M.Sc. 1st Semester ; Course Code: Zoo-02-CR; Unit: III (3.2)

Modification of foot in molluscs

Brief Introduction:

Phylum Mollusca is characterised by the pronounced development of musculature known as the foot. It is the locomotory organ in Molluscs. This organ is quite uncommon and strange to others. It is regarded as the remnant of the 'dermo-muscular tube' of the ancestral form whose ventral side became greatly developed as an adaptation for creeping movement and the dorsal portion became degenerated.

In Mollusca, the foot originates at first as the ventral or ventro-lateral elevation of the ectodermal cells behind the mantle emerging in Veliger and some other larval forms, later the mesodermal cells incorporate to give it a definite shape. Depending on different modes of locomotion and living in varying environment, the foot in Molluscs varies greatly in shape and form Variation of foot is primarily due to various physiological activities like creeping or crawling, burrowing, leaping, looping, swimming, reproduction, etc. Besides these, in parasitic and sedentary forms, the modification of foot occurs in the form of sucker, byssus apparatus, etc.

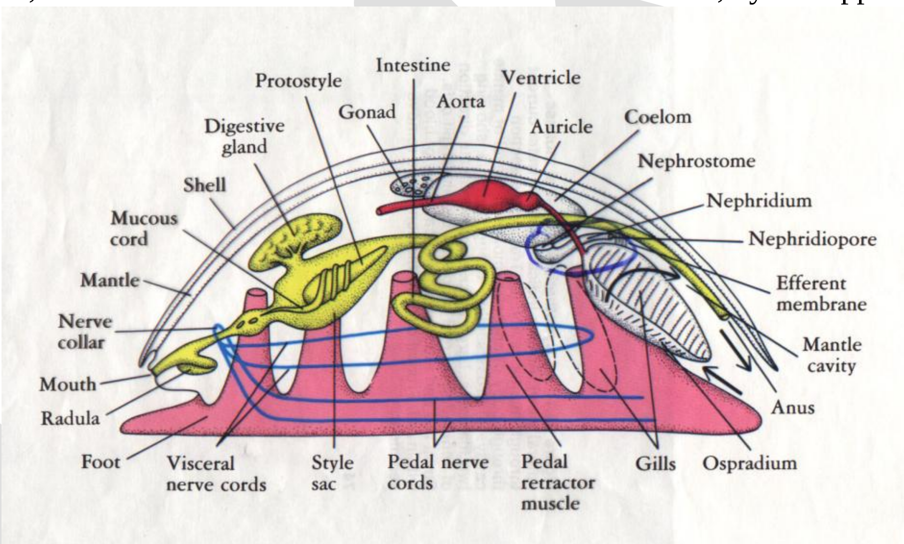


Fig: Generalized Mollusc (Lateral view)

Modifications of Foot

1. Foot-as the Creeping or Crawling Organ:

a) Class Aplacophora:

True molluscan foot is absent in Aplacophorans but some structure may be regarded to be the starting point. The ventral foot in Chaetoderma, Limifossor (Subclass Chaetodermomorpha) is absent.

In Neomenia (Subclass Neomeniomorpha), a mid-ventral groove from mouth to anus with non-muscular ciliated ridge is believed to be homologous with the foot of other molluscs and serves as locomotory organ (Fig. 2U). The foot helps to glide or to creep over the substratum with a mucous trail.

b) Class Polyplacophora:

In Polyplacophora, the foot of Chiton is broad, muscular and flattened that extends the entire ventral surface of the body (Fig. 2A). In Chitonellus and Crypsoplax the foot is narrow. In Ischnochiton the anterior portion of the foot is elongated.

The foot helps to creep or glide on the rocky substratum by the waves of muscular activity which is lubricated by mucus glands. It also helps to be attached firmly to the rocks by generating a suction, secreting the mucus along the girdle.

c) Class Monoplacophora:

In Neopilina and Vema the foot is centrally placed, broad, flattened and almost circular in outline. The foot helps in creeping by muscular movement.

d) Class Gastropoda:

In most gastropods the foot is an elongated, flat creeping sole that contains numerous mucus-producing gland cells. In the members of the subclass pulmonata the foot is undivided with a very large flat lobe containing a large pedal gland. In these cases the foot is used for creeping on a mucous trail. The terrestrial pulmonates retain the primitive type of foot.

