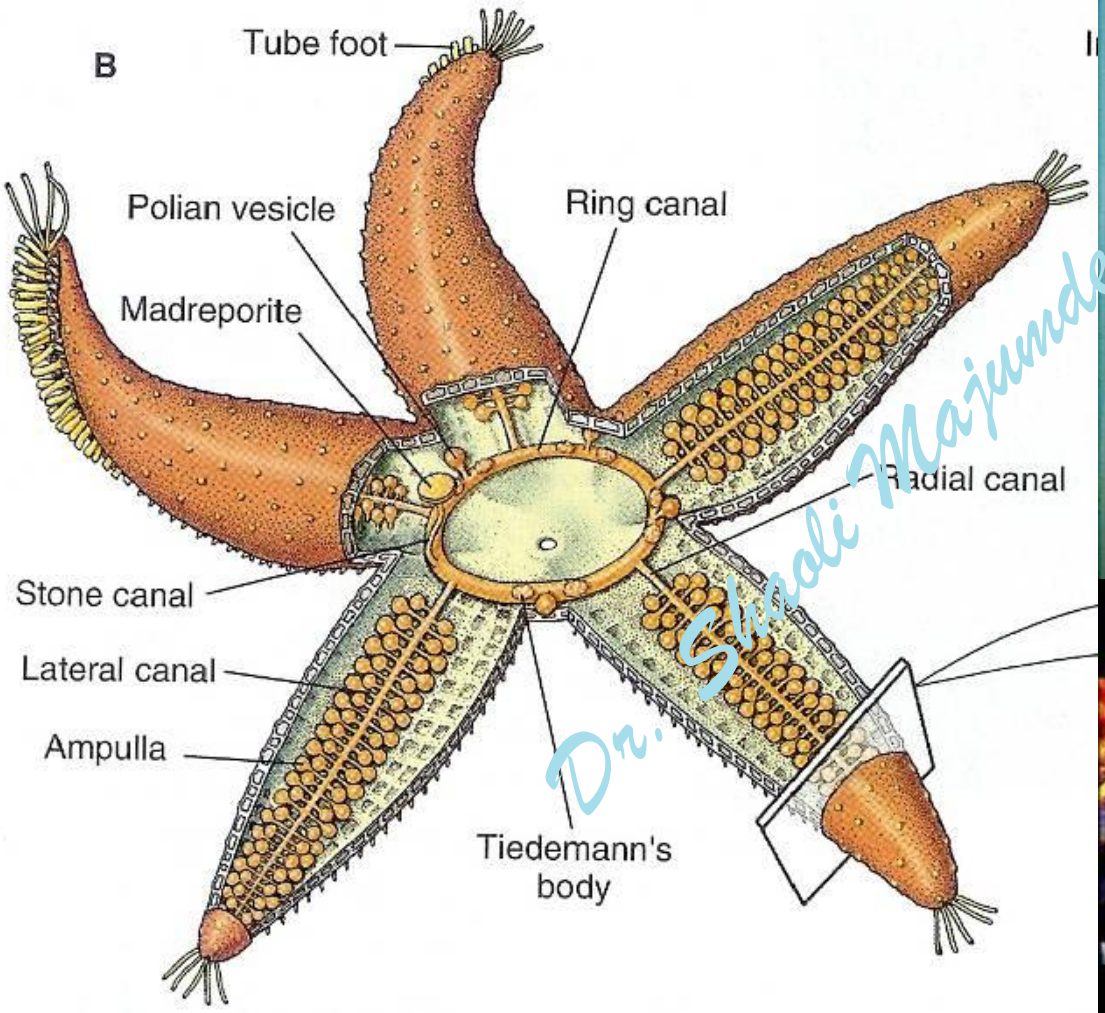
Sea Cucumber Anatomy



Holothuroidea Defense Reaction

- throwing out their intestines to entangle, frighten, or confuse their predator (intestines are regenerated)
- Eversion of the respiratory tree and lower intestine
- Some species produce toxins

Water-Vascular System (*Asterias* sp.)



