

Structure of Asterias

BSc. Part I Zoology (Subsidiary)

History of Asterias:

Asterias is commonly known by the name of starfish. The name starfish is somewhat misleading suggesting an organism to be like a star and fish but as Asterias lacks in both the characteristics, therefore, recently it is renamed as sea star. There occur about 150 species of Asterias all of which have different geographical distribution.

Asterias rubens occurs on the English and North European coasts, *A. vulgaris* is found on the North Atlantic coast of North America, *A. forbesi* occurs on the eastern sea shore from the Maine to the Gulf of Mexico, *A. amurensis* is found in the Behring sea, Japan and Korea, and *A. tenera* occurs on the sea shore from Nova Scotia to New Jersey.

Some other common sea stars are Pentaceros, Astropecten, Asterina, Heliaster, Solaster, Luidia, etc. The following account will give a general idea about the anatomical organisation of the genus Asterias.

Habit and Habitat of Asterias:

Asterias is exclusively marine, bottom dwelling or benthonic animal, inhabiting various types of bottom, mainly in the littoral zone where they crawl about or may remain quiescent at time's, either in the open or more or less concealed. *Asterias forbesi* is found equally abundant on hard, rocky, sandy or soft bottom, while other species have been found to prefer rocky sea bottoms.

The most species of Asterias are generally solitary but under certain ecological conditions, such as to avoid direct sunlight or excessive drying, many individuals may gather at some place for the purpose of protection. Most of them are nocturnal, remain quiet in day time and become active during night. They move by crawling on the bottom, mostly at a rather slow rate.

All sea stars are carnivorous and feed voraciously on almost any available slow moving or sessile animals, chiefly on polychaetes, crustaceans, molluscs and other echinoderms and even corpses.

Many species of Asterias exhibit various types of biological relationships such as parasitism and commensalism, etc., with the members of different zoological groups. Sea stars, in general, exhibit remarkable power of autotomy and regeneration.

External Features of Asterias:

(i) Shape, Size and Colour:

Asterias has a radially symmetrical and pentamerous body. The body consists of a central, pentagonal central disc from which radiate out five elongated, tapering, symmetrical spaced projections, the rays or arms. In some genera, the number of arms may be more than five, for example, there are 7-14 arms in *Solaster* and more than 40 arms in *Heliaster*.

The size varies from 10-20 cm in diameter though some forms may be much smaller or longer. The colour is variable having shades of yellow, orange, brown and purple. The body has two surfaces, the upper convex and much darker side is called the aboral or abactinal surface.

The lower surface is flat, less pigmented and is called the oral or actinal surface. The oral and aboral surfaces are not the ventral and dorsal surfaces but correspond to the left and right sides of the bilaterally symmetrical larva. The axes occupied by the arms are known as radii and the regions of the central disc between the arms are inter-radii. A well defined head is entirely absent.

