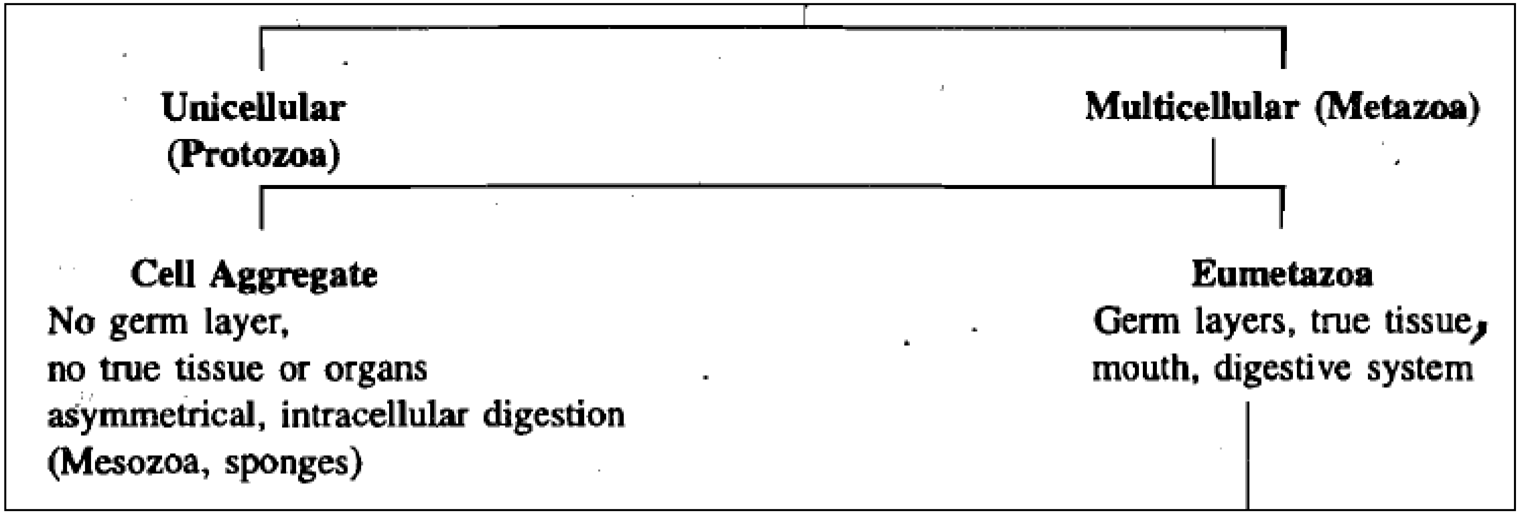
Body Symmetry & Segmentation of Metazoa



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CHARACTERISTICS OF METAZOA

1. Members of Metazoa possess a complex multicellular structural organization which may include the presence of tissues, organs and organ systems.
2. In the life history of metazoans, typically a fertilized egg passes through a blastula stage in the course of its early embryonic development before changing into an .adult.
3. Since metazoans are multicellular they are relatively larger in size than unicellular protozoans. Naturally, their nutritional requirements are more and they have to search for food. Consequently, locomotion in metazoans is highly developed and for this purpose they have evolved contractile muscular elements and nervous structures.
4. The ability for locomotion has influenced the shape of the metazoan animals which in turn has conferred specific types of symmetries to metazoan groups.
5. Most of the metazoans show differentiation of the anterior end or head (cephalization); associated with cephalisation, there is the centralization of the nervous system in the head region.

Although all metazoans share some characteristic features, their body plans differ in symmetry, internal organisation, developmental patterns and modes of formation of,body cavity. These differences provide us a means of grouping them or organising them into different phyla.

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ANCESTRAL UNICELLULAR ORGANISM

- **Unicellular (Protozoa)**
- **Multicellular (Metazoa)**
  - **Cell Aggregate**
    No germ layer,
    no true tissue or organs
    asymmetrical, intracellular digestion
    (Mesozoa, sponges)
  - **Eumetazoa**
    Germ layers, true tissue,
    mouth, digestive system
    - **Radiata**
      Radial symmetry
      tissue level organisation
      (Ctenophora, Cnidaria)
    - **Bilateria**
      Bilateral symmetry
      organ-system level
      organisation
      - **Protostomia**
        Blastopore forms mouth
        and the anus is a new formation.
        Spiral cleavage.
        Determinate type of development
        - **Acoelomata**
          (Eg. Platyhelminthes
          Nemertea
          Gnathostomulida)
        - **Pseudocoelomata**
          Cavity derived from
          blastocoel
          No peritoneal lining
          (Eg. Nematoda, Rotifers)
        - **Schizocoelomata**
          Coelom derived
          from splitting of
          mesodermal bands
          (Eg. Annelida,
          Arthropoda,
          Mollusca)
      - **Deuterostomia**
        Blastopore does not form mouth
        but anus. Mouth formed later
        from independent opening of
        body wall.
        Radial cleavage.
        Indeterminate type of development.
        - **Enterocoelomata**
          Coelom from fusion
          of enterocoelous pouches.
          (Eg. Echinoderms to Chordates)

