~ Chapter 2 b ~

General Plan of Chordate Organisation

The Variety of Chordate Life

1) Chordates occupy a wide range of **habitats**, more than any other group of animals.
2) They belong to an extremely adaptable phylum.
3) Although they possess a variety of structures, the chordates show a **uniformity** of body plan.
4) Classified into **four subphyla** and several super classes and classes.

Subphylum Cephalochordates (Amphioxus) as a generalised chordate:

- The chordate **ancestor** had basic chordate organisation.
- It was a **free swimming** marine animal feeding by collection of small particles.
- **Amphioxus** possesses all of the basic chordate characters.
- Later chordate body plan is based on **basic plan** of amphioxus body.

1) It can **swim** but it is a **burrower** animal living in the sand and wide spread.

   Figure 2.1 to see the Amphioxus body plan.
2) Elongate body is **pointed** at both ends & *no* recognisable head.
3) Skin has no pigment so muscles can be seen as a series of blocks (**myomeres**).
4) No separate eyes, nose or ears, and **no jaws**.
5) Front end carries **buccal cirri** and receptor cells.
6) Has a large number of **gill slits** but no gill tissue.
7) Ventral space called **atrium** is covered by body folds.
8) **Ectoderm**, **endoderm**, and the space between them (**coelom**) are lined by a mesoderm.

Muscle Fibres & Movement

- Adult myotomes are blocks of striated muscle fibres separated by sheets of connective tissue, the **myosepta**.

- **Muscles** are connected to the **nerve cord** in an unusual way; not by motor nerve fibres but by thin processes of the muscle cells each join the **spinal cord** & there makes a cholinergic synapse with axons of neurons.

  1) There are two types of **muscle lamellae** corresponding to the slow and fast muscle fibres of higher chordates.
  2) Animal can move forwards & backwards in a **sinusoidal** way in a serial contraction of the myotomes.
  3) Presence of **notochord** helps support the body & prevents it from shortening during longitudinal muscle contraction.
  4) Notochord is composed of a series of **flattened plates**.
  5) No fins such as those of fishes.

Skeletal Structure

1) Around the notochord there is a **sheath** & another layer of **gelatinous material**.
2) Cartilage
3) **Skeletal rods** around mouth and in gill bars.

Skin

1) Compared to vertebrates (multilayer epidermis), the skin of amphioxus is only a **single** cell layer & is **ciliated** in the larval stage and **cuticularized** in the adult.
2) There are **receptor cells** but no glands or chromatophores in the skin.
3) Below the epidermis is the **fibrous** and **gelatinous layer**. Both layers are secreted by cells similar to the fibroblasts of higher forms.

Mouth and Pharynx & Control of Feeding

1) Amphioxus obtains its food by **filtering** using ciliated structures that are protected by the pharynx wall and atrium.
2) Mouth is covered by an **oral hood** extended to buccal cirri & provided with **sense cells** some of which are **mechanoreceptors**.
3) When feeding, the **cirii** are curved forming a funnel-like sieve.
4) Around the mouth there is a ring of sensory tentacles (the **velum**).

5) Oral hood contains **ciliated tracts**, the wheel organ which sweeps food particles & has a groove in its centre as an opening (**Hatschek's**) of the left first coelomic sac to the exterior.

6) Food is collected by **pharynx** whose wall is perforated by nearly 200 slits. **Slits** are separated by rods and further divided by cross bars. Gill bars are ciliated.

7) Nerve cells and fibres occur in the pharynx wall.

8) In the floor of the pharynx is the **endostyle** which contains **ciliated cells** & **mucous cells** producing sticky threads.

9) Food particles attach to the **sticky threads**, which reach to the midgut.

10) Cilia of gill bars produce an **upward current**.

11) **Radioactive iodine** is concentrated by cells of pharynx, indicating that these may be the origin of thyroid cells of higher chordates.

12) These cells produce **iodinated mucoproteins** which are absorbed by the gut.

13) Mono- and Di-iodotyrosine and Tri-iodothyronine (T3) and thyroxine (T4) are all present. Possible endocrine activity.

14) Unlike higher vertebrates, **T3** is more abundant than **T4**.

15) Pharynx opens into **midgut** & there is large **diverticula** producing digestive enzymes. Some cells of diverticulum secrete protein while other cells contain glycogen and lipids & may be compared to the liver cells.

16) Amphioxus show **intracellular** as well as **extracellular digestion**.

17) Hind end of midgut is marked by a ciliated region (**ileo-colon ring**) whose cilia help in mixing the food and mucous.