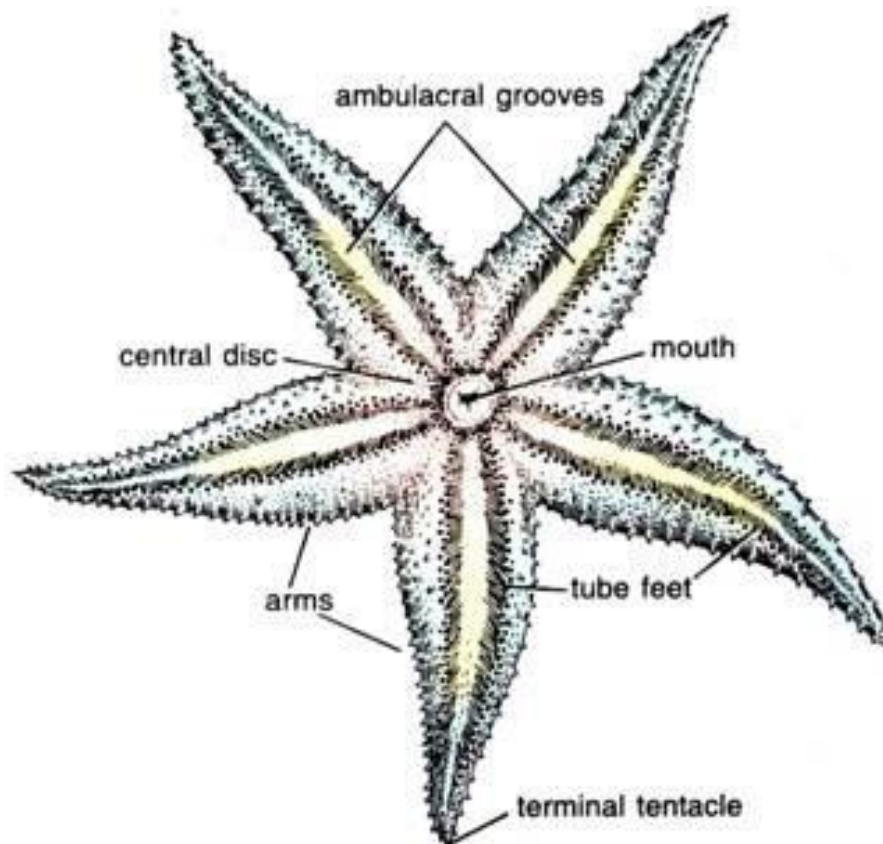


Fig. 85.1. *Asterias*. External features (Oral view).

(ii) Oral Surface:

The side of body, which in natural condition remains towards the substratum and contains the mouth or oral opening, is flat and of dark orange to purplish colour, is called oral or actinal surface.

The oral surface bears the following structures:

1. Mouth:

On the oral surface, in the centre of the pentagonal central disc is an aperture, the actinosome or mouth. It is a pentagonal aperture with five angles, each directed towards an arm. The mouth is surrounded by a soft and delicate membrane, the peristomial membrane or peristome and is guarded by five groups of oral spines or mouth papillae.

2. Ambulacral Grooves:

From each angle of the mouth radiates a narrow groove called the ambulacral groove which runs all along the middle of oral surface of each arm.

3. Tube Feet or Podia:

Each ambulacral groove contains four rows of locomotory, food capturing, respiratory and sensory organs called tube feet or podia. The tube feet are soft, thin-walled, tubular, retractile structures provided with terminal discs or suckers. The suckers function as suction cups to afford a firm attachment on the surface to which they are applied.

4. Ambulacral Spines:

Each ambulacral groove is bordered and guarded laterally by 2 or 3 rows of movable calcareous ambulacral spines which are capable of closing over the groove. Near the mouth, these spines often become larger, stouter, assemble in five groups, one at each inter-radius of disc and are called mouth papilla.

Outside the ambulacral spines are three rows of stout immovable spines, beyond which occurs another series of marginal spines along the borders of the arms demarcating the oral from the aboral surface.

5. Sense Organs:

Sense organs include five unpaired terminal tentacles and five unpaired eyespots. The tip of each arm bears a small median, non-retractile and hollow projection, the terminal tentacle. It acts as a tactile and olfactory organ. At the base of each tentacle occurs a bright red photosensitive eye spot made up of several ocelli.

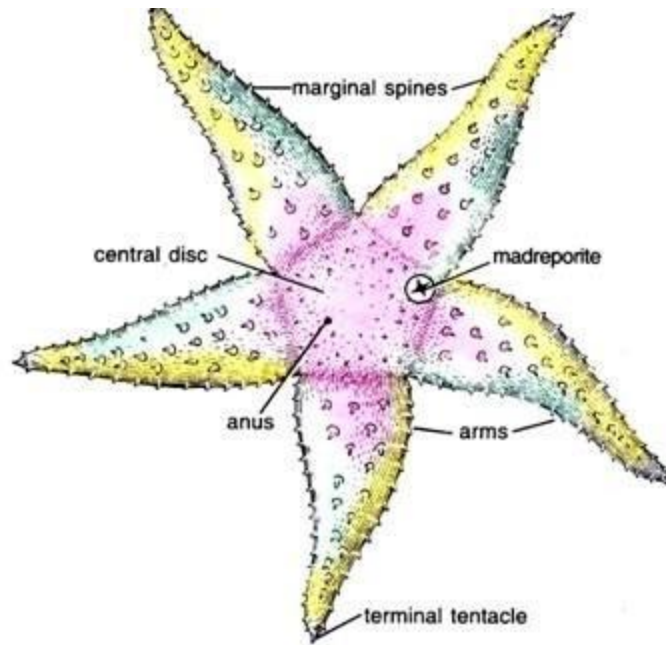


Fig. 85.2. Asterias. External features (Aboral view).

