Phylum Porifera: Canal System in Sponges, Types of Canal Systems in Sponges

Canal System Introduction

The water circulatory system of sponges also called as canal system is the characteristic feature of the phylum Porifera. Canal system is also known as aquiferous system. The canal system of sponges helps in food acquisition, respiratory gas exchange and also in excretion.

The numerous perforations on the body surface of the sponges for ingression and egression of water current are the main constituents of the canal system. Inside the body, the water current flows through a certain system of spaces where by the food is captured from the incoming water and the excretory material is sent out into the outgoing water.

Functions of the water current

Water current plays the most vital role in the physiology of the sponges. The body wall of the sponges consists of two epitheloid layers the outer pinacoderm and the inner choanoderm. Pinacoderm consists of porocytes cells which bear openings called ostia. Choanoderm is composed of choanocytes or collar cells. The choanocytes have collar of microvilli around the flagellum. The water current is caused by beating of flagella of the collar cells. The following are the functions of the water current which enters the body of the sponges through the canal system:

- All exchanges between sponge body and external medium are maintained by means of this current.
- Food and oxygen are brought into body through this water current
- Also the excreta are taken out of the body with the help of this water current.
- The reproductive bodies are carried out and into the body of the sponges by the water current.

Types of canal systems

Different sponges have different arrangement and grades of complexity of internal channels and accordingly the canal system is been divided into the following three types:

Ascon type of canal system

This canal system is the simples of all the three. It is found in asconoid type of sponges like Leucosolenia and also in some of the developmental stages of all the syconoid sponges.

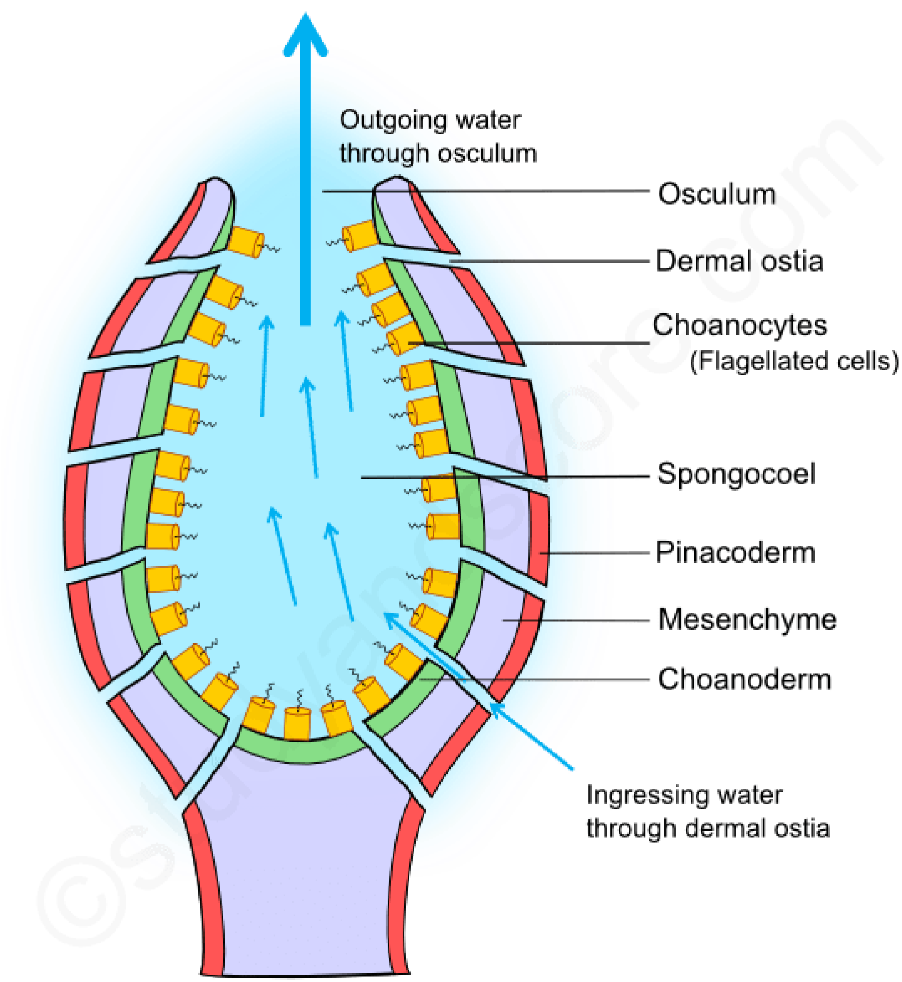
The body surface of the asconoid type of sponges is pierced by a large number of minute openings called as incurrent pores or ostia. These pores are intracellular spaces within the tube like cells called porocytes. These pores extend radially into mesenchyme and open directly into the spongocoel.