The locomotion of most pulmonates is accomplished by the monotaxic waves, i.e., the amplitude of the wave proceeds across the entire width of the foot. In prosobranchs, Patella has a well-developed ventral foot with a flat creeping sole which is adapted for clinging or moving over the rocks (Fig. 2C). The creeping foot may be contractile as in Triton. In some cases foot shows partial regional modification.

In Pirulus only the left part of the foot acts as creeping organ. In Acteon (Fig. 2K) and Cypraea foot has a large creeping sole. They move by producing waves of contraction on the foot.

In Bullia (Fig. 2R) the foot is peculiar and encircles the whole of the body. In Atlanta the posterior part of the creeping foot is altered into a sucker. In Haliotis (Fig. 2B), the epipodium is well- developed with many small tentacles (sensory in function).

The flat sole of Murex (Fig. 2S) and the highly glandular foot of Conus (Fig. 2G) with a long backwardly bent siphon are efficient creeping organs. In Caecum, the creeping movement is performed only by the action of cilia present in the ventral surface of the foot. The bubble snail, Bulla crawl rapidly on the surface of soft bottom as their foot is widely extended on all sides.

Mechanism of Locomotion:

Typical creeping movement in molluscs, especially in gastropods, is brought about either by muscular activity or by a combination of ciliary and muscular activity. Muscular activity of the foot during creeping movement is affected by a series of wave-like contractions of the longitudinal muscles of foot.

The waves of contraction may be monotaxic, i.e., the wave spreads along the entire width of the foot or ditaxic, i.e., the wave spreads only half of the width of the foot and the animals are progressed by advancing alternately the right and left sides of the foot.

The wave of muscular contraction may be direct, i.e., the wave is moving in the same direction as the movement of the animal or may be retrograde, i.e., when the pedal wave passes from forwards to backwards.

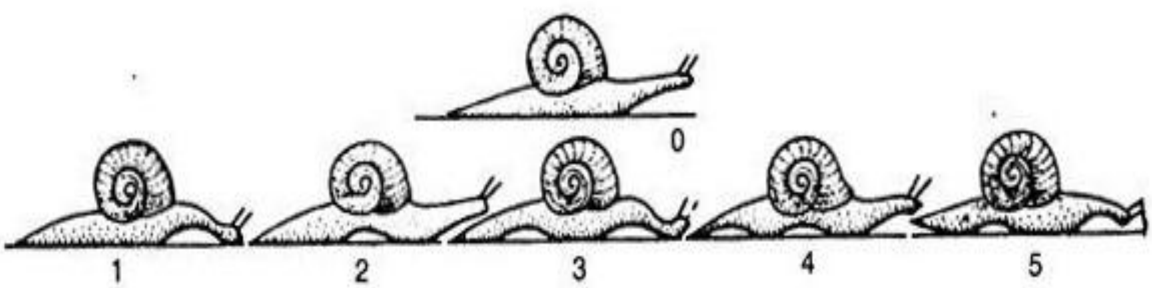


Fig.1: Showing successive events in 'galloping' movements in *Helminthoglyptadupetithouarsi*.

In most of the molluscs the amplitude of the waves is small but in some gastropods as exemplified by Helminthoglyptadupetithouarsi (Fig.1) the amplitude as well as wavelength are increased during galloping motion. During galloping motion the anterior portion of foot is elevated and thrust forward (Fig. 2). Foot gets the nerve supply from the pedal ganglion.

d) Bivalvia:

The foot in Nucula and Area are considered as primitive type, which possess a flat, ventral surface of sole on which the animal creeps.

2. Foot-as the burrowing organ:

In some molluscs foot becomes greatly deviated to act as burrowing organ.

a) Class Scaphopoda:

In Dentalium the foot is conical, trilobed and protrusible (Fig. 2H). In Siphonodentalium, the foot terminates in a retractile disc with papillated margins. The foot of the Scaphopoda is adapted rowing habit in sand and the co foot is buried into sand and lateral the foot, epipodial lobes assist in burrowing.