- **MADREPORITE** - the opening of the water vascular system; a rounded calcareous plate (=sieve plate) occurring on the aboral surface of the central disc in inter-radial position. Its surface bears a number of radiating, narrow, straight or wavy grooves or furrows. Each furrow contains many minute pores at its bottom. Each pore leads into a very short, fine, tubular pore-canal which passes inward. There may be about 200 pores and pore-canal. The pore-canals unite to form the collecting canals. Which open into an ampulla beneath the madreporite
- **STONE CANAL** - The ampulla opens into a "S" shaped stone canal. The stone canal extends downwards (orally) and opens into a ring canal, around the mouth. The walls of stone canal are supported by a series of calcareous rings. The lumen of stone canal is lined by very tall flagellated cells.

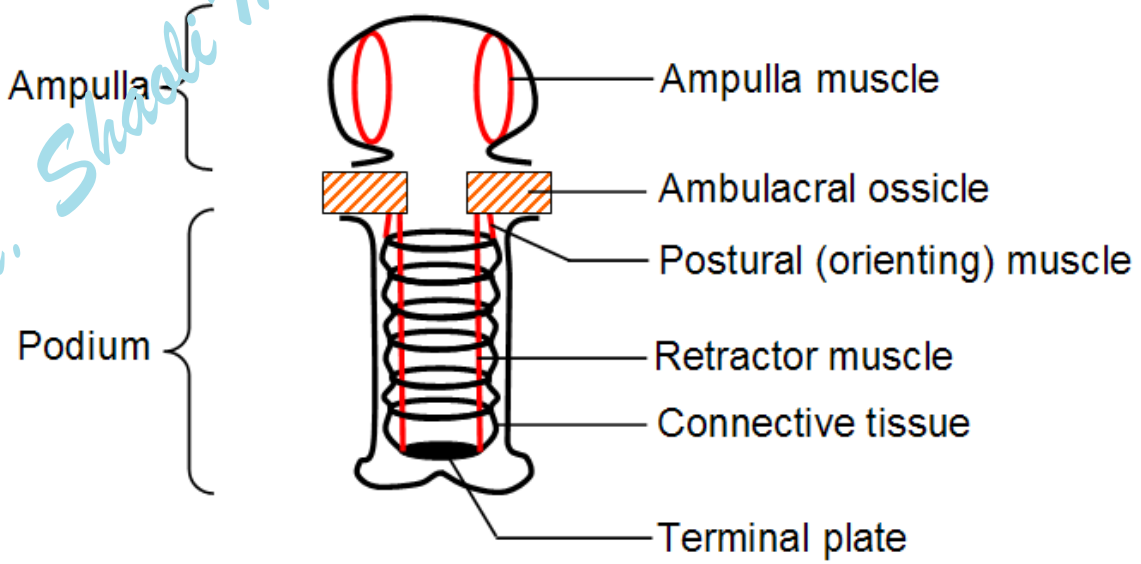
➢ **RING CANAL** - is located to the inner side of the peristomial ring of ossicles and directly above (aboral) to the hyponeural ring sinus. It is wide and pentagonal.

➢ **TIEDMANN'S BODIES** - ring canal gives out inter radially nine small, yellowish, irregular or rounded glandular bodies called racemose or Tiedmann's bodies from its inner margins. The Tiedmann's body rest upon the peristomial ring of ossicles. The actual function of tiedmann's bodies is still unknown, however they are supposed to be lymphatic glands to manufacture the amoebocytes of the water vascular system.

➢ **POLLIAN VESICLES** - ring canal gives off on its outer side in the inter radial position one, two or four little, pear shaped, thin walled contractile bladder or reservoirs with long necks called pollian vesicles. They are supposed to regulate pressure inside ambulacral system and to manufacture amoeboid cells of ambulacral system.

- **RADIAL CANAL** - From its outer surface the ring canal gives off a radial water canal into each arm that runs throughout the length of the arm and terminates as the lumen of terminal tentacle. In the arm radial water canal runs immediately to the oral side of the ambulacral muscles.
- **LATERAL CANAL** - In each arm, the radial canal gives out two series of short, narrow, transverse branches called lateral or podial canals. Each lateral canal is attached to the base of a tube foot and its provided with a valve to prevent backward flow of fluid into the radial canal.

➢ **TUBE FEET** – it is a hollow, elastic, thin walled, closed cylinder or sac-like structure having an upper sac like ampulla, a middle tubular podium & a lower disc like sucker. The ampulla lies within the arm, projecting into the coelom above the ambulacral pore which is a gap between the adjacent ambulacral ossicles for the passage of the podium. The tube feet are chief locomotory organ of ***Asterias***.



