Course: Biology-IV (6454)
Semester: Spring, 2021
ASSIGNMENT No. 2

Q. 1 What is Torsion? Draw different stages of Torsion. Write advantages and disadvantages of Torsion.

Torsion is a gastropod synapomorphy which occurs in all gastropods during larval development. Torsion is the rotation of the visceral mass, mantle, and shell 180˚ with respect to the head and foot of the gastropod. This rotation brings the mantle cavity and the anus to an anterior position above the head.

In some groups of gastropods (Opisthobranchia) there is a degree of secondary **detorsion** or rotation towards the original position; this may be only partial detorsion or full detorsion.

The torsion or twisting of the visceral mass of larval gastropods is not the same thing as the spiral coiling of the shell, which is also present in many shelled gastropods.

There are two different developmental stages which cause torsion. The first stage is caused by the development of the asymmetrical velar/foot muscle which has one end attached to the left side of the shell and the other end has fibres attached to the left side of the foot and head. At a certain point in larval development this muscle contracts, causing an anticlockwise rotation of the visceral mass and mantle of roughly 90˚. This process is very rapid, taking from a few minutes to a few hours. After this transformation the second stage of torsion development is achieved by differential tissue growth of the left hand side of the organism compared to the right hand side. This second stage is much slower and rotates the visceral mass and mantle a further 90˚. Detorsion is brought about by reversal of the above phases.

During torsion the visceral mass remains almost unchanged anatomically. There are, however, other important changes to other internal parts of the gastropod. Before torsion the gastropod has an euthyneural nervous system, where the two visceral nerves run parallel down the body. Torsion results in a streptoneural nervous system, where the visceral nerves cross over in a figure of eight fashion. As a result, the parietal ganglions end up at different heights. Because of differences between the left and right hand sides of the body, there are different evolutionary pressures on left and right hand side organs and as a result in some species there are considerable differences. Some examples of this are: in the ctenidia (equivalent to lungs or gills) in some species, one side may be reduced or absent; or in some hermaphrodite species the right hand renal system has been transformed into part of the reproductive system.

The original advantage of torsion for gastropods is unclear. It is further complicated by potential problems that accompany torsion. For example, having the place where wastes are excreted positioned above the head could result in fouling of the mouth and sense organs. Nevertheless, the diversity and success of the gastropods suggests torsion is advantageous, or at least has no strong disadvantages.

One likely candidate for the original purpose of torsion is defence against predators in adult gastropods. By moving the mantle cavity over the head, the gastropod can retract its vulnerable head into its shell. Some gastropods can also close the entrance to their shell with a tough operculum, a door-like structure which is attached to the dorsal surface of their foot. In evolutionary terms, the appearance of an operculum occurred shortly after that of torsion, which suggests a possible link with the role of torsion, though there is not sufficient evidence for or against this hypothesis. The English zoologist Walter Garstang wrote a famous poem in 1928, The Ballad of the Veliger, in which he argued with gentle humour in favour of the defence theory, including the lines

Predaceous foes, still drifting by in numbers unabated,
Were baffled now by tactics which their dining plans frustrated.
Their prey upon alarm collapsed, but promptly turned about,
With the tender morsel safe within and the horny foot without!

Torsion can provide other advantages. For aquatic gastropods, anterior positioning of the mantle cavity may be useful for preventing sediment getting into the mantle cavity, an event which is more likely with posterior positioning because sediment can be stirred up by the motion of the gastropod. Another possible advantage for aquatic species is that moving the osphradium (olfactory sense organs) to an anterior position means they are sampling water the gastropod is entering rather than leaving. This may help the gastropod locate food or avoid predators. In terrestrial species, ventilation is better with anterior positioning. This is due to the back and forth motion of the shell during movement, which would tend to block the mantle opening against the foot if it was in a posterior position. The evolution of an asymmetrical conispiral shell allowed gastropods to grow larger, but resulted in an unbalanced shell. Torsion allows repositioning of the shell, bringing the centre of gravity back to the middle of the gastropod's body, and thus helps prevent the animal or the shell from falling over.

Whatever original advantage resulted in the initial evolutionary success of torsion, subsequent adaptations linked to torsion have provided modern gastropods with further advantages.

Acquisition of secondary symmetry observed in some Opisthobranch Gastropod is regarded as the result of detorsion. The distortion means the reversion to the changes that have occurred during torsion. As a result of detorsion the pallial complex travels towards the posterior end along the right side.

The ctenidia are pointed backwards and the auricles come behind the ventricle. The visceral loop becomes untwisted and symmetrical. In this way a secondary external symmetry is established again. Detorsion is always associated with the loss of shell and the liberation of gills (ctenidia) from their enclosing case.

The gills become exposed and subjected to external current. Different gradations of detorsions are encountered in the different members of opisthobranchs. In Acteon and Bulla detorsion is partial, and complete detorsion is observed in Aplysia. In some nudibranchs (e.g., Doris, Apolidia, etc.), the shell and mantle cavity are absent and the body becomes secondarily bilaterally symmetrical.