The spongocoel is the single largest spacious cavity in the body of the sponge. The spongocoel is lined by the flattened collar cells or choanocytes. Spongocoel opens outside through a narrow circular opening called as osculum located at the distal end and it is fringed with large monaxon spicules.

The surrounding sea water enters the canal system through the ostia. The flow of the water is maintained by the beating of the flagella of the collar cells. The rate of water flow is slow as the large spongocoel contains much water which cannot be pumped out through a single osculum.

Course of water current in Asconoid type canal system

Ingressing water Ostia Spongocoel Osculum outside



Ascon type canal system (Ex: Leucosolenia)

Sycon type of canal system

Sycon type of canal system is more complex compared to the ascon type. This type of canal system is the characteristic of syconoid sponges like Scypha. Theoretically this canal system can be derived from asconoid type by horizontal folding of its walls. Also embryonic development of Scypha clearly shows the asconoid pattern being converted into syconoid pattern.

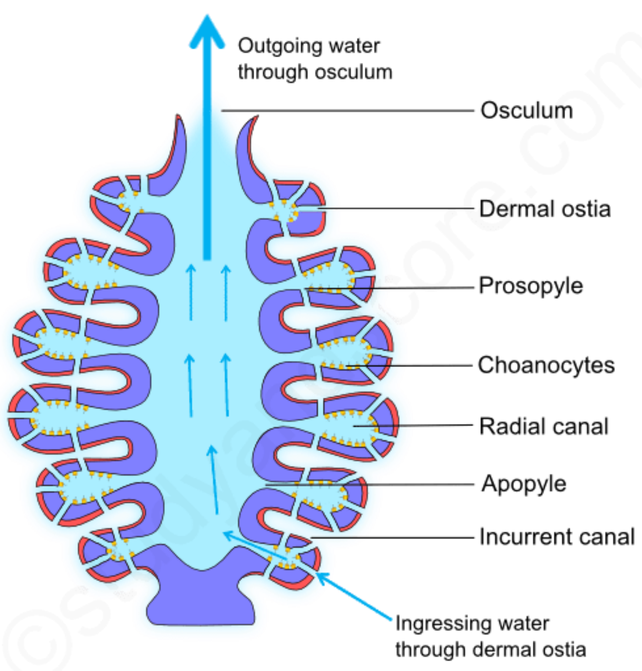
Body walls of syconoid sponges include two types of canals, the radial canals and the incurrent canals paralleling and alternating with each other. Both these canals blindly end into the body wall but are interconnected by minute pores. Incurrent pores also known as dermal ostia are found on the outer surface of the body. These incurrent pores open into incurrent canals.

The incurrent canals are non-flagellated as they are lined by pinacocytes and not choanocytes. The incurrent canals leas into adjacent radial canals through the minute openings called prosopyles. On the other hand radial canals are flagellated as they are lined by choanocytes. These canals open into the central spongocoel by internal ostia or apopyles.

In sycon type of canal system, spongocoel is a narrow, non-flagellated cavity lined by pinacocytes. It opens to the exterior though an excurrent opening called osculum which is similar to that of the ascon type of canal system.

Course of water current in Syconoid type canal system

Ingressing water dermal ostia incurrent canal Prosopyles Radial canals Apopyles Spongocoel Osculum Outside



Sycon type canal system (Ex: Scypha)

Sycon canal system takes a more complex form in few species like Grantia, where the incurrent canals are irregular and branching forming large sub-dermal spaces. This is due to the development of cortex, involving pinacoderm and mesenchyme spreading over the entire outer surface of sponge.