Basic structure of a tube-foot

Function of Water Vascular System **:-**

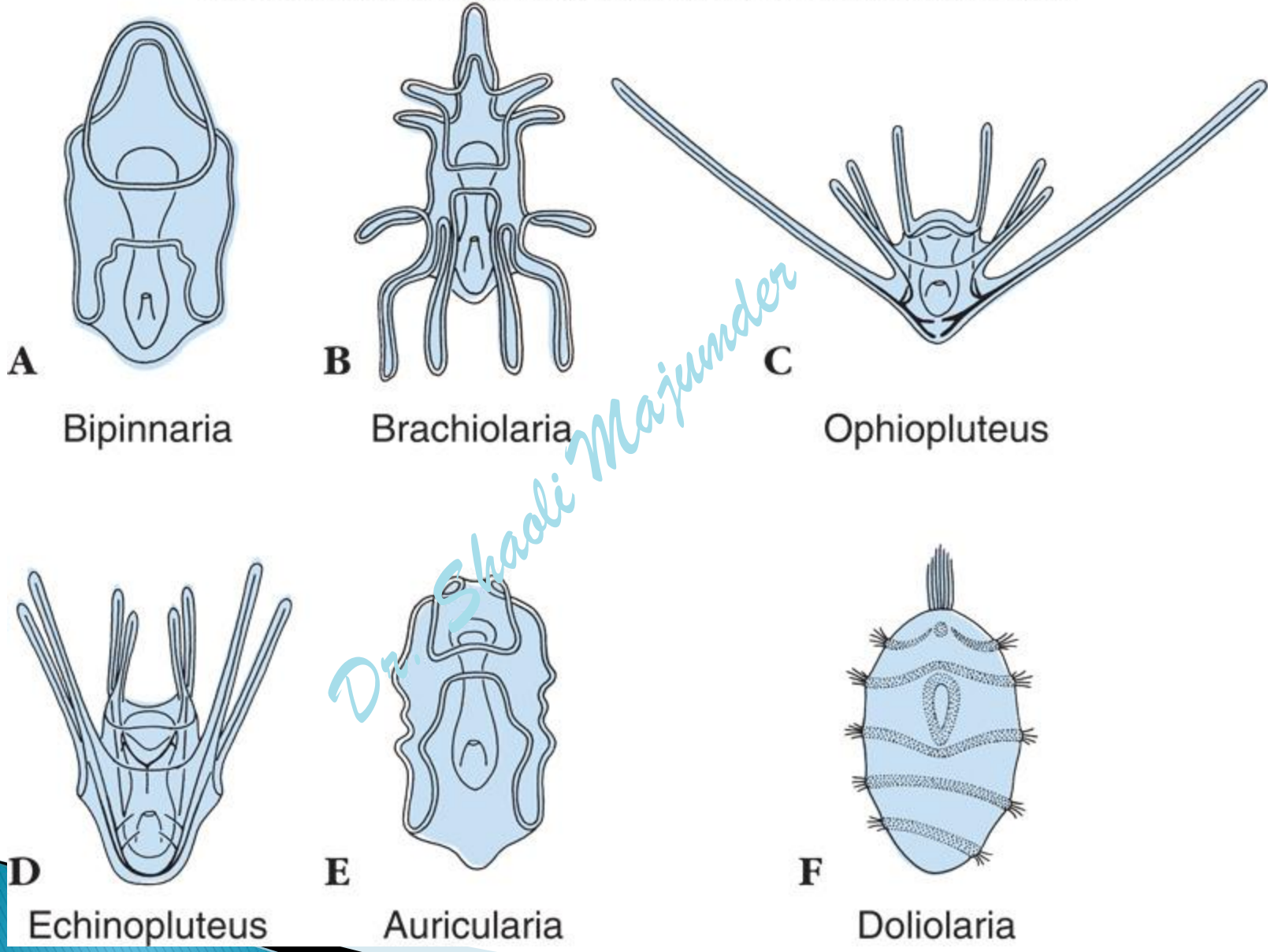
The water vascular system has three main functions. They are as follows-