SYMMETRY

All living organisms have some body shape and form. The general body plan of animals may be organized in one of several ways (Fig. 3.7 a-f). Arrangement of parts or organs on either side of an imaginary dividing line or around a common axis or radially around a point so that opposite parts are mirror images of one another is called **symmetry**. There are two broad divisions of symmetry, (i) primary, or embryonic (ii) secondary, or adult. The latter may or may not be the same as the primary one. For example, the larva of starfish is bilaterally symmetry but the adult starfish is radially symmetrical. The primary symmetry is bilateral and secondary symmetry is radial. With regard to symmetry animals can be basically of five types (i) asymmetrical (ii) spherical (iii) bilateral (iv) radial and (v) biradial.

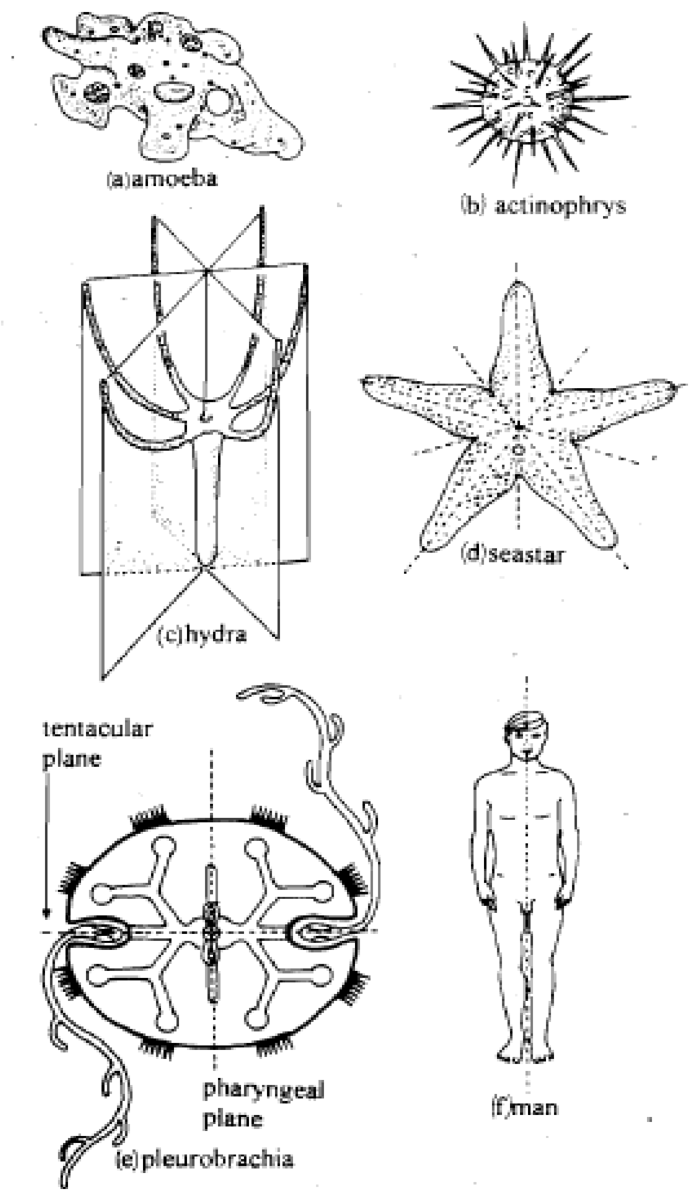


Fig. 3.7: Different types of body symmetries a) asymmetrical b) spherically symmetrical, (c-d) radially symmetrical. (e) biradially symmetrical (f) bilaterally symmetrical.

Asymmetrical and Spherical Symmetry

Some creatures are **asymmetrical** : no matter which way we try to divide them through the middle, no two halves would appear alike (Fig. 3.7 a). In simpler words : these are animals which cannot be cut into two identical halves through any plane or axis (longitudinal, sagittal or transverse), Amoeba and most of the poriferans are examples.