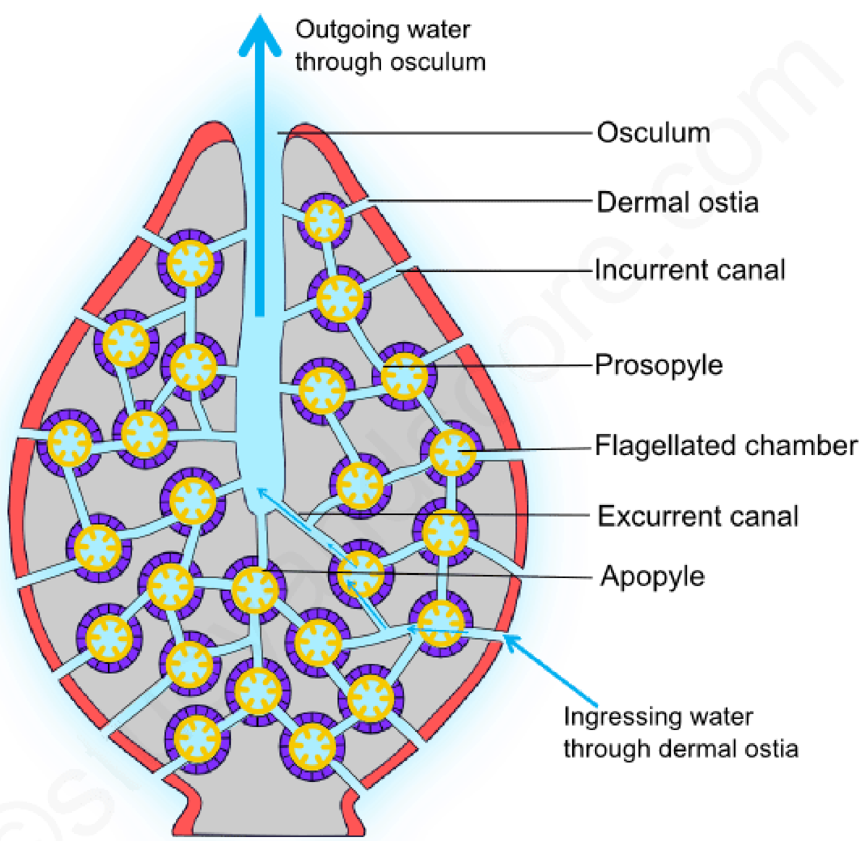
Leucon type of canal system

This type of canal system results due to further folding of body wall of the sycon type of canal system. This canal system is the characteristic of the leuconoid type of sponges like Spongilla. In this type the radial symmetry is lost due to the complexity of the canal system and this result in an irregular symmetry.

The flagellated chambers are small compared to that of the asconoid and syconoid type. These chambers are lined by choanocytes and are spherical in shape. All other spaces are lined by pinacocytes. The incurrent canals open into flagellated chambers through prosopyles. These flagellated chambers in turn communicate with the excurrent canals through apopyles. The excurrent canals develop as a result of shrinkage and division of spongocoel. The large and spacious spongocoel which is present in the asconoid and syconoid type of canal systems is absent here. Here the spongocoel is much reduced. This excurrent canal finally communicates with the outside through the osculum.

Course of water current in Leuconoid type canal system

Ingressing water dermal ostia incurrent canal Prosopyles Flagellated chambers Apopyles excurrent canals Osculum Outside



Leucon type canal system (Ex: Spongilla)

Leucon type of canal system has the following three successive grades in its evolutionary pattern:

Eurypylous type: This is the simplest and the most primitive type of leuconoid canal system. In this type the flagellated chambers directly communicate with the excurrent canal through broad apertures called the apopyles.

Ex: *Plakina*

Aphodal type: In this type of canal system the apopyles are drawn out as a narrow canal called aphodas. This connects the flagellated chambers with the excurrent canals.