(1) *Locomotion*

(2) *Food Capture*

3) *Attachment*

Larval Echinoderms



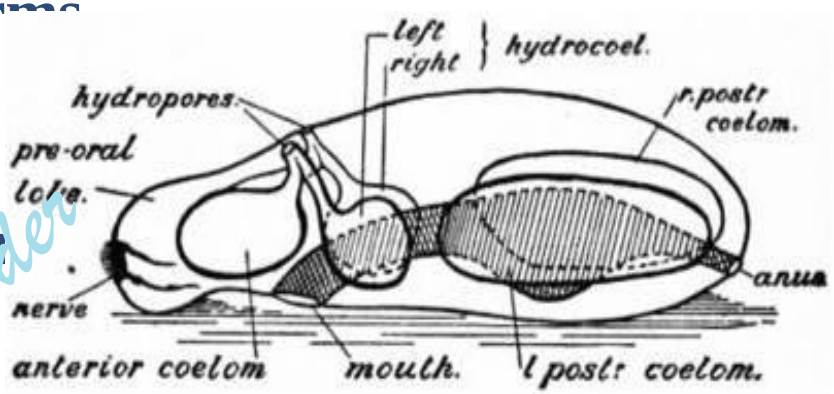
(1) *Dipleurula Larva* :-

This larva develops from gastrula. It has the following features-

(a) fundamental larva of all echinoderms

(b) microscopic, free swimming

(c) bilaterally symmetrical and oval in shape.



(a) gut formed of the mouth, the oesophagus, the intestine, the stomach & the anus.

(b) two ciliary bands, viz a pre-oral band around the mouth and an adoral band inside; pre-oral band is used for locomotion & aboral band is used for the collection of food.

(c) dipleurula develops into Bipinnaria larva.

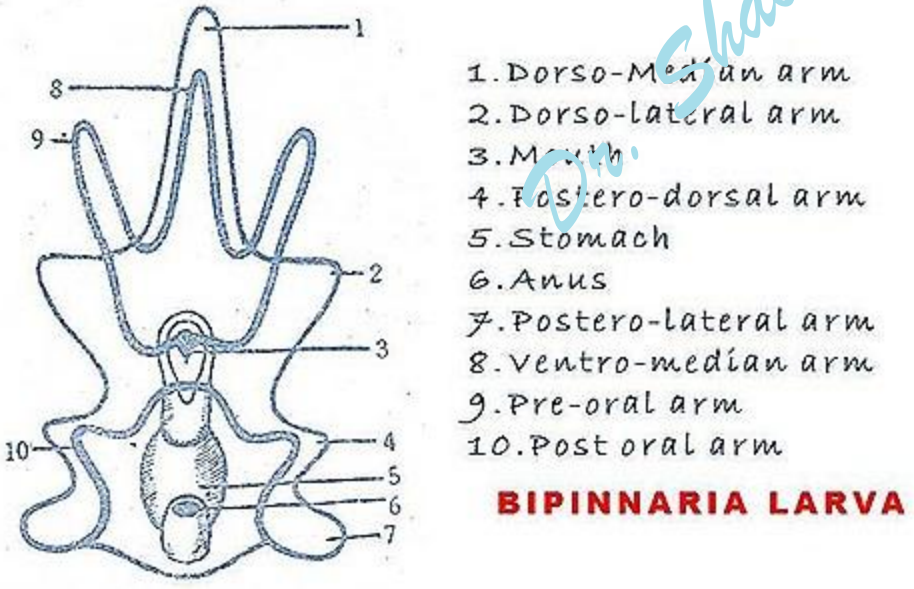
(2) *Bipinnaria Larva* :-

It is the second larva of Starfish. It develops from dipleurula larva. It has the following salient features-

(a) minute, microscopic and swims freely on the water surface.

(b) bilaterally symmetrical and has alimentary canal with a mouth at anterior end and an anus at posterior end.

(c) body has a number of outgrowths called arms. The arms are covered by ciliated bands and are used for locomotion. It has two unpaired arms and five pairs of paired arms. They

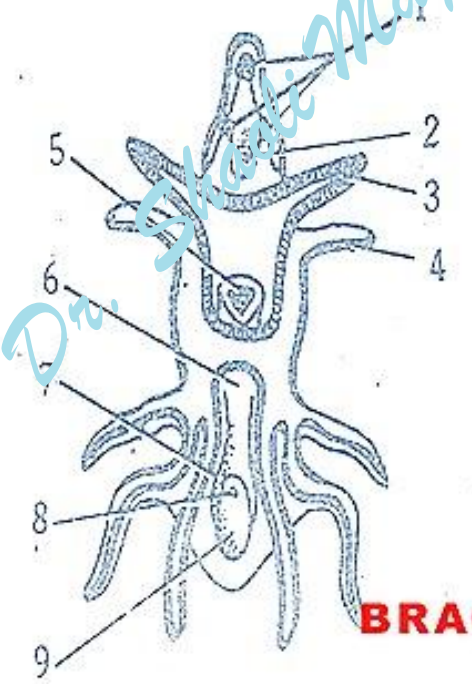


(i) Median dorsal arms
(ii) Median ventral arms
(iii) Pre-oral arms
(iv) Post-oral arms
(v) Antero dorsal arms
(vi) Postero dorsal arms
(vii) Postero lateral arms