At the other extreme, is **spherical symmetry**. The animals with spherical symmetry can be divided into identical halves along a number of planes which pass through the centre or in other words every plane through the centre will yield two halves which arc mirror images of each other. This type of symmetry is found chiefly in some protozoa and is rare in other groups of animals. *Actinophrys* (Fig. 3.7 b) and colonial *Volvox* are typical examples.

Radial and Biradial Symmetry

Radial symmetry is the symmetry in which the parts are so arranged around a central axis or shaft, like the spokes of a wheel, that any verticaI cut through the axis would divide the whole animal into two identical halves. The common jelly fish and hydra (cnidaria) - exhibit radial symmetry (Fig. 3.7 c). The starfish and their relatives have a modified form of radial symmetry. They cah be divided along 5 planes, each giving two distinct halves. This is known as pentermerous symmetry. One side of the body has the mouth and is known as the oral surface; the opposite side is aboral (Fig. 3.7). Cuts made along the oral-aboral axis will result in identical halves.

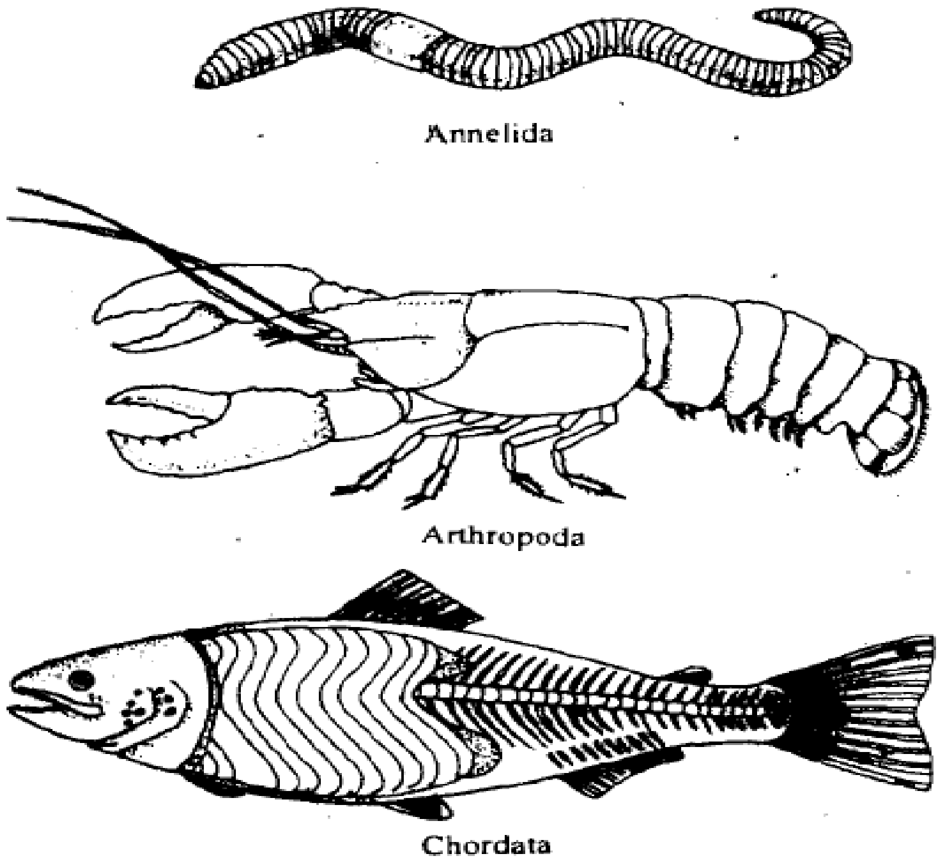
Biradial symmetry is a variant of this and it is found in sea anemones and ctenophores. Though the animal appears to be radially symmetrical, it can be divided only into two equal halves along two per-radial positions - along the tenticular plane and along the sagittal plane at right angles to it. Radial and biradial animals are usually sessile, floating freely or weak swimmers. These animals are called the **Radiata.**

Bilateral Symmetry

Bilaterally symmetrical animals have the major axis running from head (anterior) to tail (posterior). They have a ventral (lower) and dorsal (upper) surface that are different from each other. They have only two sides that look alike, the right and left. The animal can be divided into just two identical halves through a plane which passes from anterior to posterior end. Almost all animals including human beings except for sponges, ctenophores and cnidarians show bilateral symmetry. Adult echinoderms, though radially symmetrical (pentamerous) have larvae that are bilateral. This is because they have evolved from bilaterally symmetrical ancestors. In general, bilateral animals that adopt a sessile existence commonly exhibit a shift towards radial symmetry. The shift may be slight as in acorn barnacles where only protective circular wall plates are arranged radially or the shift may be profound as in the case of sea stars or starfishes. Bilateral animals are called **Bilateria.**

SEGMENTATION

Segmentation or metamerism is the division of the body into smaller transverse compartments along the anterior-posterior axis. Segmentation is widespread among animals, with true segmentation occurring in annelids, arthropods and most chordates though some other groups show superficial segmentation of ectodermal body wall.