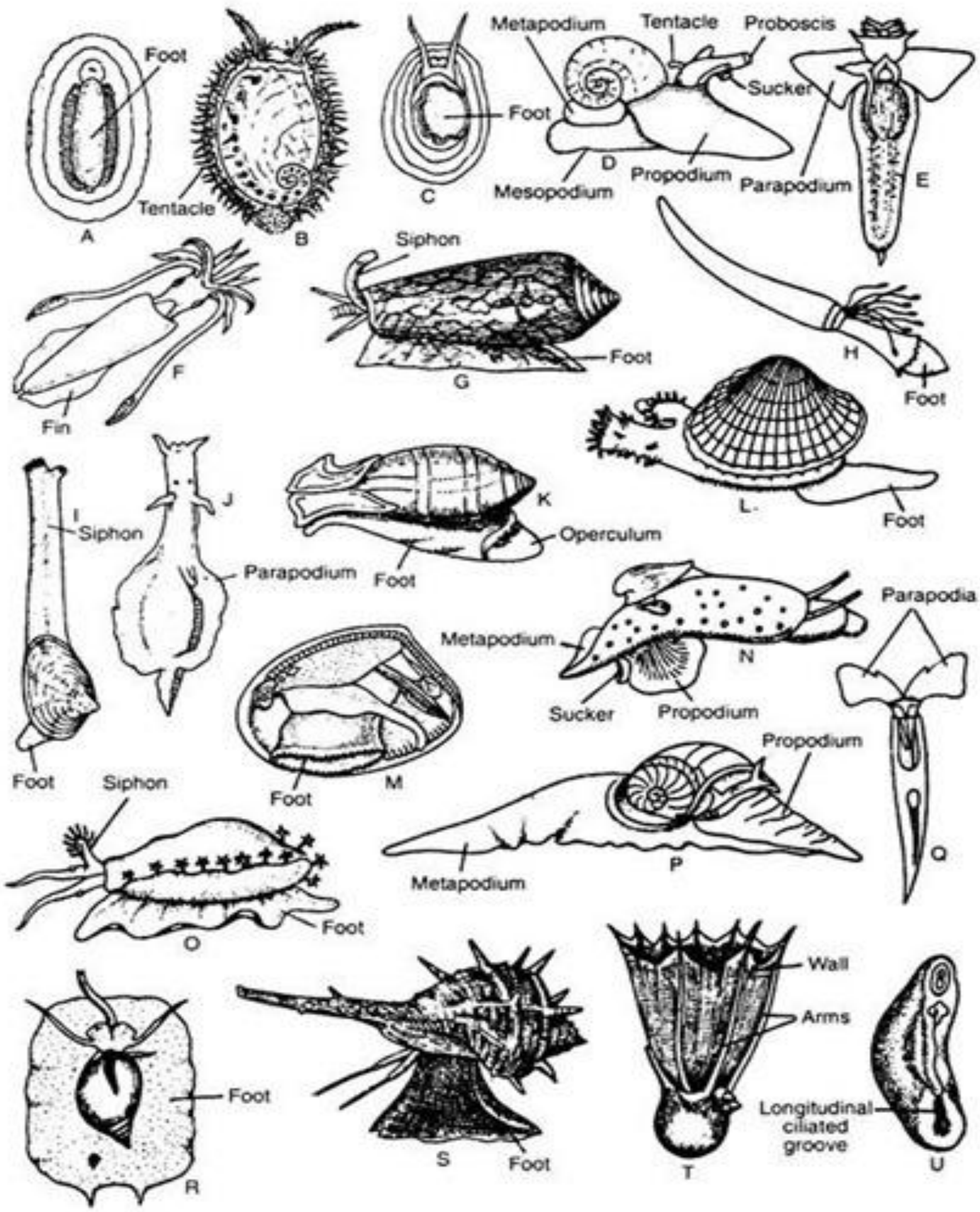
b) Class Gastropoda:

In Terebra, the extremity of foot with flow of blood is extended and acts as anchor. In Natica (Fig. 2D), Polinices, Sigaretus (Fig. 2P), the propodium is demarcated from the rest of the body by deep transverse grooves as a semicircular flap and the metapodium is provided with lateral parapodium.