(3) *Brachiolaria Larva* :-

a) It is the third larva of after a short free swimming life.

b) The pre-oral region of this larva has three processes called Brachiolar arms. These three arms are tipped with suckers. It swims and feed like a Bipinnaria.



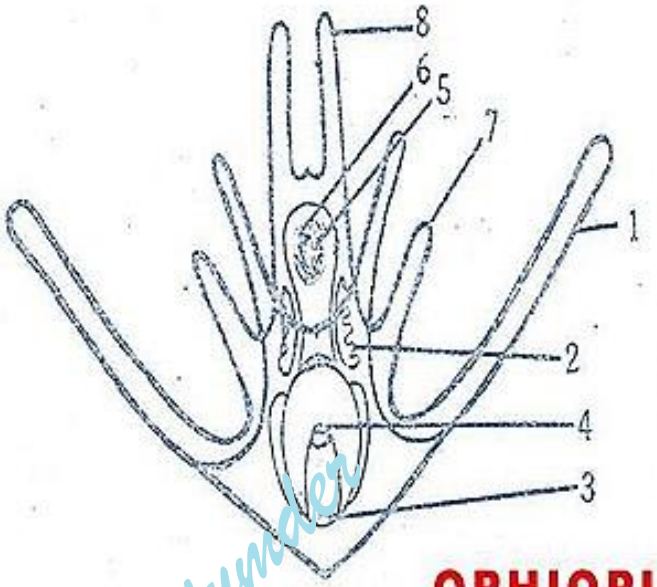
BRACHIOLARIA LARVA

(4) *Ophiopluteus* :-

(a) larva of Ophiuroidea.

(b) pre- oral lobe is small.

(c) ciliated band is single.



OPHIOPLUTEUS LARVA

(d) arms are supported by Calcareous rods.

(e) The larva has a pair of pre-oral arms, a pair of post oral arms, a pair of postero dorsal arms and a pair of postero lateral arms.

(f) The postero lateral arms are always longer and directed forward, so that the larva appears like a "V" shaped.

(5) *Echinopluteus* :-

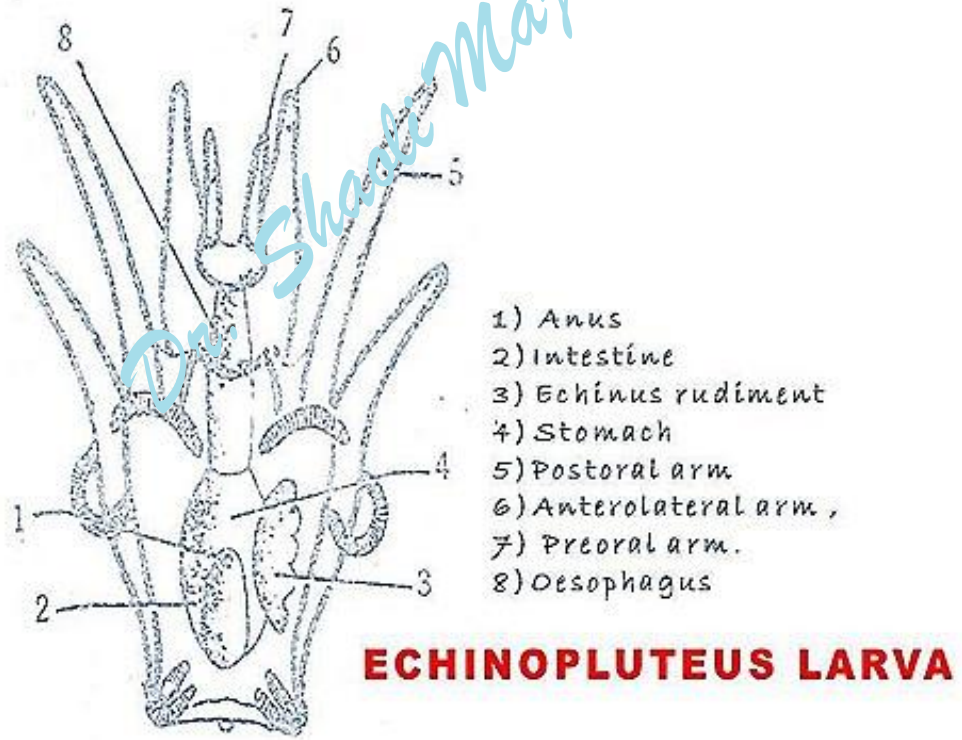
(a) larva of Echinoidea.

