EVOLUTION OF COELOM

Special Features of Coelom:

1. Developmentally coelom arises as a split in the mesoderm which becomes bifurcated into two layers, a somatic layer lying next to the epidermis and a splanchnic layer around the endoderm.

2. Coelom becomes bounded on all sides by coelomic epithelium which secretes coelomic fluid.

3.The greater part of the coelom forms the perivisceral cavity or splanchnocoel.

4. It is a fluid-filled space inside which is lodged the viscera.

5. Because of this packing the viscera remains independent of the movements of the muscles of body wall.

6. In some higher animals part of the perivisceral cavity is kept separate to form restricted cavities whose coelomic nature can and only be realised if their developmental history is followed.

7.In all probabilities the ancestral coelomate animals had segmentally arranged mesodermal pouches.

8. From these pouches gametes were formed by the process of proliferation of the epithelial lining.

9. Later on, these pouches became modified in structure and function.

10. The evolution of mesodermal pouches is evident in present day coelomates.

Types of Coelom:

There are three types of coelom, such as:

(i) Acoelom,

(ii) Pseudocoelom and

(iii) Coelom or Eucoelom.

(i) Acoelom: It means without a coelom or fluid-filled cavity is absent. The space between the gut and body wall is filled by a kind of densely packed connective tissue derived from both ectoderm and endomesoderm (entomesoderm), called parenchyme. Animals are without a body cavity in triplooblastic animals, called acoelomates and the group is referred to as acoelomata.

Examples:
Gnathostomulida, Platyhelminthes and Nemertea, Gastrotricha, Kinorhyncha.

(ii) Pseudocoelom: It means false cavity. The fluid-filled body cavity lying between the gut and outer body wall musculature and generally formed by persistence of embryonic blastocoel is called pseudocoel. The term 'pseudocoelom' usually refers to the space which does not develop from embryonic mesoderm and not lined by coelomic epithelium derived from the mesoderm.

The body cavity is bounded externally by the fibrous processes of the longitudinal muscle cells (mesoderm) and internally by the intestine (endoderm).

The pseudocoelomic fluid acts as a hydrostatic skeleton to maintain body shape and circulate nutrients. Animals that contain a pseudocoel are called pseudo- coelmates or pseudocoelomate animals. Pseudocoelomate animals are also referred to as haemocoelomate or blastocoelomate animals (Brusca and Brusca, 2003).

Examples: Rotifera,Nematoda, Nematomorpha, Loricifera. In small free-living nematodes, the pseudocoel is small or non-existent but may be voluminous in large-sized nematodes. The pseudocoel in Nematomorphos contains stellate mesenchymal cells. In rotifers, a spacious fluid-filled pseudocoel occurs beneath the body wall and surrounds the gut and other internal organs.

(iii) Coelom or Eucoelom:

It is a true coelom lying between the gut and outer body wall musculature and lined by coelomic epithelium derived from the embryonic mesoderm. It is a mesodermal origin and opens to the exterior through the coelomoducts, e.g., the oviducts and the excretory ducts. The coelomic fluid contains amoeboid cells or amoebocytes. The animals containing such a body cavity or coelom, called coelomates.

Examples: Sipuncula, Echiura, Priapulida, Mollusca, Annelida, Arthropoda, Onychophora, Phoronida, Brachiopoda, Bryozoa, Echinodermata, Chaetognatha, Hemichordata and Chordata

Mode of Coelom Formation:

According to the mode of coelom formation, there are generally two types which are noted in protostomes and deuterostomes:

1. Schizocoely:

The process by which coelom arises by the splitting of mesodermal bands or masses during embryonic development. Protostomia (e.g., Mollusca, Sipuncula, Echiura, Priapulida, Annelida, Arthropoda, Tardigrada and Onychophora).

2. Enterocoely:

The process by which coelom is formed by the evagination from the embryonic archenteron. The pouch-like structures are detached from the archenteron and gradually occupy the whole body by enlargement.

Examples:

Deuterostomia (e.g., Echinochordata, Hemichordata and Chordata).

3. Myocoel:

This type of coelom originates in Phoronida in which the mesenchyme rearranges to enclose a place called coelom (Marshall and Williams, 1972). It is an unusual method of coelom formation. It is neither entero-coeloms nor schizocoelous.

