

HOLOCEPHALI STRUCTURE AND AFFINITIES
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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:

- (1) Endoskeleton cartilaginous, often calcified.
- (2) Persistent (unconstricted) notochord; poorly developed vertebrae.
- (3) Holostylic jaw suspension, i.e., the upper jaw is immovably united with cranium, hence the name holocephali.
- (4) Teeth united to form crushing plates, devoid of enamel. This is an adaptation for crushing molluscs, crustaceans and sea urchins.
- (5) The occipital condyles are well developed and are marked better than that of the sharks.
- (6) 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.
- (7) Median and paired fins are well developed.
- (8) No spiracle; no air bladder; no cloaca.
- (9) Absence of stomach and presence of spiral valve in the intestine.
- (10) Kidney is opisthonephric corresponding fundamental pattern of other fishes.
- (11) Sexual dimorphism is well marked. Females attain larger size than the males.
- (12) Mature male with cephalic or frontal clasper on forehead, a pair of pelvic claspers and a pair of prepelvic tenacula.
- (13) Oviparous.

(14) Fertilization internal and cleavage holoblastic.

Biology 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 marked. 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.

Endoskeleton:

The vertebral column consists of a persistent (unconstricted) notochord, poorly developed vertebrae with cartilaginous arches. In Chimaera, calcified rings are embedded in the notochordal sheath. The neural arches of first three-four vertebrae are fused forming a plate and give attachment to the first dorsal fin. Holostylic skull and palatoquadrate fused with cranium. Lateral cartilages are fully developed.

The occipital condyles are well developed. Jaw suspension is autostylic. In Callorhynchus, three cartilaginous rods grow forward from the cranium providing support to the snout. Such rods are very much reduced in Chimaera. The nasal capsules are devoid of cartilaginous wall and are, therefore, continuous with the cranial cavity.

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.

Cranio-Vertebral Joint:

Specialised type of flexibility is accomplished between the skull and the vertebral column. Such a joint is of special interest because the chondrocranium extends behind into a saddle shaped

surface to articulate with the centrum of the first vertebra and bears a facet for articulation with the neural arch of the first vertebra.

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 holocephalians 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. Claspings 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:

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

Modern Shark's Features of Holocephali:

- (1) Skin smooth and silvery.
- (2) Cartilaginous endoskeleton, devoid of any replacing or dermal bones.
- (3) The vertebral column is ancestrous and ribless consisting of a persistent notochord with cartilaginous arches.
- (4) Lack of bony jaws.
- (5) Simplified brain (Diencephalon only elongated due to large sized eyes).
- (6) The general development of chondrocranium.
- (7) 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.
- (8) The paired fins and girdles are built upon the elasmobranch pattern.
- (9) The tail is heterocercal.
- (10) The nasal and labial cartilages along with the orbital margins of cartilages are present.

- (11) Air bladder is absent.
- (12) A spiral valve is present in the intestine.
- (13) A separate posterior superficial ophthalmic foramen is present.
- (14) The reproductive organs on the elasmobranch pattern.
- (15) The conus arteriosus is present in the heart and contains three rows of valves.
- (16) Urea is retained in the blood for osmoregulation.
- (17) Presence of egg capsule.
- (18) The lateral line canals are distinct and suggestive of the sharks.
- (19) Excretory system on the elasmobranch pattern.

Differences from Elasmobranchs:

- (1) Holostylic jaw suspension.
- (2) No spiracle.
- (3) Presence of skinny operculum.
- (4) Extra pelvic clasper and cephalic clasper in male.

Resemblances with Dipnoi:

- (1) Nature of skull.
- (2) Unconstricted notochord.
- (3) Presence of crushing tooth plates.

Resemblances with Teleosts:

- (1) An operculum is present so that the gills do not open directly to the exterior but into a common chamber situated beneath the operculum.
- (2) Single external branchial chamber is present.
- (3) Reduced interbranchial septum, allowing gill filament to project beyond it.
- (4) Spiracle is absent.

(5) Cloaca absent.

(6) Four complete aortic arches serving the four gill openings.

Primitive Characteristics:

(1) Cartilaginous endoskeleton.

(2) Persistent notochord with cartilaginous arches.

(3) Separate external openings for each gill slit.

(4) Large opercular covering of the gill slits.

Specialized Features:

(1) Jaw suspension holostylic.

(2) Presence of unusual frontal claspers.

(3) Absence of scales.

Resemblances with Placoderms:

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

(1) Presence of a large labial cartilage.

(2) Presence of large tooth plates.

(3) Presence of long tail.

(4) Presence of a pair of rostral process to support fleshy snout.

(5) Presence of prepelvic claspers in male.

(6) Presence of short and deep platoquadrate.