The animals have adapted for burrowing on soft bottom habitat. The propodium acts like a plough and anchor, and a dorsal flap-like fold of the foot protective shield. In Harpa the propodium is separated by a constriction.

c) Class Bivalvia:

In Anodonta and Unio, the foot is triangular and plough-share like. The foot can perform the effective burrowing organ in addition to acting as a creeping organ. In Solemya, Yoldia the foot has a flattened sole and two sides of the sole can be folded to form a blade-like edge which can penetrate into the mud or sand and act as soft bottom burrowers.



In Pholas foot assumes a short and blunt form. In Mya (Fig. 2I) the foot is feebly developed and used as a weak burrowing organ. Donax has a thin pointed foot. Tagelus, a razor clam possesses an elongated foot which acts as burrower. The foot of Solen and Ensis is large and cylindrical, and can be outstretched into a wide sheet of Muscles as it plunges into the sand**.** In most bivalves, the foot is laterally compressed and blade-like, and the anterior part of the foot acts as a burrowing organ in the soft substratum where they live.

Mechanism of burrowing:

Foot movement is effected usually by the muscle actions of pedal retractors and protractors in a combination with blood pressure that acts as a hydrostatic skeleton. Foot is extended forward into the mud or sand by the extension of the protractor muscles, and the retractor muscles help to draw the animal deeper into the substrate. The retractor muscles contract sequentially, so the shells rock forward and backward and the animal progresses through the sediment.

3. Foot—as the leaping organ:

This type of modification is very characteristic in certain forms of Molluscs. In Cardium (Fig. 2L), the foot is bent upon itself as a leaping organ. In Trigonia it is compressed antero-posteriorly as an elongated keel. In Poromya, the foot is curved with well- formed protractor and retractor muscles. In Mytilus, the cylindrical foot acts as spring- tail. A median triangular outgrowth in Birabia acts as leaping organ.

4. Foot—as a looping organ:

In Pedipus, the propodium of the foot is sharply marked off from the rest by a groove and helps in looping movement.

5. Foot in sessile forms:

A number of sessile bivalves such as sea mussels (e.g., Mytilus, Perna, Modiolus) or oysters (e.g., Ostrea, Crassostrea) are attached to the hard substrates (e.g., rock, corals, shells, wood, sea walls, jetties and pilings, etc.) either by byssus or by the one valve to the substrates. Byssus is a bunch of fine silky threads by which the bivalves are attached to the objects.

The byssal threads are proteinaceous secretions from byssus gland of the foot. The members of mytilids use the byssus for attachment to other objects. The foot is elongated and not used for the lead of sessile life.

Pen shells (e.g., Pinna, Atrina) are attached to the underlying solid substrate by byssus and partly remain buried in sandy sediment. Oysters are firmly cemented to the rock and other substrates. They lack foot and byssal threads.

Crepidula (class Gastropoda) is a sedentary animal which possesses the reduced foot, and the ventral sole acts as an effective sucker for attachment. Vermicularia (Gastropoda) a worm-shell snail is a sessile gastropoda and its foot is reduced. The shell is attached to solid substrates such as rocks and other shells, or entangled in sponges.

6. Foot-as the swimming organ:

In many Molluscs the foot becomes variously modified to swim in water. The development of parapodia is observed in many forms. Carinaria (Fig. 2N), Atlanta and Pterotrachea swims by a flat ventral fin which bears a small sucker representing the original foot. The parapodia is fan-like in Aplysia (Fig. 2J) and used for pelegic existence.

It may have wing-like processes as in Pteropoda (Fig. 2Q). In Oxygurus the parapodia are hollow and possess fin-like outgrowth. In Atlanta, the metapodium is produced into laterally flattened swimming lobe. In Clione (Fig. 2E) the parapodia are well-developed and are placed on the lateral sides of the anterior end.