Ex: *Geodia*

Diplodal type: in some of the sponges, along with aphodas another narrow tube called prosodus is present between incurrent canal and flagellated chamber. This arrangement gives rise to diplodal type of canal system.

Ex: *Spongilla*

Neoteny and Paedogenesis of Amphibia

In the genus Amblystoma (urodele) the animal sometimes becomes sexually mature in the larval condition and does not metamorphose (Siredon, the axolotl). This phenomenon of the retention of larval characters in the sexually mature state has been called neoteny or paedogenesis. It is not confined to Amblystoma but is found occasionally in the genus Triton.

It is a physiological adaptation. It also happens in Necturus and Amphiuma (obligate neoteny) and in these metamorphosis cannot be induced by thyroxine T_4. While in axolotl, Amblystoma, some or all of the individuals of a given population metamorphose. In these facultative neotenes thyroxine T_4 generally induces metamorphosis. Neoteny is due to a low level of thyrotropin releasing hormone (TRH) probably due to a combination of genetic predisposition with environmental factors.
Lack of iodine has been shown to produce epigenetic suppression of metamorphosis as in an English population of Triturus. In neoteny the terrestrial phase is eliminated, the aquatic larva becomes sexually mature. The larval stage is often considered as a survival of the ancestral fish type.

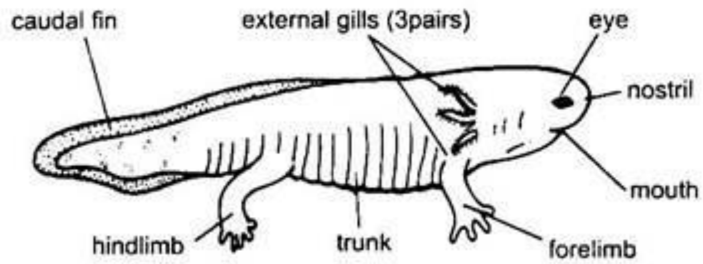


Fig. 20.3. Axolotl larva of *Amblystoma tigrinum* (tiger salamander).

Paedomorphosis is the retention of those characters which occurred in younger stages of the ancestors of a sexually mature descendant. It is considered that paedogenesis (reproduction in a pre-adult form) has been a powerful influence in the evolution of at least some animal types (Garstang). A classical case of paedogenesis is provided by the Mexican Axolotl, which frequently breeds in the gilled or larval state.

The experimental administration of thyroxin, especially when the animal is very young, causes it to lose its gills, develop lungs, and emerge from the water in an adult form very like the black and orange tiger salamander (Amblystoma tigrinum) of North America.

Metamorphosis can be induced also by reducing the water level in which the axolotl lives and, thus, making gill respiration difficult, while at the same time facilitating pulmonary respiration. It is to the branchiate stage that the name Axolotl properly applies.

Feeding Mechanism of Snakes

Snakes do not “slime” their victims before swallowing. Teeth are sharp-pointed, curved backwards and ankylosed to the jaws. They are present on the maxillae, palatines, pterygoids and on the dentaries. Teeth occasionally absent from pterygoid. They chiefly serve to hold the prey while it is being swallowed. Snakes feed exclusively on living animals, both warm- and cold-blooded. They swallow the prey without mastication.

Swallowing is effected thus- teeth on the lower jaw are alternately hooked further and further forwards into the body of prey (the two halves of the mandible moving forwards alternately), as a result of which mouth and pharynx of the snake are gradually drawn over the animal, the surface of which is at the same time made slippery by the secretion of the buccal glands.

During this process the larynx is projected forwards between the rami of the jaws, so that respiration can be maintained. After the completion of the laborious process of swallowing, the animal appears to be entirely prostrated and passes a long period in inactivity, during which slow digestion takes place.