Coelom in Different Groups:

In Sipuncula, there are two coelomic cavities, one of which is a ring-like tentacular coelom which is situated at the base of the tentacles and extending three branches in each tentacle. Another is trunk coelom which is spacious and occupies the trunk region separated from the tentacular coelom.

The coelomic fluid within the coelom is in constant circulation by the movement of cilia of the peritoneal cells and by the contraction of the muscular body. The coelomic fluid contains wandering leucocytes, disc-like haemerythrin containing cells, reproductive cells and excretory cells.

Like the sipunculans, similar types of coelomic cavities are found in echiurans. The trunk coelom is spacious and uninterrupted. The coelom is fluid is circulated by muscular contraction of the body and by the cilia of the coelomic lining.

In priapulida, it is not clear whether the body cavity is a pseudocoelom or a coelom. The body cavity fluid contains amoebocytes and erythrocytes.

In Pogonophora, the coelom is compartmented and extended into tentacles. The coelomic fluid contains respiratory pigment and haemoglobin.

In Onychophora, the main body cavity is a haemocoel, not a true coelom. The body cavity is known as mixocoel. True coelom is restricted to the gonadal cavities and excretory organs.

In some coelomate animals such as molluscs and arthropods the cavities of blood- vascular system become greatly enlarged and this enlargement obliterates the perivisceral coelom and as a result the viscera lies in a spacious cavity filled with blood.

This blood-filled cavity is called haemocoel. In Mollusca, the coelom comprises a pericardial coelom around the heart, a gonadal coelom, and paired coelomic ducts serve as excretory organs. In Arthropoda, the coelom is represented by the cavity of gonads and the excretory organs in some species.

In annelids there is a pair of sacs—the right and left coelomic vesicles lying between each segment of the gut and the corresponding segment of the body wall. The cavities of the coelomic vesicles contain a fluid and corpuscles and are lined by peritoneum derived from mesodermic epithelium. Each segment of annelida has a dorsal mesentery, ventral mesentery and a transverse septum.

Two sheets of peritoneum meeting in the mid-line above and below the gut form the dorsal mesentery and ventral mesentery respectively. The septum which is a screen between two successive segments is formed by the meeting of two peritoneal sheets at the boundary between the segments.

The mesentery is composed of a double-fold of peritoneum of coelomic epithelium. In rare exceptions, the septa and mesenteries form a complete series of transverse or longitudinal partitions throughout the entire length of ' the body of the animal. In most cases the septa are perforated and the mesenteries are incomplete so that there exists a close communication between coelomic vesicle and coelom.

In Echinodermata, the coelom in the adult echinoderms is represented as several distinct spaces. It develops as a pair of lateral pouches and becomes separated from the embryonic enteron.

These pouches represent the future coelomic cavity and the cells which comprise the pouch wall become the mesoderm. The two original pouches, one on each side, give rise by subdivisions to coelomic vesicles, arranged one behind the other and called respectively, the axocoel, the hydrocoel, and the somatocoel.

These coelomic vesicles correspond to the protocoel, mesocoel and metacoel of the hemichordates. The water vascular system arises

from the hydrocoel. The two somatocoels convert into gut mesenteries and left axocoel transforms into the hydropore.

Views Regarding the Coelom Formation:

Regarding the origin of coelom there are four basic theories which have been discussed in details by Clark (1964).

1. Enterocoel theory— First proposed by Lankester in 1877, supported by Lang (1881), Sedgwick (1884):

This theory states that the coelom may have originated by evagination as pouch-like structures in the wall of embryonic archenteron. This type of coelom formation occurs in many existing enterocoelous animals.

This concept was proposed by Lankester in 1877. Sedgwick (1884) suggested that the gastric pouches of anthozoans (Cnidaria) became separated from the main gastric cavity (gastrovascular cavity) and were transformed into coelomic pouches (Fig. 17.52).