(b) has small pre-oral lobe & a single ciliary band

(c) arms are supported by calcareous rods.

(d) larva is provided with a pair of pre-oral arms, a pair of post-oral arms, a pair of antero lateral arms, a pair of antero dorsal arms & a median posterior arm.

(e) postero lateral arms are very short & directed backwards.



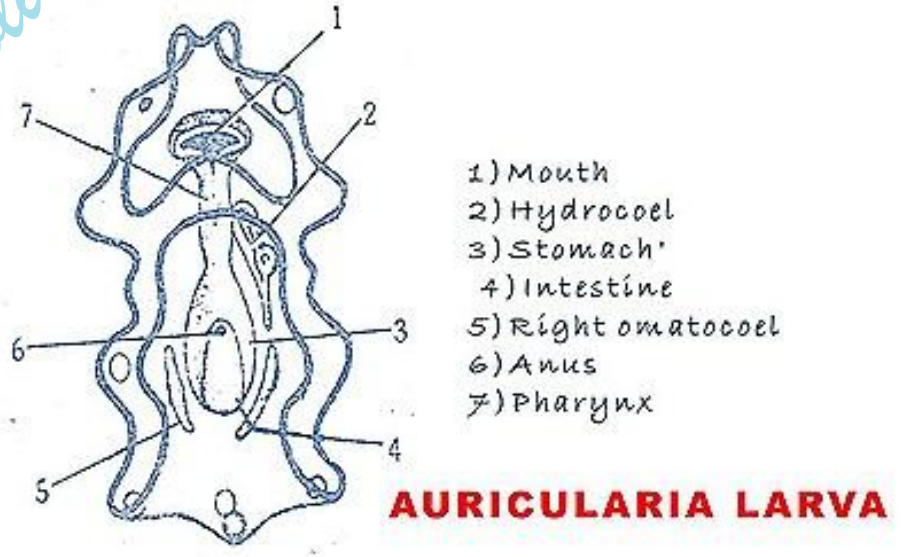
ECHINOPLUTEUS LARVA

(6) *Auricularia* :-

(a) larval form of Holothuroidea.

(b) a well developed pre-oral lobe.

(c) Arms are not supported by calcareous rods but the calcareous structures are in the form of wheels, spheres, star shaped bodies etc.



(7) *Doliolaria of holothuroidea (Pupa)*:-

(a) In holothuroidea (sea-cucumber) the auricularia larva develops into doliolaria larva (also called a pupa).

(b) It is free swimming larva.

(c) It is barrel shaped.

(d) The calcareous skeleton is in the form spheres.

(e) The ciliated bands are broken into pieces.

(f) After metamorphosis, the larva sinks into the bottom to become the adult.

(8) *Doliolaria of Crinoidea* :-

(a) larva of Antedone.

(b) free-swimming, bilaterally symmetrical, barrel shaped.

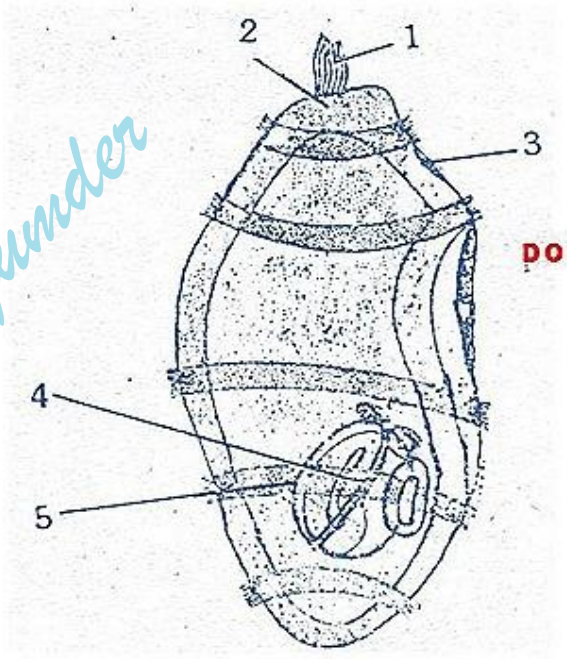
(c) has four or five ciliary bands.