Phyla showing segmentation. Annelids and arthropods are related but chordates have acquired metamerism independently.

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Fundamentally there are three body forms. First, monomeric where there is no division of the large body cavity at all. ***Ascaris*** has this type of body form. Second, oligomeric where the body cavity is divided into three and each region has a separate body cavity with no divisions on the abdomen. ***Phorona*** is a worm with this body plan. Third. metameric in which the body is divided into head, thorax and abdomen and where abdomen is further divided into a chain of segments.

Segmented body forms can be seen in tape worms, annelids, arthropods and chordates. Of these segmentation in tape worms is quite different from that seen in the others. We can observe that segmentation in tape worm is superficial, a series of ring like creases develop in the cuticle and the body wall which facilitate bending and telescoping of the body.

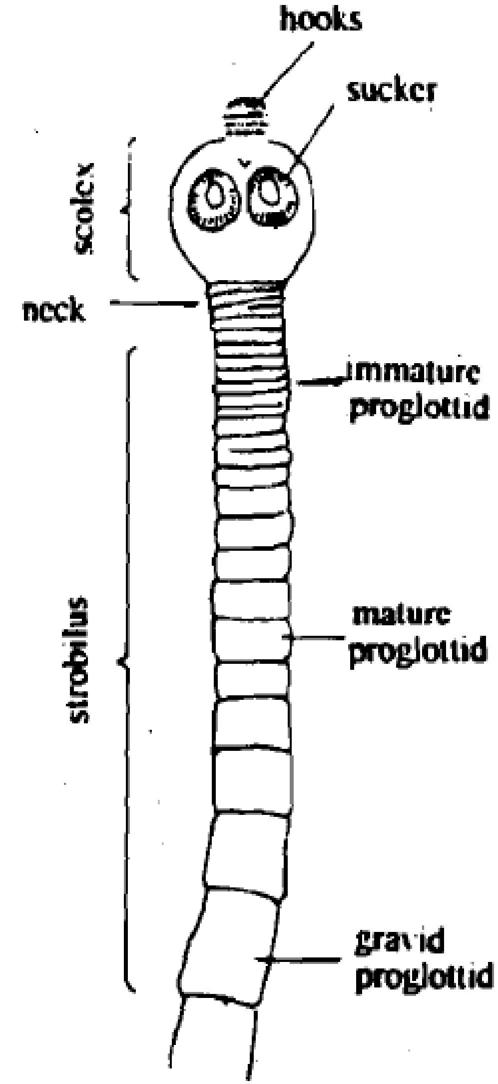

Fig. 3.15: Superficial segmentation seem in tape-worms.

Segmented animals have a specialised anterior **acron (prostomium)** and posterior **pygidium or telson** both of which are not segments. In between there are a varying number of segments. In near perfect segmentation, appendages, musculature, ganglion, nerves, blood vessels, coelom and all body organs are replicated in each segment. This arrangement is best seen in annelids. In chordates, segmentation is usually apparent in the axial skeleton. muscles and nerves. The most important advantage is that segmentation divides a body into a series of compartments, each of which can be regulated almost independently. This in a way provided the framework for **specialisation**. The second significant feature of metameric segmentation is its importance in the locomotion of soft bodied animals. The acoelomate animals use their musculature of longitudinal and circular muscles for locomotion but the evolution of a coelomic cavity has allowed the fluid to act as hydraulic skeleton. In invertebrates like annelids, muscles of the body wall act against this pressure. When circular muscles contract, hydrostatic pressure on coelomic fluid will result in lengthening of the body; when longitudinal muscles contract, it will result in widening of the body. Since metameric segmentation results in compartmentalisation of the body, this elongation and widening of the body can be restricted to a few segments at a time. This local change in the shape of the elongate body increases the locomotory efficiency. The broadened part of the body can be firmly fixed against the burrow especially if there are clinging structure such as setae and the lengthening of the body will produce considerable thrust resulting in progression of the animal. Thus the alternate peristaltic waves enable the animal to move forwards faster and efficiently.