Poison apparatus and the biting mechanism of snakes

B.Sc. Part – I (Honours)

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Contents

Poisonous Apparatus Structure

Poison Gland

The poison apparatus of snakes consists of a pair of poison glands, their ducts and a pair of fangs. In poisonous snakes the poison glands are situated one on either side of the upper jaw. The poison glands are possibly the superior labial glands or parotid glands. Each poison gland is sac-like and provided with a narrow duct at its anterior end. Capsule sends vascular fibrous septa that separate the glandular substances into secretory pockets.

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. The poison gland is held in position by ligaments. An anterior ligament attaches the anterior end of the gland to the maxilla. A posterior ligament extends between the gland and the quadrate. Fan-shaped ligaments are situated between the side walls and squamoso-quadrate junction.

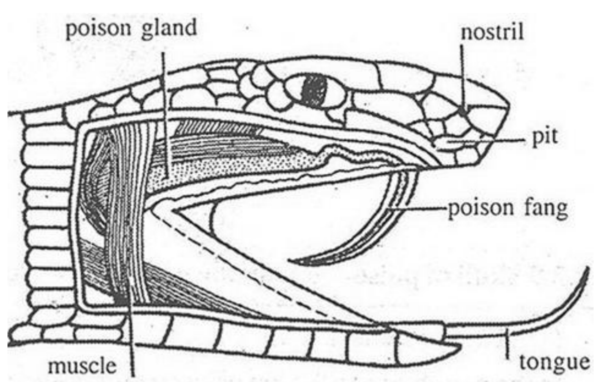


Figure 1: Poison apparatus of snake

Fangs

The fangs are sharply pointed and enlarged maxillary teeth. Snakes eject venoms by their two hollow maxillary teeth called fangs. Fangs are long sharply pointed and hook like, being extremely hard and calcified with a superficial enamel layer. Fangs regenerates when lost. **Fangs** can be classified as follows:

According to the structural differences of poison fangs:

i. Open type and ii. Closed type.

In **open type** as in cobras the poison groove is open and in **closed type** as in vipers, the poison groove forms a tunnel having two openings one at the base and one near the apex.

According to the position of poison fangs

Most snakes have several tooth bearing bones including four (the premaxilla, maxilla, pterygoid and palatine) in the upper jaw and the dentine in the lower jaw.

The teeth of modern snakes are classically divided into four types, three of which are classically called fangs. The name of all the teeth involves the Greek word *glyph,* which literally means grooves. They are as follows:

Solenoglyphous

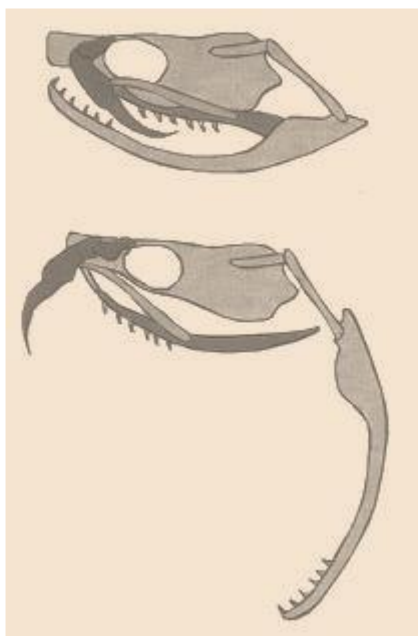


Figure 2: Folding of Solenoglyphous fangs.

- Fangs are long and tubular and attached to the snake's maxillary bone.
- Only single tooth, the fang is present on the maxilla, the maxilla is hinged so that the fangs can be folded back parallel to the jaws when the mouth is closed, or erected perpendicular to the jaw when the snake is striking.

- The teeth in pterygoid and dentine works together to manipulate food once inside the mouth.
- Solenoglyphous fangs are strikingly similar to hypodermic needles. They have a hollow core that receives venom from the venom gland at the entrance orifice near the base and injects it from a slit-like exit orifice on the front of the fang near the tip. If the opening were at the very tip of the fang, its strength would be compromised and it would lack the sharp point needed to penetrate the target.
- Example – vipers and rattle snakes.