(iii) Aboral Surface:

The side of the body, which remains directed upward or towards the upper surface, is convex and of light orange to purplish colour, is called aboral or abactinal surface.

The aboral surface bears following structures:

1. Anus:

A minute circular aperture, called the anus, is situated close to the centre of the central disc of aboral surface.

2. Madreporite:

At the aboral surface of the central disc occurs a flat, sub-circular, asymmetrical and grooved plate called madreporite plate or madreporite between the bases of two of the five arms. The surface of madreporite is marked by a number of radiating, narrow, straight or slightly wavy grooves with pores in them. The madreporite is, thus, a sieve-like porous plate and it leads to the stone canal of water vascular system.

The number of madreporite to an individual though remains one, but the presence of more than one madreporite in some species is due to the increase in number of arms beyond the normal number of five.

The two arms having madreporite between their bases are collectively referred to as a bivium and the other three arms as a trivium. The symmetrical position of madreporite, thus, converts the radial symmetry of Asterias into bilateral symmetry.

3. Spines:

The entire aboral surface is covered with numerous short, stout, blunt, calcareous spines or tubercles. The spines are variable in size and are arranged in irregular rows running parallel to the long axes of the arms. The spines are supported by the irregularly-shaped calcareous plates or ossicles which remain buried in the integument and form the endoskeleton.

4. Papulae or Gills:

Between the ossicles of integument are present a large number of minute dermal pores. Through each dermal pore projects out a very small, delicate, tubular or conical, finger-like or thread-like, thin-walled, membranous and retractile projection called the dermal branchia or gill or papula.

The papulae are hollow evaginations of the body wall and their lumen remains in continuation with the coelom. They are internally lined by coelom. They have respiratory, as well as excretory functions.

5. Pedicellariae:

Besides the spines and gills, entire aboral surface is covered by many whitish modified spine-like tiny pincers or jaws called pedicellariae. The oral surface also bears pedicellariae. Each pedicellaria consists of a long or short, stout, flexible stalk having no internal calcareous support.

The stalk bears three calcareous ossicles or plates a basilar piece or plate at the extremity of the stalk and jaws or valves which remain movably articulated with the basilar piece and serrated along their apposed edges. Pedicellariae having three calcareous pieces and a stalk are called forcipulate pedunculate pedicellariae.

Asterias possesses two types of forcipulate pedunculate pedicellariae. viz.:

(i) Straight type and

(ii) Crossed type.

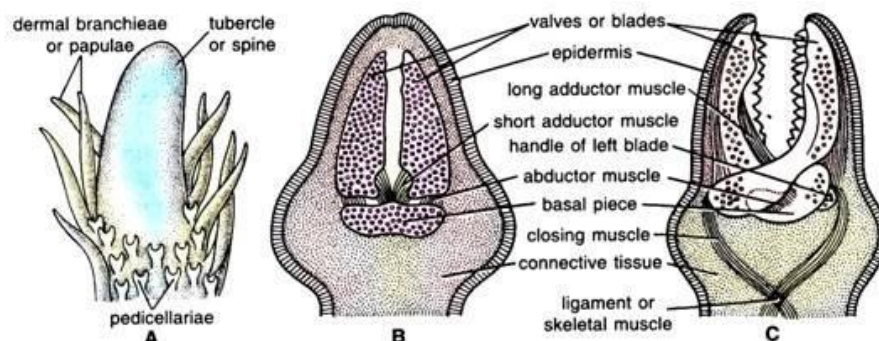


Fig. 85.3. *Asterias*. A—A cluster of pedicellariae, papulae, and tubercle; B—Straight type pedicellaria; C—Crossed type pedicellaria.