The most notable transformation of the foot as swimming organ is observed in cephalopods. The foot is partly modified into muscular arms and tentacles around head for food capturing, adhesion and locomotion, and partly into a ventral siphon for jet propulsion.

The cuttle fish and squids move backwards and not forwards on the basis of jet-propelled mechanism. The siphon (= funnel) squirts water forward, pressure of the action squirts the animal simultaneously backwards.

The siphon (also called funnel or in-fundibulum) is a ventral, muscular, sub-conical tube helps in swimming via jet propulsion by expelling water from the mantle cavity.
The expulsion of water is achieved by muscular contraction of the siphon or funnel. In Nautilus (Subclass Nautiloidea) the funnel consists of two separate lateral muscular lobes that fold together to form a tube-like structure which serves for jet propulsion. The funnel of Nautilus is not a complete tube.

In subclass Coleoidea (e.g., cuttle fish, squids) the siphon is a complete one and is made up of two muscular lobes which are completely fused. In both groups the funnel is used for swimming.

7. Foot-as an organ helping reproduction:

One or more arms in some male cephalopods during breeding season are modified for the transference of spermatophores to the female, called hectocotylus. In Sepia the fourth left arm of the male becomes hectocotylus in which some basal rows of suckers are suppressed. In Loligo and Octopus the third right arm is modified to form hectocotylus. The modifications may involve suckers, calimus and ligula, etc.

8. Accessory glands associated with the foot:

The foot in Molluscs is also a highly glandular structure. Some glands become intimately associated with the foot to help in locomotion. The secretion of the glands lubricate the passage during movement. In Gastropods the pedal glands and the unpaired sole gland are the typical instances.

In some Bivalves, in adult or in larval stages the byssus apparatus helps in the process of adhesion. The Organ of Valenciennes in some Cephalopod females, Van der Hoeven in Nautilus males are the other notable accessory organs associated with the foot.

9. Parasitic forms:

The foot of the parasitic forms of molluscs like Entoconcha, Entocolax, Enteroxemes, Thyone (live within sea cucumbers echinoderms), Eulima, Stylifer (endoparasites of echinoderms), is either reduced to small appendages or completely absent.

The further details on the above topic can be obtained from the following Books

1. **Biology of Mollusca** — **By D. R. Khanna and P.R. YadavLove**
2. **Phylogny and Evolution of The Mollusca** — **By Winston F. Ponder and David R. Lindberg**
3. **Invertebrate Zoology** — **By Edward E. Ruppert and Robert D. Barnes**

Economic importance of Mollusca

Molluscs are of general importance within food chains and as members of ecosystems. Many gastropods, bivalves, and cephalopods are a source of food for many cultures and therefore play an important role in the fishing industries of many countries. In addition to their economic value as food, mollusks are also used to make jewelry the most notable and valuable example of which is pearl jewelry. While clams, oysters, snails and squid frequently contribute to many coastal economies as food sources, the shells of various mollusks have also been used as a form of currency at times throughout history. Molluscs are of great important in various ways. Certain species are of direct or indirect commercial and even medical importance to humans. Many gastropod species, for example, are necessary intermediate hosts for parasitic flatworms (class Trematoda, phylum Platyhelminthes), such as the species that cause schistosomiasis in humans. Most bivalves contribute to the organic turnover in the intertidal (littoral) zones of marine and fresh water because, as filter feeders, they filter up to 40 litres (10 gallons) of water per hour. This filtering activity, however, may also seriously interfere with the various populations of invertebrate larvae (plankton) found suspended and free-swimming in the water. One species, the zebra mussel (*Dreissena polymorpha*), is regarded as a particularly harmful exotic invader. Carried from Europe in ship ballast water, zebra mussels were taken to the Great Lakes in 1986. To date, they have caused millions of dollars in commercial damage by clogging the water pipes of power plants and cooling systems. They are driving many native freshwater bivalve species to extinction.