Proteroglyphous

- Proteroglyphous fangs are in the front of the mouth and are about three times shorter than solenoglyphous fangs.
- Unlike solenoglyphs, some proteroglyphs have other teeth on the maxilla behind the fang. However, the fang is always separated from the other teeth by a gap, called a diastema.
- . Some elapids have more than one functional fang on each side.
- In both vipers and elapids, there are usually at least two fangs on each maxilla at any one time, one that is in use and one that is a reserve fang.
- Both fangs are draped in a layer of connective tissue and skin called the fang sheath.
- Some proteroglyphs have partially movable fangs, including many of the most dangerous species such as mambas, taipans, and death adders.
- A few, such as spitting cobras, have modified exit orifices to their fangs that are smaller and rounder than in other cobras, a modification that increases the velocity with which venom is ejected.
- Example – Elapids and sea snakes.

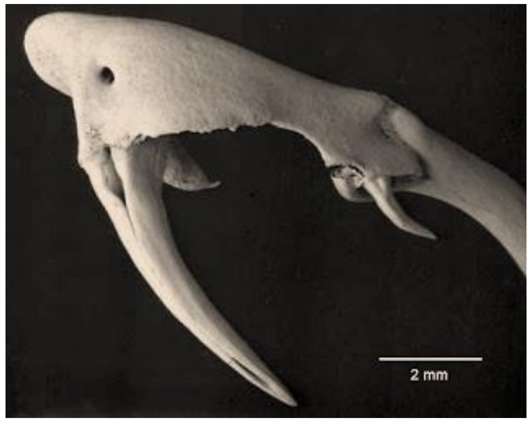


Figure 3: Maxilla of a proteroglyphous snake.

Opisthoglyphous

- Opisthoglyphous fangs are grooved rather than hollow and are found near the back of the maxilla, behind the normal teeth.
- Most opisthoglyphous fangs are connected to Duvernoy's glands, which differ from true venom glands in several important ways, most notably in that they lack associated muscles to generate the pressure needed to evacuate venom, as in solenoglyphous and proteroglyphous snakes
- The pressure on the venom glands of biting solenoglyphs and proteroglyphs can exceed 30 psi, the pressure of a car tire, whereas the pressure inside the Duvernoy's glands of opisthoglyphs is generally less than 5 psi.
- Because Duvernoy's glands also lack a chamber for storing venom, the idea is emerging that opisthoglyphous snakes probably secrete their venom only during chewing.
- Example – some colubrid snakes.

Figure 4: Opisthoglyphous fangs of Boomslang (Dispholidus typus)

Aglyphous

- This word is used to describe unmodified teeth, essentially non-fangs. All snakes, even those that possess fangs of the first three types, have aglyphous teeth which they use for gripping their prey as they manipulate it during swallowing.
- This species has enlarged posterior maxillary teeth that lack grooves, so they are by definition aglyphous.
- Among colubrid, the distinction between opisthoglyphs and aglyphs has never been entirely clear.
- Example – *Python, Boa*

Muscles associated with snake biting mechanism

The poison apparatus is associated with specialized bands of three types of muscles viz. i. digastrics ii. Sphenopterygoid iii, anterior and posterior temporalis

i. Digastric muscle – Attached to the squamosal of the skull at one end and articular of the lower jaw at the other end.
It helps in opening jaws.

ii. Sphenopterygoid – attached anteriorly to the spheroidal region and posteriorly to the dorsal surface of the pterygoid.
It assists in pulling the pterygoid forward.

iii. Anterior and posterior temporalis – attached to the side walls of the cranium and the lower jaw.
They help in closing the lower jaw.