(i) Straight type Pedunculate Pedicellariae:

This type of pedicellariae are simple. Their two jaws are more or less straight and attached basally to the basal piece. When closed they remain parallel and meet throughout their length. The two jaws work against one another like the blades of a force with the help of three pairs of muscles. There are two pairs of adductor muscles for closing the jaws and a pair of abductor muscles for opening them.

(ii) Crossed type Pedunculate Pedicellariae:

In the crossed type of pedicellariae, the basal ends of the two jaws cross each other like the mandibles of a crossbill, so that the basal piece is enclosed between their crossed portions. In this type of pedicellariae, the jaws are also operated by two pairs of adductor muscles and one pair of abductor muscles.

Certain other pedicellariae having no stalk and, thus, called sessile pedicellariae are also found on the body of Asterias. They serve as defensive and offensive organs and provide protection to gills and general body surface by keeping the body surface free from debris and organisms like sponges and coelenterates setting on the body.

Body Wall of Asterias:

The body wall of Asterias consists of following tissue layers:

(i) Cuticle:

The body surface is clothed with a definite cuticle consisting of two layers, an outer thick homogeneous layer and an inner delicate layer.

(ii) Epidermis:

Just beneath the cuticle lies a layer of ciliated epithelium which extends over all the external appendages of body such as spines, pedicellariae, tube feet and gills, etc.

The epidermis is composed of a variety of cells such as ordinary flagellated or ciliated columnar cells, neurosensory cells, mucous gland cells or goblet cells having finely granular contents, muriform gland cells filled with coarse spherules and the pigment granules which provide characteristic external colouration to the animal.

(iii) Nervous Layer:

Beneath the epidermis lies a nervous layer, varying in thickness in different areas and penetrated by the attenuated bases of the epidermal cells on their elastic filaments.

(iv) Basement Membrane:

Just below the nervous layer lies a delicate basement membrane which separates the nervous layer and epidermis from the underlying dermis.

(v) Dermis:

The dermis is composed of fibrous connective tissue developed from the mesoderm. It is the thickest layer of body wall and has two regions outer and inner. The outer dermal region secretes and houses the endoskeletal ossicles and binds them together, while the inner dermal region contains numerous blood containing spaces called periahaemal spaces.

(vi) Muscular Layer:

The muscular layer consists of smooth muscle-fibres. It is differentiated into an outer circular muscle layer and inner longitudinal muscle layer. These muscle layers are on the whole weakly developed except in the aboral wall where stronger longitudinal bundles radiate from the centre of the disc along the mid-dorsal line of each arm, to bend the arms aborally.

(vii) Coelomic Epithelium:

The innermost layer of body wall lines the coelom and is composed of flagellated cuboidal cells of mesodermal origin. The innermost layer of body wall is called coelomic epithelium or peritoneum.