18) Extracellular digestion occurs in midgut. Amylase is present in midgut, hindgut & diverticulum.

19) **Lipase** and **protease** have the same acidity of pepsin of higher chordates.

20) Behind the ileo-colon is the hindgut and anus. Absorption of food occurs in hindgut & maybe also in midgut.

Regulation of Feeding

Feeding is regulated by the rate of beat of the cilia & the degree of **contraction** of inhalant & exhalent apertures:

1) Nerve fibres, receptor cells (with no axons) in contact with the nerve cells which are located under the **atrial epithelium** and have axons.

   Figure 2.11

2) **Motor fibres** without synapse.

3) Food is tested by **receptor cells** of velum and atrium & if noxious material is present it is expelled. The system can select between organic and inorganic materials.

- **Atrial nervous system** may regulate spawning as well as feeding.

Circulation

1) **Blood vessels** of amphioxus show the basic plan on the circulation of all chordates.
2) Slow contraction of the body drives blood **forward** in ventral vessels; **backwards** in dorsal.
3) Blood is collected into **sinous venousus** (a large sac) located behind the pharynx. Ventral aorta extend from sinous venousus and divide into **branchial arches,** at the base of each arch there is bulb (**branchial hearts**).
4) Blood moves from gill bars into **dorsal aortae** which join behind the pharynx.
5) From the aortae blood is carried into lacunae supplying the tissues. There are no capillaries.
6) From the **lacunae**, blood is collected into veins (caudal and cardinals and gut). The **cardinals** bring blood to the **S.V.** through **ductus cuvieri**. Caudal veins & veins on gut wall collect the blood into intestinal vein to the liver (diverticulum).
    - Blood is **colourless** and with no cells. No **oxygenation** occurs in the gills but it occurs in lacunae close to the skin

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Excretory System

1) System of flame cells (**solynocytes**) which are modified coelomic epithelial cells.
2) They are similar to the **podocytes** that line the renal capsule of vertebrates.
3) Solenocytes are not similar to those of the polychaetes because there is no **basement membrane** between blood and coelomic spaces in the case of amphioxus.
4) Some parts of the **atrium** may function as excretory. In the **gonads**, large yellow masses contain **uric acid** which is released with the gametes.

Nervous System

1) A hollow dorsal nerve cord and at the front, it is enlarged into a brain. Nervous system is connected to the **periphery** in a unique way: **muscle fibres** send processes to the nerve cord, forming a structure called nerve roots.

2) Fibres of **peripheral nerves** are different from those of vertebrates in that they have no **myelin sheath** and no Schwann cells accompanying the nerve fibres.

3) **Spinal cord** has a narrow cavity and its elements are arranged as in vertebrates (**epedyma**). No blood vessels in spinal cord.

4) Amphioxus responds to all **stimuli** by movements of flight.

5) No cephalisation is obvious in the animals. **Brain** is divided into four regions.

6) Amphioxus has **receptor** & **motor systems** that serve to keep the animal sedentary, able to collect food, and make escape movement and touch receptors of the buccal cerrii produce rejection of large particles. Receptors of the velum are **chemoreceptors**.

Gonads & Development

Gonads are hollow segmental **sacs** developing from the mesoderm with no common duct.

Figure 2.6

1) Separate sexes; **gametes** are released into the atrium.

2) External fertilization & **development** occurs in the water.

3) **Eggs** are small and numerous, but with large amount of yolk.

4) Cleavage is fast and complete. **Blastula** leads to gastrula as in other chordates.

5) Formation of **neural tube**, **mesoderm**, **notochord**, and the **gut** all involve an upward movement of cells towards the middorsal line. This is a feature of all chordates.

Figures 2.25 and 2.26

1) Larva hatches when only two gill slits have been formed and swim by its **ciliated epidermis**.

2) Development is initially **asymmetrical** followed by symmetry in development of gill slits.

3) Presence of eight gill slits with eight branchial arches is similar to other craniates at this stage.

4) Further **slits** are then gradually added in pairs on both sides.

5) Metamorphoses continue in the **larval amphioxus** until it sinks to the bottom.

Basic Chordate Organisation

1) Amphioxus provides us with an example of a chordate that retains **ciliary mode** of feeding which was perhaps similar to the chordate ancestors.

2) Many **specializations** found in amphioxus such as for the **developed pharynx** with atrium and the asymmetry during development etc.

3) Amphioxus shows us the condition of the early fish-like chordates.