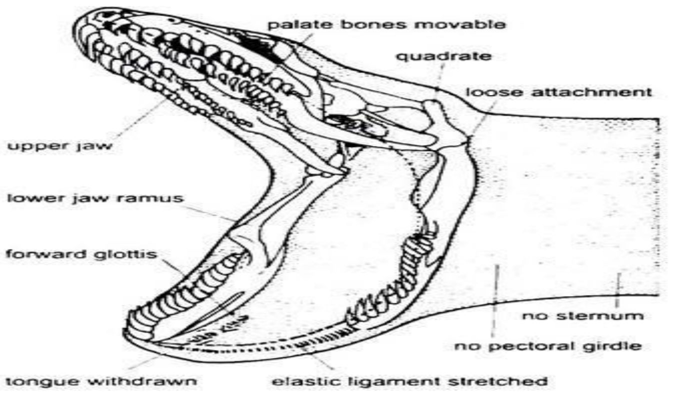


Fig. 23.1. Snake. Mechanism of swallowing large objects.

Some snakes kill their prey by crushing, e.g., Python; some by poison and others, the majority, swallow their prey directly. Digestion begins in the stomach and is rapid. When a large animal is being slowly engulfed, the first part of the prey is partly digested before the hind-parts have been swallowed. After taking in a large meal, pythons are able to do without another for more than a year.

Besides pepsin secreted by fundic region of stomach, snake venom also assist in digestion. Swallowed rat by a boa constrictor, bones of its head have disappeared in two days and the whole skeleton in five days. Dasypeltis, the egg-eating snake, swallows the eggs whole and crushes them with special tooth-like processes of the neck vertebrae.

Poison Apparatus in Snakes

The poisonous snakes possess poison apparatus in their heads. It is absent in non-poisonous snakes.

The poison apparatus consists of a pair of:

1. Poison glands, 2. Their ducts, 3. A pair of fangs and muscles.

The poison glands are situated one on either side of the upper jaw. Each poison gland is sac-like (oval) in sea snakes or large and tubular in vipers.

In Naja naja, the poison gland is about the shape and size of an almond kernel. The gland is thickly encapsulated with fibrous connective tissue. It is composed of a body and a neck. The roughly fan-shaped capito-mandibularis superficial muscle, originating on the post-frontal (post-orbital) bone and parietal ridges, embraces much of the body of the poison gland.

Its contraction during biting, swiftly and synchronously squeezes poison into the poison duct. The duct passes forward along the side of the upper jaw and loops over itself just in front of the fang and opens either at the base of the fang or at the base of the tunnel on the fang.

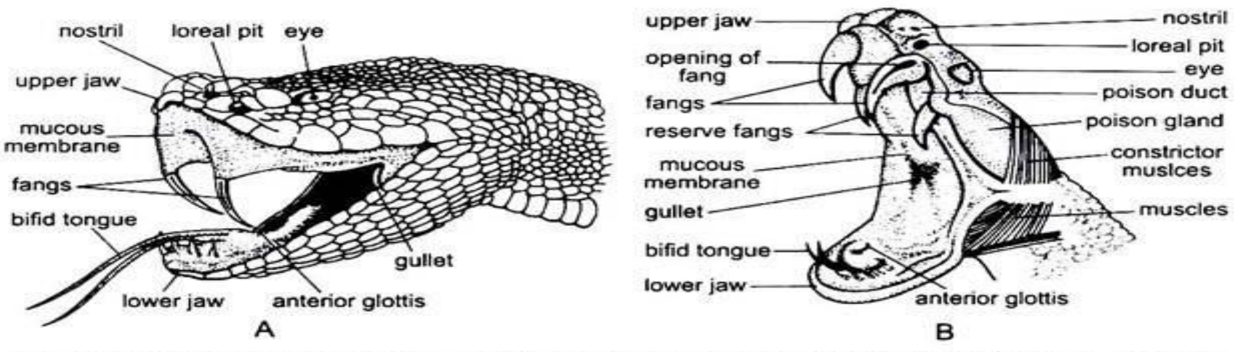


Fig. 23.2. Pit viper. A–Head of *Lachesis muta* (undissected); B–Head of rattle snake, *Crotalus*, dissected to show poison apparatus.

1. Poison Glands:

The labial glands are present in a row in the upper and lower jaw. The posterior labial gland of the upper jaw is modified as the poison gland in the poisonous snakes. It is larger than the rest and different in structure.