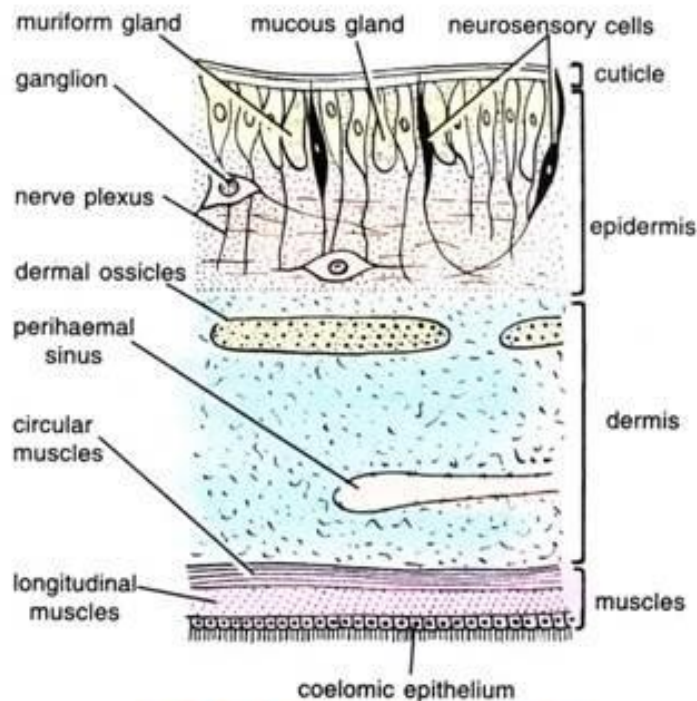


Fig. 85.4. Asterias. Body wall in V.S.

Endoskeleton of Asterias:

The rigidity of the body of Asterias is due to the presence of definite skeleton. In Asterias, the endoskeleton is unique in being mesodermal in origin instead of ectodermal as in other invertebrates. It consists of numerous calcareous ossicles. The ossicles are of various shapes and are bound together by connective tissue. They form a reticulate skeleton, leaving spaces for the emergence of groups of papulae.

The ossicles have irregular arrangement on the aboral surface but have definite and regular arrangement on the oral surface. On the oral surface, they are regularly around the mouth and in the ambulacral groove. Five plate-like ossicles called oral ossicles remain arranged around the mouth. Each ambulacral groove is supported by double rows of large, transversely placed opposite rod-shaped ambulacral ossicles.

The ossicles of the two opposite rows are arranged like an inverted V, their aboral ends meeting at the apex of the V, like the rafters supporting the roof of a shed and forming a conspicuous ambulacral ridge. The ambulacral ossicles do not bear any spines, tubercles or other external appendages. Because they are movably articulated in the ambulacral groove, they permit the opening or closing of the latter.

Further, each ambulacral ossicle has a notch on its outer as well as inner margin. The two notches of the adjacent ossicles together form an oval aperture, the ambulacral pore for the passage of tube-foot. The ambulacral pores are so arranged that they form two rows on each side of the ambulacral groove.

At its outer end, each ambulacral groove articulates with one ambulacral ossicle forming the edge of the groove and bearing two or three movable spines on small tubercles. Next to the ambulacral ossicle there are two rows of the ossicles called supra- and inframariginal ossicles.

Section of an Arm:

The arm is covered all around by a thin two-layered cuticle, a ciliated epidermis and an underlying thick dermis which has many periaermal spaces and ossicles.

Epidermis and dermis are thinned over the projecting spines, pedicellariae and papulae but they wear off from spines. The aboral side is a thick convex arch, and the oral side is like an inverted a, between the two limbs of the a is an ambulacral groove. The arm encloses a perivisceral coelom.