Q. 2 Describe nervous and sensory function in Leech.

The medicinal leech is a semiaquatic annelid worm that has been an important model organism in many studies in the field of systems neuroscience. As in other annelids, the leech nervous system consists of a ventral nerve cord comprising the cephalic ganglia (or 'head brain', which includes supra- and subesophageal ganglia) and the segmental ganglia. Additionally, leeches have a prominent ganglion at the caudal end of the nerve cord (the 'tail brain'), the main function of which is thought to be control of the rear sucker. The majority of the neurons of a leech are located in the segmental ganglia. Each of these 21 nearly identical ganglia contains ∼400 neurons, mostly as bilateral pairs. The cell bodies are organized at the ganglion surface in a shell surrounding a central neuropil. Conveniently, the geometric arrangement of those neurons is highly stereotyped, allowing the identification of homologous neurons both across ganglia within an individual leech and across animals. Helpfully for both electrophysiology and imaging, the somata of most leech neurons are relatively large (15–70 μm in diameter). These facts, combined with the large repertoire of simple behaviors that leeches possess, have facilitated a remarkable range of studies on the neurons and circuits that underlie specific leech behaviors.

Accordingly, this Commentary focuses on the use of the leech as an experimental organism in systems neuroscience and, in particular, on progress in the decade since the appearance of the last major review of leech systems neuroscience. I discuss recent lessons in circuit function, behavior and the development of the nervous system. Of particular interest are studies that explain behaviors in terms of neuronal mechanisms. As a comprehensive review of leech cellular neuroscience and molecular biology is beyond the scope of this article, I focus primarily on works that study behavior in terms of neuronal activity.

The leech is a particularly good model for level-spanning studies of behavior. Because the leech has a relatively rich behavioral repertoire and a simple, robust and readily accessible nervous system, it is frequently possible to identify specific roles for individual neurons in particular leech behaviors, such as feeding, locomotion and reproduction. Remarkably, even though the leech nervous system is obviously much simpler than vertebrate nervous systems, principles of its function have in several cases been found to have counterparts in more complex animals. To cite but one example, population coding of sensory information, a common principle in the mammalian cortex, can be studied in an attractively simple setting in the leech 'local bend' response system.

Although leeches eat infrequently, their meals are large; a single meal can be up to ten times the original biomass of the leech. Consequently, the animal becomes severely distended, and for several days after feeding it will move sluggishly, becoming particularly reluctant to swim. Gaudry and Kristan (2010) used another semi-intact preparation in which the posterior of a leech and most of its digestive system was intact while several anterior ganglia were exposed for electrophysiology to demonstrate a direct relationship between the degree of distention and the duration of evoked swim bouts in response to electrical stimuli. This relationship held both when the leech was feeding naturally and when its intestines were artificially distended using a saline-filled syringe. So how do leeches sense that they are distended? Mechanically stretching an isolated nerve cord did not substantially affect swimming, excluding a role for stretch receptors embedded in the nervous system. To investigate whether stretch receptors in the gut lining or in the body wall play a role in sensing distention, Gaudry and Kristan dissected away the entire digestive tract, using a procedure in which a leech is turned inside-out. Remarkably, when turned outside-out again, gutted leeches swam with a very nearly normal rhythm, and their response to saline-mediated distension was qualitatively preserved. This experiment, which would have been impossible to perform in most other species, provided strong support for stretch receptors in the body wall as the key players for sensing satiation in the leech.

Recent research on the leech has yielded multiple instances where function and behavior can be explained in a detailed and quantitative manner in terms of the neuronal mechanisms involved – I have discussed swimming and the heartbeat system as two striking examples. One other behavior, mating, has just recently been quantified and is now amenable to the same treatment. Furthermore, some highly general questions in biology – I have mentioned the neural implementation of behavioral hierarchies, the detection of satiation, and the role of gap junctions in the establishment of chemical synapses – have been addressed in the leech. A new specific sensitivity to UV light has been found, indicating that the visual system of the leech has more secrets awaiting discovery. The past decade has expanded our understanding of prey localization and yielded the first description of social behavior in the leech, paving the way for investigation of the neural basis of more complex behavior. In addition, the leech has been an important model organism in the development of optical tools that may be broadly useful to neuroscience, and even in safety testing.

It has been a very rewarding decade for researchers working with the leech, and the future is even brighter. Progress in voltage-sensitive dye imaging continues at an ever increasing pace, enabling activity mapping at the scale of the entire ganglion with cellular detail and useful temporal resolution. From farther afield, the CRISPR revolution may soon make any animal genetically tractable, which will open a world of new possibilities for all those animals, including the leech that previously did not have a wide array of genetic tools available. Applying these developments to exciting questions such as those posed above could make the next decade of leech research the most exciting yet.

Q. 3 Chelicerata is sub-phylum of Arthropod. Explain this sub-phylum up to class level.

Arthropoda is the largest phylum with about nine lakh species. They may be aquatic, terrestrial or even parasitic. They have jointed appendages and a chitinous exoskeleton.

This phylum includes several large classes and contains the class Insecta which itself represents a major portion of the animal species in the world. They possess the ability to survive in every habitat.

