M.Sc. II Sem. (Zoology)

Holocephali - General organization and affinities

- Holocephali (Gr. Holos = entire + kephale = head), is a very small ancient group of highly specialized marine fishes.
- It comprises of rat-tailed fishes. They appeared first in the lower Jurassic and at present, are represented by a few marine genera only.
- It includes the only cartilaginous fishes having fleshy opercular covering of the gills.
- Like the Acanthodians, they seem to represent divergent and specialized descendants of some primitive elasmobranch ancestor.

Key Characters of Holocephali

- Endoskeleton cartilaginous, often calcified.
- Persistent (unconstricted) notochord; poorly developed vertebrae.
- Holostylic jaw suspension, i.e., the upper jaw is immovably united with cranium, hence the name holocephali.
- Teeth united to form crushing plates, devoid of enamel. This is an adaptation for crushing molluscs, crustaceans and sea urchins.
- The occipital condyles are well developed and are marked better than that of the sharks.
- The gill openings are only four in number and the spiracular cleft is absent. A fleshy operculum, supported by branchial rays, is attached to the hyoid arch and forms covering of the gill openings on each side.
- Median and paired fins are well developed.
- No spiracle; no air bladder; no cloaca.
- Absence of stomach and presence of spiral valve in the intestine.
- Kidney is opisthonephric corresponding fundamental pattern of other fishes.

- Sexual dimorphism is well marked. Females attain larger size than the males.
- Mature male with cephalic or frontal clasper on forehead, a pair of pelvic claspers and a pair of prepelvic tenacula.
- Oviparous.
- Fertilization internal and cleavage holoblastic.

General organization of Holocephalians

- **External Features of Holocephali:**

- Body appearance is shark-like but the head is large and compressed, having a small mouth.
- Operculum is formed by a fold of skin to cover the gill slits so that a single branchial aperture is found.
- Spiracle and cloaca are absent. Two dorsal and a ventral fin present.
- Tail appears to be heterocercal, but in Chimaera, it is whip-like. The pectoral as well as pelvic fins are large in size.
- The anal fin is small. The urinogenital aperture is distinct from the anus.
- Sexes are separate and sexual dimorphism well mark. Females are larger than the males.
- Males having cephalic or frontal clasper on forehead covered with denticles. Skin is smooth and silvery.
- Lateral line system has open grooves, with many branches on head.
- The hyomandibular does not participate in the suspension of the jaw.
- Such suspension is often called holostylic, to emphasize, that it probably evolved independently of that in dipnoans and the tetrapods.
- There are 5 gill arches with four gill openings protected by cover.
- The spiracular cleft is completely closed.

- All the pterygiophores of the first dorsal fin are fused into a single plate, the remaining fins and the pectoral girdle are on elasmobranch pattern.
- Each pelvic half consists of a narrow iliac region and a broad pubo-ischial region.
- A fleshy operculum, supported by branchial rays is attached to the hyoid arch and forms covering of the gill openings on each side.

➢ **Fins and Locomotion:**

- There are two dorsal fins. Usually the first dorsal has strong spines as in Chimaera. Anal fin is small.
- Tail is of ordinary heterocercal type but in Chimaera and Hydrolagus, it is of isocercal type.
- The paired fins are represented by a set of large pectoral and smaller pelvic fins. Pelvics are abdominal in position.
- The graceful flapping movement of large sized pectoral fins enables the holocephalians to swim by sculling the body in contrast to the swimming of the sharks.

➢ **Digestive System:**

- The mouth in holocephali is small as compared to the wide mouth of elasmobranch.
- It is bounded by three lips-like folds and equipped with the tooth plates having irregular surfaces and sharp cutting edges.
- The tooth plates have reduced pulp cavities and the layer of enamel, replaced by vasodentine.
- Vomarine, palatine and mandibular teeth are present. The gut is straight and a simple tube.
- A short oesophagus opens behind directly into a broad intestine and the latter into a short rectum, opening to the exterior by an anal aperture.
- The true stomach is altogether absent and the intestine has a well-developed spiral valve.

- **Respiratory System**:

- A mandibular pseudobranch is absent and the hyoid bears only a posterior hemibranch.
- The first, second, and third branchial arches have holobranchs but the fourth has a hemibranch.
- The fifth arch is gillless and lacks a cleft between it and its predecessor.

- **Circulatory System:**

- Heart is built upon the pattern, similar to other fishes.
- The heart consists of a sinus venosus, atrium, ventricle and conus with three rows of valves.
- The holocepalians retain urea in the blood for osmoregulation as in sharks.

- **Nervous System:**

- Cerebellum is small. Medulla oblongata is produced laterally into restiform bodies.
- The cerebral hemispheres are small and each is connected with an olfactory bulb by means of a narrow peduncle.
- Diencephalon is long and trough shaped.
- The small rounded pineal body is present at the end of a pineal stalk.