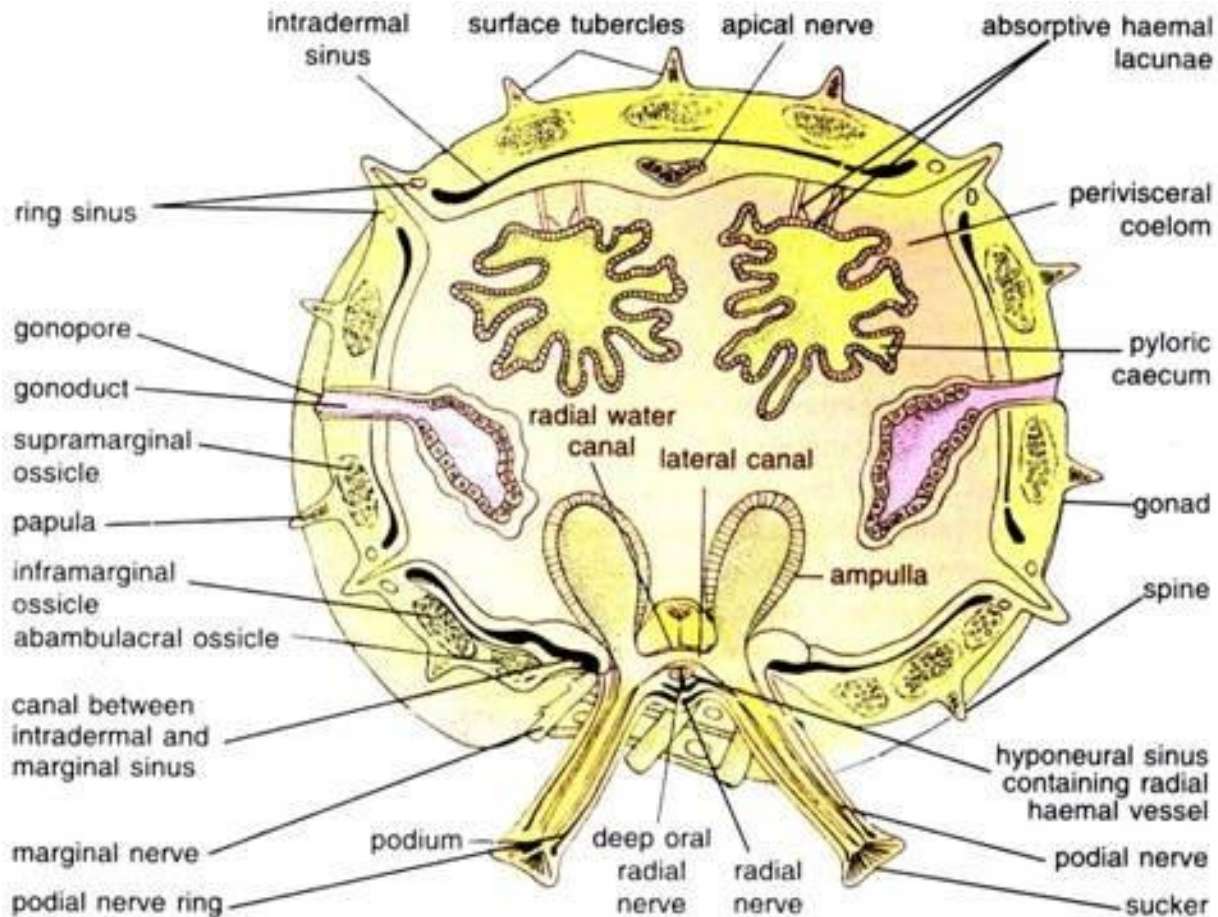


Fig. 85.5. Asterias. Diagrammatic transverse section of an arm.

The aboral wall has a number of irregular, fenestrated ossicles which are calcareous, on some ossicles rest projecting spines.

From the aboral side dermal papulae project out, the coelom is continued into the papulae. Between the spines and attached to them are many pedicellariae. Each lateral margin of the arm has two large spines, they are a supra marginal spines and below it an inframarignal spine. Mid-dorsally the arm has a large cardinal spine.

On the oral surface the ambulacral groove is supported by two elongated ambulacral ossicles meeting at the summit of the groove, at each end of the ambulacral groove is an adambulacral ossicles and spine. The ambulacral ossicles form two columns in the oral surface of each arm and on each side there is a single column of adambulacrals.

The adambulacral spine can touch the substratum or bend inwards to protect the ambulacral groove. Above the ambulacral groove runs a radial canal which is joined on each side by a podial branch to two ampullae and one tube foot. Below the radial canal is a radial hyponeural sinus enclosing a radial haemal channel.

Muscles:

The median aboral side below the body wall has an apical longitudinal muscle which stretches the arm. Each pair of ambulacral ossicles has an upper and a lower transverse ambulacral muscle, the upper or superior transverse ambulacral muscle widens the ambulacral groove, and the lower or inferior transverse ambulacral muscle makes the ambulacral groove narrow.

Between the adjacent ambulacral ossicles of each side is a longitudinal ambulacral muscle which shortens the arm and the ambulacral groove. The outer end of each ambulacral ossicle is connected to the adambulacral ossicle by a lateral transverse ambulacral muscle which widens the ambulacral groove.

Nerves:

In the middle of the ambulacral groove is a radial nerve cord in the shape of a V. Above the radial nerve cord are two Lange's nerves. Close to the outer end of each ambulacral ossicle is a marginal nerve. Each podium has a nerve ring.