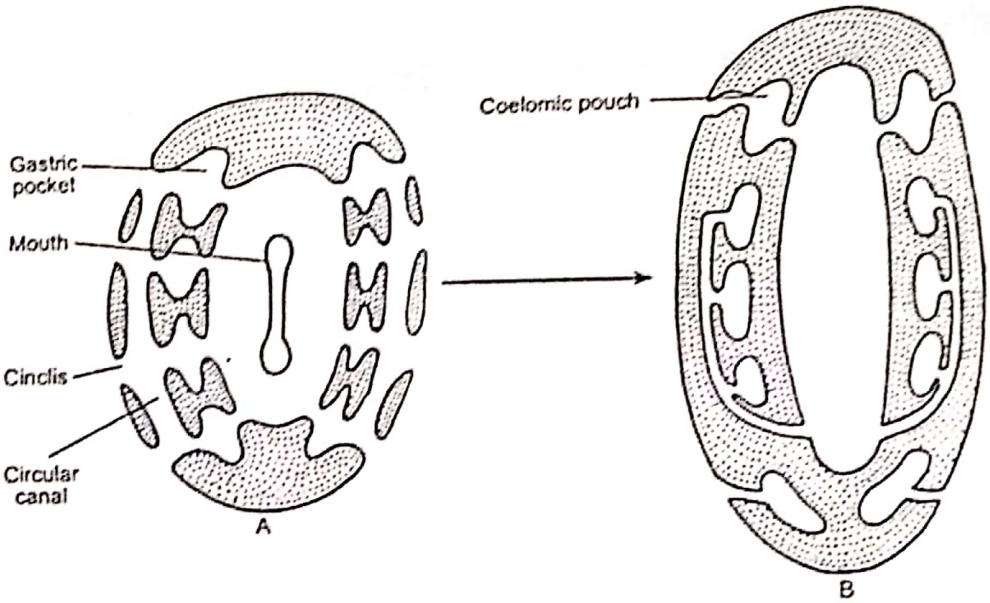


Fig. 17.52: Digrams showing the enterocoel theory of coelom formation. A. Diagramillustrating the gastric pockets of an anthozoan animal. B. Fig. shows the coelomic pouches after transformation of the gastric pockets of anthozoans.

2. Gonocoel theory (HatSchek, 1877, 1878), Bergh (1885), Meyer (1890), Goodrich (1946):

The origin of coelom in favour of gonocoel theory is that first coelomic cavities arose from the mesodermally derived expanded gonadal cavities and the cavities persisted after the release of gametes. For example, the gonads of tricladid flatworms are arranged in a linear order and the segmental coelom of annelida may have developed from this tricladid (Fig. 17.53).