Molluscs are indirectly harmful to man but most of them are beneficial. The harmful molluscs are slugs and shipworms. Slugs are injurious in gardens and cultivations. They not only eat leaves but also destroy plants by cutting up their roots and stems. Teredo, a shipworm damages wooden parts of ship. Many mollusks are great source of food for man in many parts of world. China is a leader in the worldwide mollusk catch and reached an 80 percent global share in 2010. France is the industry leader in the European catch. The pearl industry has become a vital part of some countries economies, and significant sums of money are allocated to the monitoring of the health of mollusks produced on farms. Large quantity of calms, oysters and mussels are eaten in Fareast, Europe and America. Oysters are regarded as delicacy. Shell of fresh water mussels is used in button industry. The shell of oyster are mixed with tar for making roads in America. Shells in certain parts of world are also used for making ornaments. Some oysters also make valuable pearls e.g. the pearl oyster. Some pearls are used for making jewellery. Some animals including in this phyla are use to eat in some countries. Their shell are also used in art and craft industries.

<u>There are some benefits of mollusks which are listed as under:</u>

1. Many molluscs including mussels, oysters, clams and cephalopods are fished for food and support small scale sustenance fisheries in developing countries. Various species in this phylum are very important to the human beings. Clams and Mussels are an important food source in different parts of the world. Octopuses, squids, whelks, oysters and scallops are also eaten by the human beings. They form an important part of the fisheries and agricultural industry.
2. Oysters are nutritious as they contain vitamin A and B, minerals and appreciable amount of glycogen and protein.
3. Pearl oyster produces pearl, considered a highly valuable jewel, within its shell. Most precious pearls are found in pearl oysters of the genus *Pinctada.*
4. Chank fishery, a great source of revenue in India is based on a turbinellid gastropod, *Xanus pyrum*, the shell of which is called the ‘chank’. Chanks are used as trumphet in temples and in the manufacture of bangles.

5. Thick shells having lustrous pearly layer are valued high in the manufacture of buttons, brooches and the like objects.
6. The shells of *Cymbium*, *Dolium*, *Murex*, etc are made into useful articles like lamp stands, lamp shades, etc.
7. Tools, utensils and objects of delight have been formed from gastropodan shells.
8. *Nautilus* shell is much used for decoration, art and for many other useful purposes.
9. Many shells go into the making of toys, some are polished and sold as curios like the calcareous operculum of turban shells.
10. Dead shells drifted ashore at estuaries by currents, sub-fossil deposits in lakes and broken shells of surf beaten beaches, form the raw material for superior quality lime, which is used in every type of masonry constructions and in whitewashing the buildings.
11. Good quantities of shells are used in carbide and cement manufacture.
12. Many gastropods like squids and small octopus are used as bait for catching fish.
13. Gastropodan shells were used as source of money by various native races as Red Indian tribes of America used the common *Dendallium* as money.
14. Some gastropods like *Nucella* and *Murex*, are sources of *Tyrian* purple, a dye obtained from their juices. Ink sac of cuttle-fish provides a rich brown pigment called ‘sepia’, used by artists.
15. Fossil cephalopods have a medicinal importance among the red Indians of Montana and Wyoming. They collect the preserved fossil ammonoids and keep them as ‘medicine’.
16. The credit of “jet propulsion”, only recently discovered by man, goes to cephalopods, who have been using it for millions of years.
17. Some gastropods like land slugs and snails cause damage to gardens, orchards, green houses and mushroom beds by feeding upon the succulent parts of seedlings and mature plants.
18. The shipworm, *Teredo*, a bivalve mollusc bores in wooden boats and ships, causing millions of dollars of damage to wooden structures.
19. Some gastropods cause damage to other molluscs like the marine snail *Urossalprinx*, causes serious loses to oyster industry by drilling the oyster shells.
20. Some predacious and carnivorous molluscs cause distruction to fishery industry.
21. Snails have importance from a medical point of view as they serve as intermediate host for flatworms, like *Fasciola* and *Schistosoma.*

Medicinal Importance

1. The deadly venoms of some Cone Shells (Conidae) are today being used to help victims of strokes and heart disease, and to produce a revolutionary new drug for chronic pain control.
2. An extract from the hard clam or "Quahog" *(Mercenaria mercenaria* L.) is a strong growth inhibitor of cancers in mice. It is called mercenine, after the clam's scientific name.
3. Paolin, a drug made from abalone juice, is an effective inhibitor of penicillin- resistant strains of bacteria.
4. Ground and processed oyster shells Olympia Oyster (*Ostrea conchaphila*) are used as a calcium supplements both for humans and animals.
5. Oyster juice has been found to have anti-viral properties, and may be made into a drug eventually.