Inside the perivisceral coelom of the arm is a pair of pyloric caeca, each suspended by two longitudinal mesenteries from the aboral surface. If the section passes through the base of the arm the perivisceral coelom has a pair of gonads attached to the body wall by their ducts.

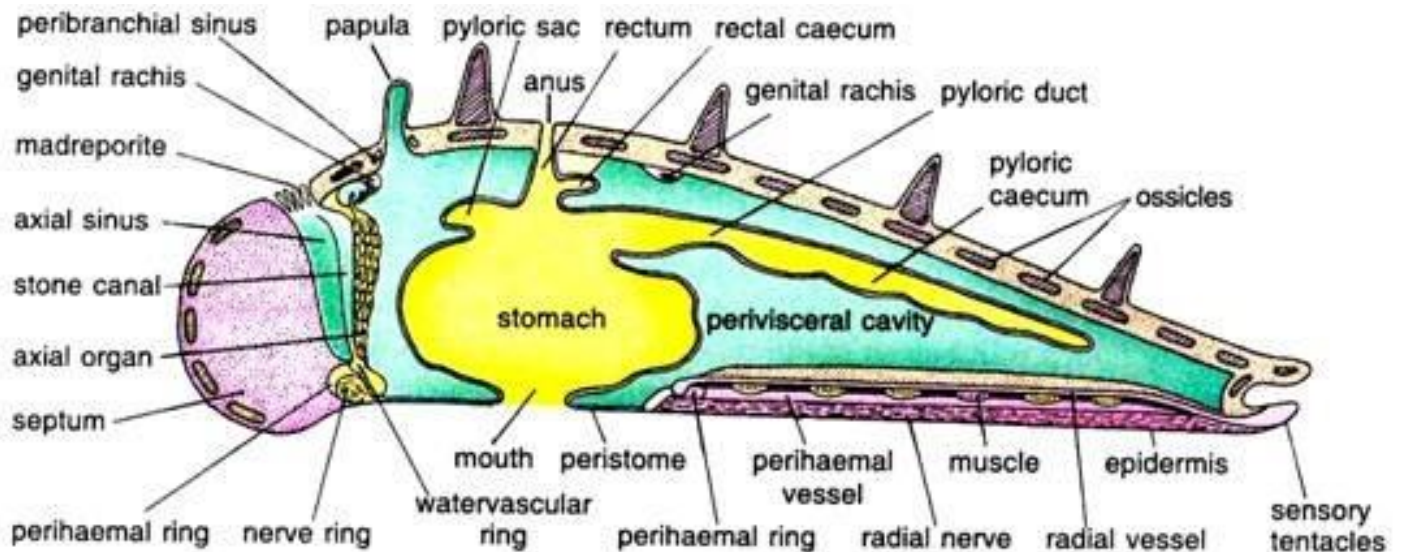


Fig. 85.6. Asterias. Diagrammatic longitudinal section of the disc and an arm.

Coelom in Asterias:

Asterias possesses a true and spacious coelom which is lined by a coelomic epithelium of ciliated cuboidal cells.

It consists of various compartments, viz.:

- (i) A perivisceral coelom extending in central disc and rays and surrounding the visceral organs such as digestive tract and the gonads,
- (ii) Coelom of water vascular system,
- (iii) Axial sinus,
- (iv) Perihaemal sinus and canals and,
- (v) Genital sinuses, etc.

The coelom is filled with a colourless, alkaline coelomic fluid which contains various dissolved nutrients such as amino acids, fatty acids, glycerol and glucoses, etc. Besides nutrients, the coelomic fluid also contains two main types of phagocytic amoeboid corpuscles, the amoebocytes or coelomocytes; coelomocytes with ordinary slender pseudopodia and coelomocytes with petaloid pseudopodia.

The coelomic fluid, like the haemolymph of Arthropoda, bathes the tissue of the body and performs the function of circulatory system. It distributes the nutrients to various body cells and also performs the respiratory as well as excretory functions.