(d) At anterior end the ectoderm thickens to form an apical plate.

(e) apical plate bears a tuft of cilia called apical sensor tuft.

(f) adhesive pit present between first and second ciliary bands. It is used for attachment.

(g) A mouth is located between the second and third ciliary bands.



DOLIOLARIA LARVA

1) Apical sensory tuft
2) Apical plate
3) Adhesive pit
4) Primary mesenteron
5) Enteric sac

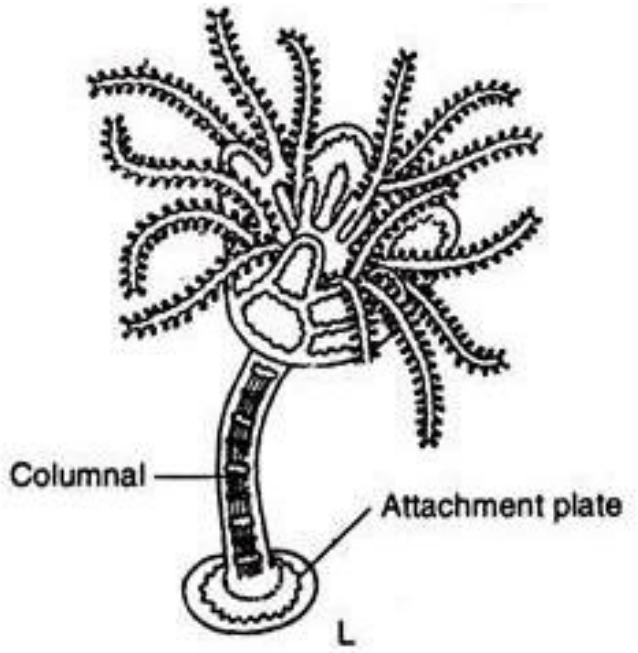
(9) *Pentacrinoid larva* :-

(a) second larva of antedone, develops from Doliolaria larva.

(b) It looks like a sea-lily.

(c) It has a stalk which develops from the pre-oral lobe of Doliolaria.

(d) One end of the stalk is attached to the substratum with the help of a disc and the free ends bears a crown.



(e) The crown consists of a central mouth surrounded by a circle of tentacles.

(f) During metamorphosis the crown develops cirri & breaks off from the stalk as a free living antedone.

Relationship with Chordata:

The most convincing affinities are noted between the echinoderms and the chordates. Hence many workers regarded the echinoderms to be the nearest group to the chordates. However, modern workers do not support the contention and they hold that the echinoderms and the chordates diverged separately from a common basic ancestor.

The affinities are discussed below:

1. Mesodermal skeletal substance is present in both.

2. Presence of infra-epidermal nervous system in hemichordata.

3. The perforations on the calyx of carpoid echinoderms are compared with pha-ryngeal gill-slits of Amphioxus.

4. Needham (1932) has tried to show a relationship between these two groups by analysing biochemical evidences. Invertebrates have the phosphogen in the form of arginine phosphate whereas chordates usually have creatine phos-phate. But the echinoids among echinodermata and hemichor-dates among Chordata have both arginine phosphate and creatine phosphate.

5. Wilhelmi (1942) has shown similari-ties between the two groups by sero-logical tests as well.

6. Cleavage is radial, holoblastic.

7. Blastopore changes into anus.

8. Enterocoelous mode of coelom forma-tion.

9. The similarities between adult echinoderms and chordates are very few, but the affinities between the larval forms are highly notable.

Metschnikoff (1869) tried to show the following affinities between the tornaria larva of *Balanoglossus* and the bipinnaria and auricularia larvae of the echinoderms:

1. free-swimming and bilateral symmetrical larvae in both,
2. transparent body with similar ciliated bands,
3. enterocoelous coelom with similar disposition,
4. similar location of mouth and anus,
5. the madreporic vesicles in bipinnaria are thought to be homologous with heart vesicle of *Balanoglossus*.

THANK YOU