2. Poison Ducts:

From the anterior end or neck of each poison gland arises a poison duct.

3. Fangs:

In poisonous snakes some of the maxillary teeth become poison fangs. These are usually larger than the ordinary teeth and are either grooved or perforated by a canal for the passage of the duct of the poison gland. Fangs are long, curved and pointed. The fangs regenerate by one of the small reserve fangs at its base (vipers). On the basis of structure and position, three types of fangs occur in poisonous snakes.

These are as follows:

(a) Solenoglyphous (solen = pipe + glyph = hollowed):

In Viperidae (vipers and rattle snakes), there is a single, large, curved, poison fang on the maxilla with small reserve-fangs at its base. These are the only teeth borne by the maxilla, which is very short. The large poison fang is capable of being rotated through a considerable angle, and moved nearly horizontal position (in which it lies along the roof of the mouth embedded in folds of the mucous membrane) to a nearly vertical position, when snake opens its mouth to strike its prey. Each poison fang contains a canal open at each end.

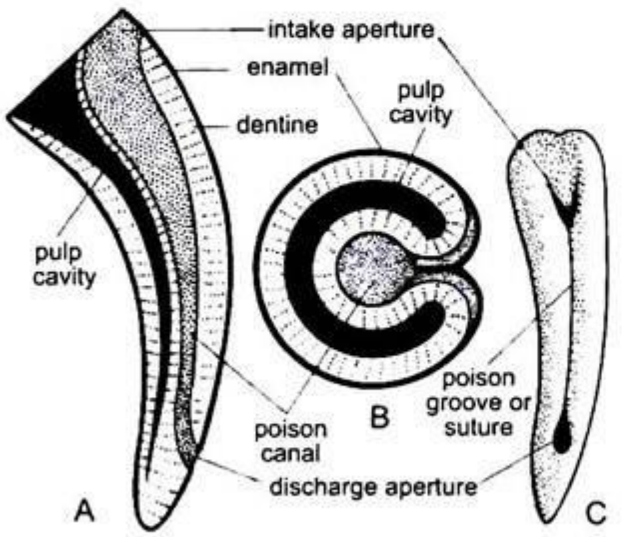


Fig. 23.3. Snake fangs. A–Solenoglyphous fang in L.S; B–Solenoglyphous fang in T.S.; C–Entire grooved fang.

(b) Opisthoglyphous (opistho = behind):
In some poisonous snakes of the family Colubridae (subfamily Homalopsinae, Dipsadomorphinae and Elachiostodontinae) such as Dryophis, Elapops, Lycognathus, Elachistodon westermanni found in Bengal, etc., one or more of the posterior maxillary teeth grooved along its posterior border. There are more or less poisonous and poison is weak.

(c) Proteroglyphous (protero = first):
In sea snakes, Bungarus (krait), cobras (Naja), fangs (anterior maxillary teeth) are small, permanently erect and grooved along its anterior face.

(d) Aglyphous:
Fangs are lacking, so such snakes are non-poisonous.

4. Muscles:
The poison apparatus is associated with specialised bands of three types of muscles, viz.
(i) Digastric

(ii) Sphenopterygoid or protractor-pterygoid and

(iii) Anterior and posterior temporalis.

Digastric muscle is attached to the squamosal of the skull at one end and the articular of the lower jaw.

Sphenopterygoid is attached anteriorly to the sphenoidal region and posteriorly to the dorsal surface of the pterygoid. It helps in pulling the pterygoid forward Anterior and posterior temporalis muscles are attached to the sidewalls of the cranium and the lower jaw. They help in closing the lower jaw.

Biting Mechanism of Snakes:
The skull and jaw bones in poisonous snakes are loosely and movably articulated, thus, allowing an enormous gape and swallowing whole of large prey. In cobras fangs are small and remain permanently erect, but in vipers the fangs are large and curved and lie against the root of mouth cavity when closed. Premaxilla, usually toothless and the bones of the upper jaw are loosely attached to rest of the skull. Quadrate jointed to the squamosal.