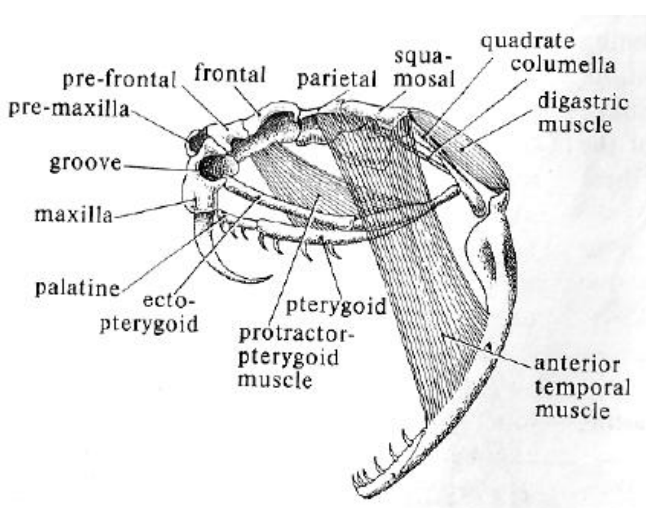


Figure 5: Muscles associated with poison apparatus

Snake Biting Mechanism

There are four distinct phases when a poisonous snake bites: (1) The strike; (2) opening of the mouth and elevation of the fangs; (3) closing of the jaws and the injection of venom; (4) retraction of the fangs.

I. **The strike. –**

In this phase the snake throws itself forward with great rapidity and violence, the distance covered not generally exceeding one-third of its length. Vipers strike with greater velocity than the colubrids, some of which especially the hooded species raise the head from the ground thus compensating to some extent for the limited mobility of the fangs.

II. **Opening of the mouth and elevation of the fangs.-**

Most poisonous snakes commence the strike with closed jaws, but as the head approaches the victim the mandibles are depressed by a rapid contraction of the digastric, cervico-mandibular and vertebro-mandibular muscles and simultaneously the fangs are elevated or rotated forward by the forward swing of the pterygo-palatine-transverse arch produced by the contraction of the spheno- and parieto-pterygoid muscles. The fangs of the Colubrida are invariably grooved and are generally shorter than those of the viper, and their capacity for forward rotation is much more limited. The degree of elevation from extreme retraction to maximal protraction varies from 10°- 15^{o} to 45^{0}-50^{0} in different species. Each pterygo-palatine-transverse arch acts as a single entity, and then the protractor muscles of the palate draw the endo-pterygoid forward, they invariably bring with it the palatine bone and the ecto-pterygoid which impinges on the posterior arm of the maxilla, driving the maxilla forwards and upwards on the articulating surface of the prefrontal. This produces a variable degree of elevation and forward rotation of the fangs, which are ankylosed to the inferior surface of the maxilla; its extent can be judged by the angle formed at the ecto-pterygoid maxillary junction which, in the resting position, forms a straight line. In these snakes, the smaller the maxilla the greater the forward movement of the pterygo-palatine-transverse arch and the greater the degree of forward projection of the fangs (i.e. the greater the maxillary index). This mechanism differs from that of the vipers in which the movement of the maxilla on the prefrontal is a true rotary one and not a forward and upward sliding movement as described above.