- **Urinogenital System**:

- The kidney of holocephalians is opisthonephric having a large number of uriniferous tubules and built upon the basic pattern of other fishes.
- The peritoneal funnels are absent in holocephalians but the abdominal pores are present.
- Unisexual. Clasping organs are remarkable in males only.
- Females attain larger size than the males.
- The male reproductive system consists of testes, vas deferens, epididymis and vesicular seminalis.
- The testes are large oval bodies but contain only immature sperms.

- The sperms become mature in the epididymis and form spermatophores.
- Vesicula seminalis is divided internally into several chambers by means of transverse septa.
- The spermatophores are stored in these compartments and are finally released into the urinogenital sinus.
- The female reproductive organs resemble those of the elasmobranchs and consist of a pair of ovaries, shell glands and uteri.

➢ **Fertilization:**

- The fertilization is internal and the cleavage holoblastic type.
- The incubation period is fairly long, for example, in Callorhynchus, it extends from 9-12 months.

➢ **Eggs and Development:**

- The holocephalians are oviparous.
- Their eggs are characteristically spindle shaped and are surrounded by horny egg capsules secreted by the shell glands.
- The capsules of Hydrolagus measure about 15 cm and those of Callorhynchus collei, about 25 cm, in length.
- The eggs are laid in pairs, and contain three compartments.

➢ **Sensory Organs:**

- Holocephalian's eyes are large in relation to the body size, presumably as an adaptation to their total, dark habitat in the deep sea.
- The lateral-line canals are open and are specially developed on the head and on the underside of snout.
- They differ from those of the elasmobranchs possibly because of a change in the snout's structure or the style of their food detection.
- The membranous labyrinth typically consists of three semicircular canals.
- The vertical canals forming the crus, also receive the horizontal canal.
- The endolymphatic duct opens externally by a pore.

Affinities of Holocephali

- Holocephali occupies a position in between the cartilaginous and bony fishes and have conserved certain of the primitive characteristics from their so called placoderm ancestors.
- They show resemblances with the elasmobranchs on one hand and teleosts on the other.
- They also possess a number of well-defined characters that are peculiar to the group and entitle them to be a separate class.

➢ **Resemblances with the Elasmobranchs:**

- Holocephalians show both, the characters of palaeozoic elasmobranchs as well as those of modern living sharks.

➢ **Primitive Shark's Features of Holocephali:**

- The tail is heterocercal.
- A stiff spine along the anterior edge of the first dorsal spine is retained from the ancient sharks.
- Mouth placed ventrally as also in the modern sharks.

➢ **Modern Shark's Features of Holocephali:**

- Skin smooth and silvery.
- Cartilaginous endoskeleton, devoid of any replacing or dermal bones.
- The vertebral column is ancestrous and ribless consisting of a persistent notochord with cartilaginous arches.
- Lack of bony jaws.
- Simplified brain (Diencephalon only elongated due to large sized eyes).
- The general development of chondrocranium.
- A pair of claspers present posterior to the pelvic fins in the male, as in elasmobranchs. Besides these, anterior claspers and the frontal claspers are also present in holocephali.
- The paired fins and girdles are built upon the elasmobranch pattern.

- The tail is heterocercal.
- The nasal and labial cartilages along with the orbital margins of cartilages are present.
- Air bladder is absent.
- A spiral valve is present in the intestine.
- A separate posterior superficial ophthalmic foramen is present.
- The reproductive organs on the elasmobranch pattern.
- The conus arteriosus is present in the heart and contains three rows of valves.
- Urea is retained in the blood for osmoregulation.
- Presence of egg capsule.
- The lateral line canals are distinct and suggestive of the sharks.
- Excretory system on the elasmobranch pattern

➢ **Resemblances with Dipnoi:**

- Nature of skull.
- Unconstricted notochord.
- Presence of crushing tooth plates.

➢ **Resemblances with Teleosts:**

- An operculum is present so that the gills do not open directly to the exterior but into a common chamber situated beneath the operculum.
- Single external branchial chamber is present.
- Reduced interbranchial septum, allowing gill filament to project beyond it.
- Spiracle is absent.
- Cloaca absent.
- Four complete aortic arches serving the four gill openings.

➢ **Primitive Characteristics:**

- Cartilaginous endoskeleton.
- Persistent notochord with cartilaginous arches.
- Separate external openings for each gill slit.
- Large opercular covering of the gill slits.

➢ **Specialized Features:**

- Jaw suspension holostylic.
- Presence of unusual frontal claspers.
- Absence of scales.

➢ **Holocephalians show close relationship with some placoderms like-Rhamphodopsis and Ctenurella in the following points:**

- Presence of a large labial cartilage.
- Presence of large tooth plates.
- Presence of long tail.
- Presence of a pair of rostral process to support fleshy snout.
- Presence of pre-pelvic claspers in male.
- Presence of short and deep platoquadrate.