There are movable joints between the frontals behind and prefrontals and nasals in front and also between several other bones of brain case, palate and jaws. These joints have loose ligaments and allow movement in several directions and so permit a huge gap. The two halves of the lower jaw are connected together by elastic ligamentous tissue. So they are capable of being widely separated from one another.

The mechanism of biting is a complicated process and it can be described in the following four steps**:**
(i) Opening of the Mouth:
By the contraction of digastric muscles the mouth is opened (lower jaw moves down).

(ii) Rotation of Maxilla:
As the mouth opens the lower jaw moves down and the lower end of quadrate moves forward. Quadrate and squamosal are very movable. The pterygoid is movably attached to the palatine. Quadrate pushes the pterygoid forward and the pterygo-palatine joint bent.

This forward movement of the pterygoid is conveyed by the transpalatine bone to the maxilla and causes it to rotate through about 90° upon its prefrontal articulation in such a way that the surface to which the fang is attached is carried forwards and ventralwards, and the fang is erected, i.e., is made to project downwards at the front end of the mouth. The contraction of sphenopterygoid muscles also helps in the movement of pterygoid forward.

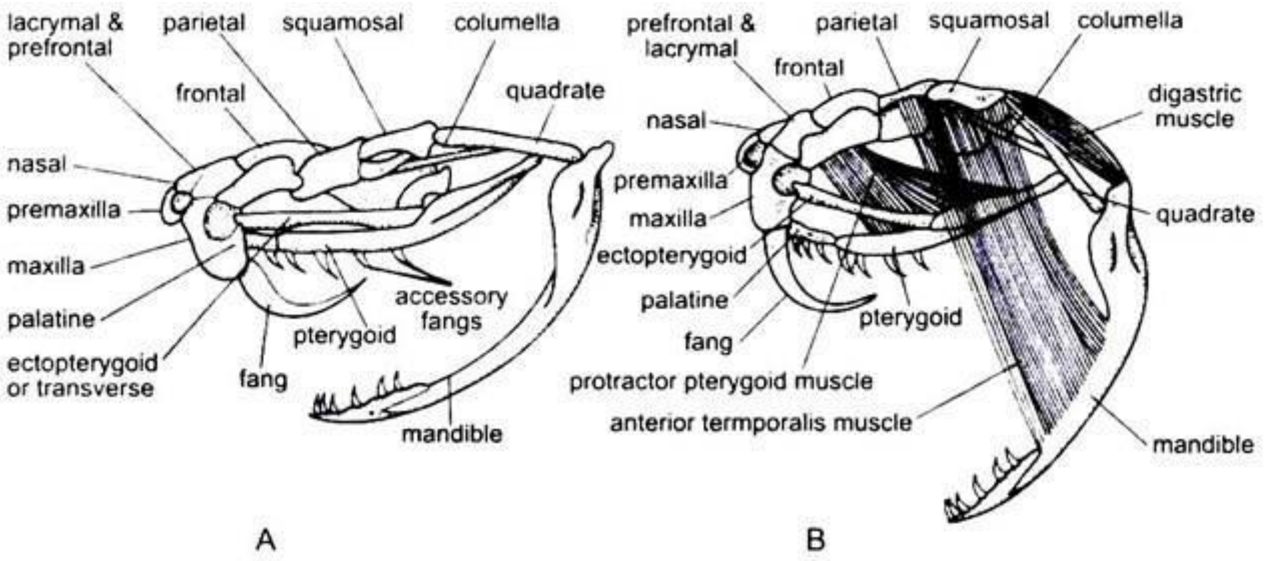


Fig. 23.4. Skull of a viper showing biting mechanism. A–Mouth closed at rest; B–Mouth opened when striking the prey.

(iii) Closing of Mouth:

The closing of the mouth is brought about by the contraction of the temporalis and sphenopterygoid muscles. The point of fang is directed backward while the mouth is closed. It takes longer time to open the mouth than to close it.

(iv) Transference of Venom:

During the contraction of the digastric muscle the posterior ligament is relaxed and during the rotation of the squamosal bone the fan-shaped ligaments are stretched to squeeze the wall of the poison gland. This makes the poison to come out of the poison gland through the poison duct and the fang.