6. The threads that some mussels (*Mytilidae*) use to attach themselves to rocks, piers, and other hard surfaces are being tested as possible glue in surgery. These are called "byssal" threads, from the Latin word byssus, which means "fine linen", which is silky, like the fine threads of many mollusks *(Mytilus edulis)*

7. The cement of the Carrier Shells (*Xenophoridae*) is being studied for use as a possible cement for bone fractures. The Carrier shells are the camouflage experts of the mollusc world: they attach all kinds of objects - shells, rocks, pieces of coral, sponges, bottle caps. to their shells, so they look like a little pile of trash on the bottom of the sea - a great way to avoid being eaten.

8. In Vietnam, traditional medicine has a wide variety of uses for shells: powdered oyster shell is taken to treat acid indigestion, fatigue and to stop hemorrhage. It is also sprinkled over open wounds and boils. Cuttlefish bones are used as a remedy for rickets (which is caused by lack of vitamin C), a healing agent in the treatment of gastro-intestinal troubles, a local anti-hemorrhagic (i.e., it stops internal bleeding), and as an antiseptic is cases of inflammation of the middle ear. The flat shell of the Abalone, with its iridescent inside, is powdered and taken orally to improve vision, to remove keratoses (cataracts), and to improve such conditions as hemeralopia (where you can see at night well, but hardly at all in the daytime!. Powdered pearls from oysters are used as a topical eye medicine and it has been scientifically proven to have some anti-inflammatory effects on a painful condition called conjunctivitis, where the surface of the eye becomes red and sore.

9. Slugs and snails are terrestrial molluscs which have similar morphology except that slugs, unlike snails, have no obvious shell, although some species possess a partial or internal vestigial shell. Widely distributed around the world, the largest species of slug in the UK, the Ashy-Grey slug (*Limax cinereoniger*), can exceed 25 cm in length. For centuries snails, and to a lesser extent slugs, have been used both as a food and as a treatment for a variety of medical conditions. In some part of Italy, the common garden slug, ***Arion hortensis***, is sometimes swallowed whole as a treatment for gastritis or stomach ulcers. In America slugs are not thought to be swallowed live in this way, but a recipe for 'Slug Syrup' made up of with sugar be used for the treatment of ulcers, bronchitis and asthma. Snail and slug slime have been used sporadically as skin treatments since the time of the Ancient Greeks. It has recommended that the use of crushed snails to relieve inflamed skin and some 20 years ago, the potential of snail slime was noted by Chilean snail (*Elicina*) farmers who found that skin lesions healed quickly, with no scars, when they handled snails for the French food market. Snail Cream with 70% snail extract 'soothes regenerates and heals skin'. Snail slime based products are claimed to be the new miracle face-fixer in the U.S where they are used to treat acne, reduce pigmentation and scarring, and combat wrinkles. It has also been reported slugs are used in Italy to treat dermatological conditions. Mucus collected from a slug is rubbed onto the skin to treat dermatitis, inflammations, calluses, and acne, and to promote wound healing. In addition, in a special ritual slugs themselves are used for the treatment of warts. Mucus from a live slug is first rubbed onto the wart, and then the slug is hung out in the sunshine to dry out and die. It is believed that once the slug has dried up, the wart should as well. The use of slugs for the treatment of warts is not, however, confined to Italy. Records exist of the use of slug slime in the US and UK some of which recommended that the slime be collected at certain phases of the moon to ensure maximum effect.

The further details on the above topic can be obtained from the following Books

1. **Invertebrate Zoology** — **By E. L. Jordan and P.S. Verma**
2. **Modern Text Book of Zoology: Invertebrates** — **By R.L. Kotpal**
3. **A text Book of Invertebrates** — **By H.H. Bhamrah and J. Kavita**