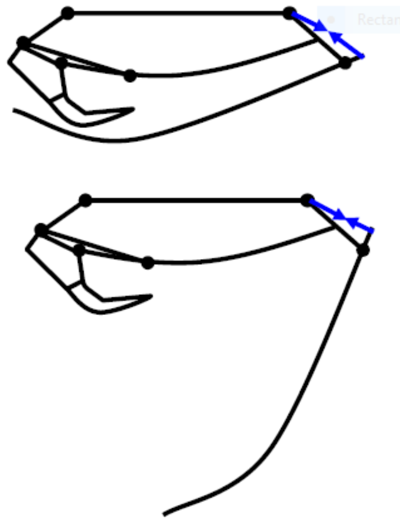


Figure 6: Contraction of the digastric brings about the opening of mouth

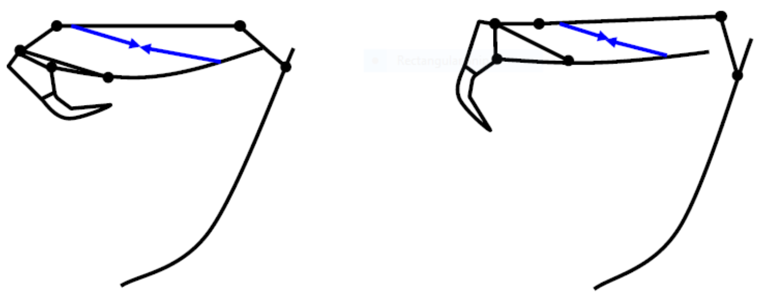


Figure 7: Sphenopterygoid contracts and brings about the rotation of maxilla and elevation of fangs

III. **Closure of the mouth and the injection of venom.-**

Closure of the jaws follows, a result brought about by the simultaneous contraction of the anterior, middle and posterior temporal muscles which strongly elevate the mandibles. In the colubrids the venom gland is also compressed by the superior and inferior portions of the anterior temporal muscles, producing torsion on its capsule with the expulsion of venom from the gland along the duct, the papilla of which becomes approximated to the groove at the base of the fang, but in certain Australian species venom may sometimes be observed to spurt a considerable distance during a snap bite at a time when no object is actually being bitten. In the vipers there is an entirely different anatomical arrangement of muscles acting on the venom gland; expulsion of its contents is instantaneous and independent of fixation of the lower jaw.

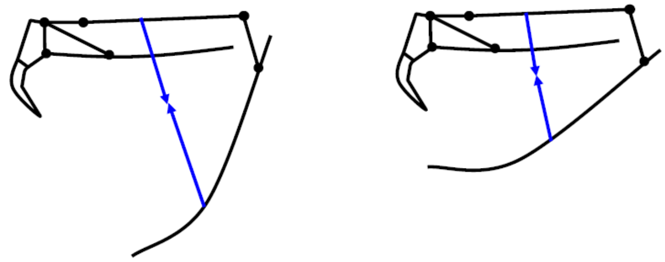
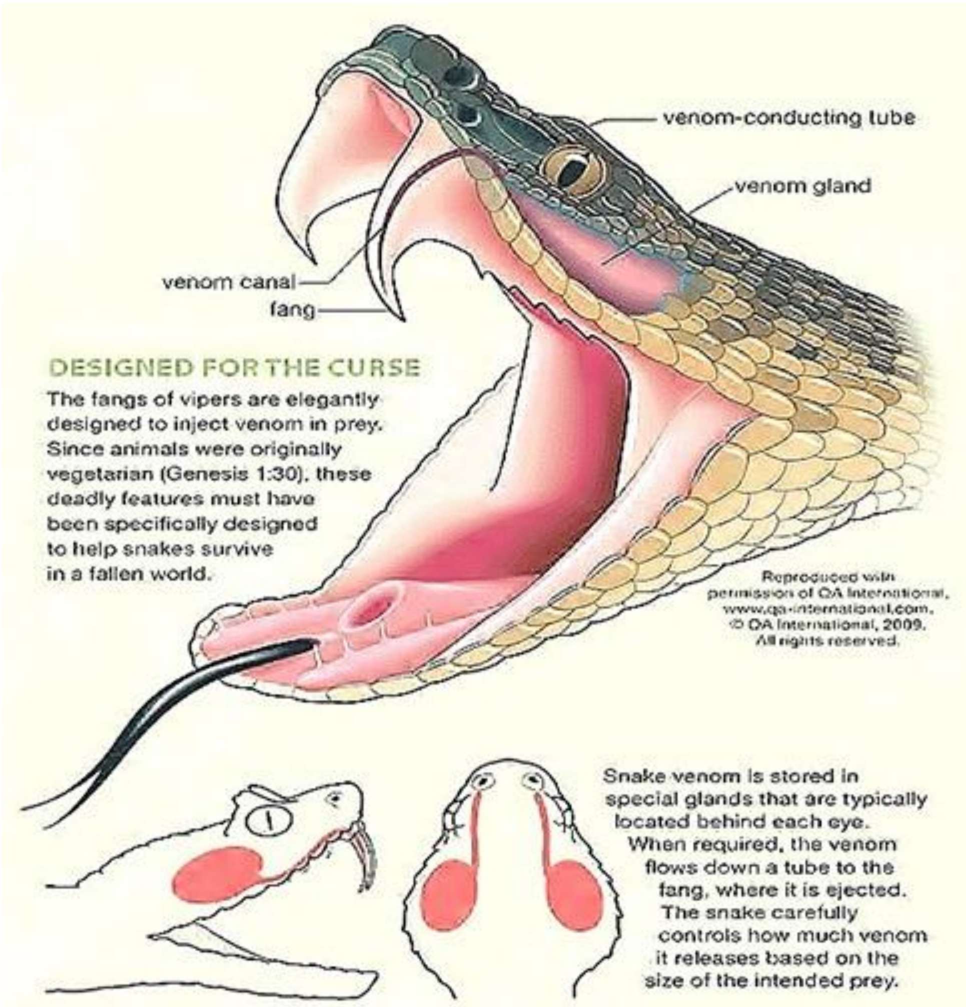