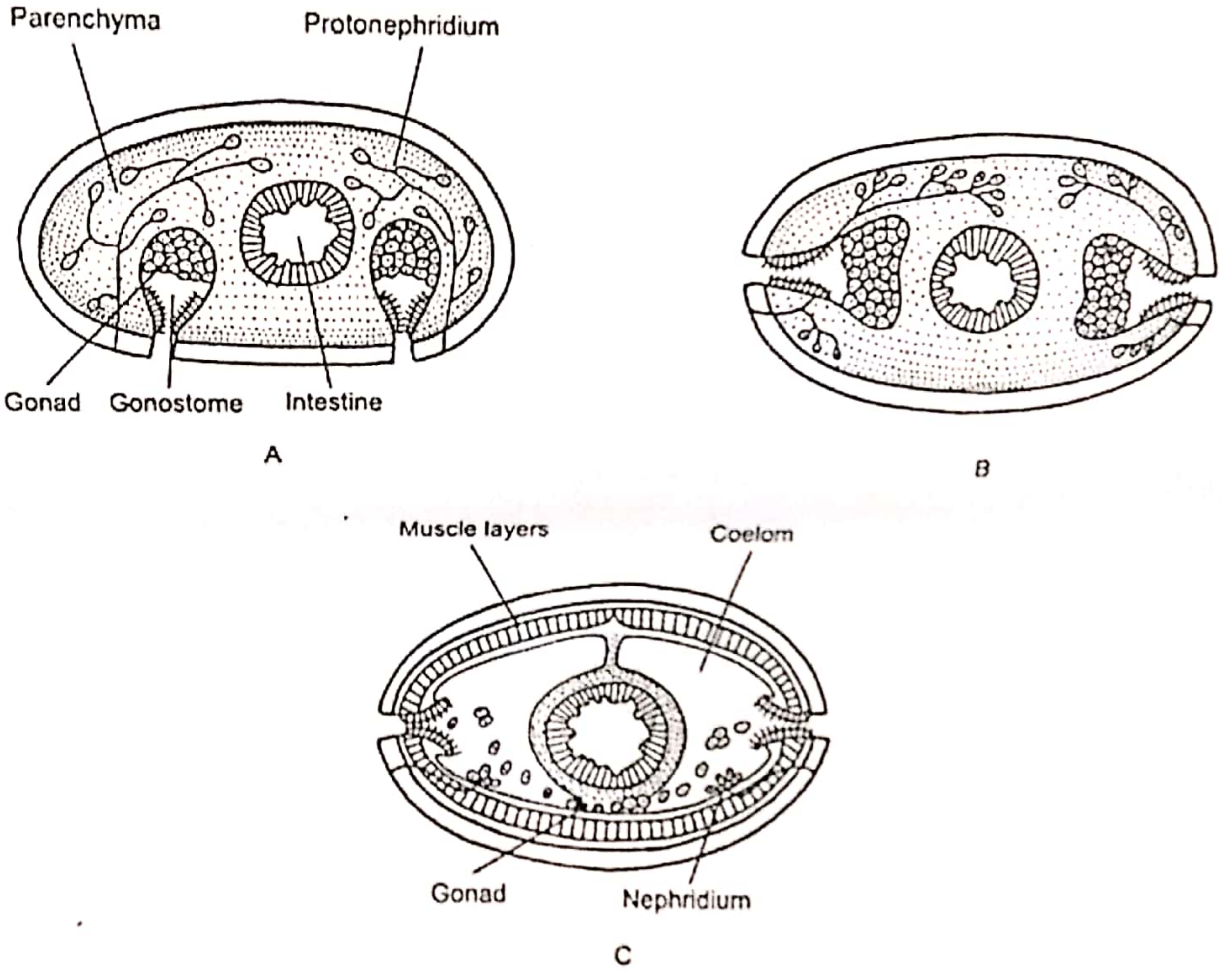


Fig. 17.53: Diagrams showing the gonocoel theory of coelom formation.

3. Nephrocoel theory (Lankester, 1874, Snodgrass, 1938):

The theory states that the coelom originated from the expanded nephridia of flatworms. The chief objection of this theory is that the protonephridia have not recorded in all coelomates, even the echinoderms do not have excretory organs.

4. Schizocoel theory (Clark, 1964):

The theory states that the coelom could have evolved by the splitting of mesodermal plates.

Significance of Coelom:

The coelom plays a great role in the life of animals.

These are:

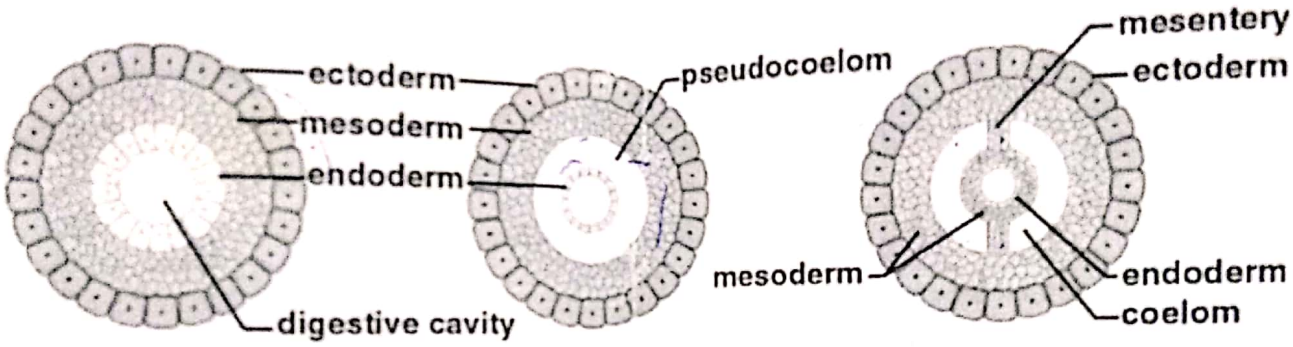
(i) The coelomic fluid content facilitates smooth transportation of particles or materials in solution.

(ii) Coelom affords flexibility to the body and extends room for the movement of the gut which remains suspended.

(iii) Gonads which develop from coelomic epithelium are housed in the cavity of the coelom. So also are the nephridial tubules, which connect the coelom to the exterior and in some cases allow the passage of eggs and sperms.

(iv) The coelom filled with incompressible coelomic fluid acts as a hydrostatic skeleton and helps in locomotion.

Acoelomate, pseudocoelomate, coelomate comparison



a. Acoelomate
flatworms

b. Pseudocoelomate
roundworms

c. Coelomate
molluscs
annelids
arthropods
echinoderms
chordates

Evolution of the Animal Body Plan