Figure 8: Temporalis helps in closing the mouth.

IV. **Retraction of the fangs.-**

Immediately following the insertion of the fangs, and actually accompanying the discharge of venom, contraction of the retractor muscles which operate on the pterygo-palatine-transverse arch occurs, dragging the elevated fangs downwards and backwards through the tissues.

Though the four stages including the inoculation of venom are described separately, they occur in nature as a series of rapidly co-ordinated movements, several lethal doses being injected in a fraction of a second in some instances-especially with the vipers.

- 

venom-conducting tube
venom gland
venom canal
fang
DESIGNED FOR THE CURSE
The fangs of vipers are elegantly designed to inject venom in prey. Since animals were originally vegetarian (Genesis 1:30), these deadly features must have been specifically designed to help snakes survive in a fallen world.
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Snake venom is stored in special glands that are typically located behind each eye. When required, the venom flows down a tube to the fang, where it is ejected. The snake carefully controls how much venom it releases based on the size of the intended prey.

Difference between Non-poisonous Poisonous snakes:

Characters	Non-Poisonous Snakes	Poisonous Snakes
1. Physical features	Stout, dull coloured.	Slender, brightly coloured
2. Head	Rounded or elliptical	Triangular or posterior broadened
3. Head Scales	Large	Small
4. Saliva	Non-toxic	Contains toxic peptides and enzymes
5. Fangs	Not present.	Present, hollow like hypodermic needles
6. Teeth	several small teeth	Two long fangs.
7. Pupils	Rounded	Elliptical pupil
8. Anal Plate	Double row	Single row
9. Tail	Not much compressed, rounded	Compressed
10. Ventral belly plates	Small, never extends across the belly	Broad and always extended across the entire width of the belly
11. Bite mark	Row of small teeth	Fang Mark
12. Family	Boidae, Uropeltidae, Xenopeltidae, Typhlopidae	Viperidae, Elapidae, Colubridae, Hydrophidae
13. Examples	*Oligodon arnensis, Dendrelaphis tristis, Ahaetulla nasuta, Zamenis longissimus*	*Bungarus caeruleus, Daboia russelii, Ophiophagus hannah, Naja naja*

Review Questions

1. State four differences between poisonous snake and non poisonous snakes citing at least three Indian examples of each. [4]
   1997, 1999, 2006, 2008, 2010
2. Describe the structure of poison gland. [3]
   1997, 2006, 2008, 2010
3. Give an account of the muscles involved in the biting mechanism of poisonous snakes, and also illustrate the biting mechanism. [3+3]
   2005, 2006, 2008, 2010
4. Distinguish between proteroglyphous and solenoglyphous fangs. [4]
   1999