Arthropoda Characteristics

The arthropoda characteristics are mentioned below:

1. The body is triploblastic, segmented, and bilaterally symmetrical.
2. They exhibit organ system level of organization.
3. The body is divided into head, thorax, and abdomen.
4. Their body has jointed appendages which help in locomotion.
5. The coelomic cavity is filled with blood.

6. They have an open circulatory system.
7. The head bears a pair of compound eyes.
8. The exoskeleton is made of chitin.
9. The terrestrial Arthropods excrete through Malpighian tubules while the aquatic ones excrete through green glands or coaxal glands.
10. They are unisexual and fertilization is either external or internal.
11. They have a well-developed digestive system.
12. They respire through the general body surface or trachea.
13. They contain sensory organs like hairs, antennae, simple and compound eyes, auditory organs, and statocysts.

Classification of Phylum Arthropoda

The classification of phylum arthropoda are as follows:

Crustacea

1. They are aquatic, terrestrial, or parasitic.
2. The head is fused with the thorax region known as the cephalothorax.
3. Respiration occurs through gills or general body surface.
4. The body is covered by a single large carapace.
5. They possess two pairs of antennae and five pairs of appendages.
6. They excrete through green glands or antennal glands.
7. They have a pair of compound eyes and gonopores.
8. Development is indirect. Larval stage is present.
9. Eg., Daphnia, Palaemon

The subphylum Crustacea is divided into six classes-

- Branchiopoda
- Remipedia
- Chephlocarida
- Maxillopoda
- Ostracoda
- Malacostraca

Myriapoda

1. These are mostly terrestrial.
2. The body is elongated with numerous segments.
3. The head is provided with antennae, two pairs of jaws, and a pair of simple eyes.
4. They contain numerous legs.

5. The upper lip of the mouth contains epistome and labrum, and the lower lip contains a pair of maxillae.
6. A pair of mandibles is present inside the mouth.
7. They respire by trachea and excretion occurs by Malpighian tubules.
8. Eg., Julus, Scolopendra

The subphylum Myriapoda is divided into the following classes:

- Chilopoda
- Diplopoda
- Pauropoda
- Symphyla

Hexapoda

1. They are mostly terrestrial.
2. The body is differentiated into head, thorax, and abdomen.
3. Head bears a pre-segmental acron.
4. The thorax is divided into three segments.
5. The abdomen has 7-11 segments.
6. They have three pair of appendages.
7. It has a pair of compound eyes
8. They respire through gills and trachea.
9. Malpighian tubules are the excretory organ.
10. Development is indirect, and the larval stage is present.
11. Eg., Tabernus, Mosquitoes, Ants.

The subphylum Hexapoda is divided into two classes:

- Insecta
- Entognatha

Chelicerata

1. They are mostly found on land.
2. The body is differentiated into cephalothorax and abdomen.
3. Antennae are absent.
4. The abdomen is divided into 13 segments.
5. It has four pairs of interior appendages.
6. They respire through trachea or gills.
7. The Malpighian tubules help in excretion.
8. Eg., Aramea, Limulus

The subphylum Chelicerata is divided into the following classes:

- Arachnida
- Merostomata
- Pycnogonida

Onychophora

1. These are small-sized, terrestrial arthropods.
2. The body is divided into segments.
3. Excretion occurs through nephridia.
4. They respire through the trachea.
5. Eg., Paripatus

Trilobitomorpha

1. These are primitive arthropods and are extinct.
2. They were found in abundance during the Paleozoic era.
3. The body was divided into three lobes- one median and two lateral lobes.
4. Head bore a pair of compound eyes and a pair of antennae.
5. There was no structural differentiation of the body parts.
6. The body was divided into head, thorax and pygidium.
7. Appendages are biramous.

The subphylum had only one class- Trilobita

Q. 4 Write salient features of class Echinoids.

The organisms belonging to the phylum Echinodermata are exclusively marine. Till date, there have been no traces of any terrestrial or freshwater Echinoderms.

These are multicellular organisms with well-developed organ systems. All the animals belonging to this phylum share the same characteristics features. They are colourful organisms with unique shapes. They are ecologically and geologically very important.

The Echinoderms are found in sea-depths as well as in the intertidal zones. An interesting feature of the phylum Echinodermata is that all the organisms belonging to this phylum are marine. None of the organisms is freshwater or marine.

The water vascular system present in echinoderms accounts for gaseous exchange, circulation of nutrients and waste elimination.

Characteristics of Echinodermata

1. They have a star-like appearance and are spherical or elongated.
2. They are exclusively marine animals.
3. The organisms are spiny-skinned.
4. They exhibit organ level of organization.

5. They are triploblastic and have a coelomic cavity.
6. The skeleton is made up of calcium carbonate.
7. They have an open circulatory system.
8. They respire through gills or cloacal respiratory tree.
9. They have a simple radial nervous system and the excretory system are absent.
10. The body is unsegmented with no distinct head. The mouth is present on the ventral side while the anus is on the dorsal side.
11. The tube feet aids in locomotion.
12. They reproduce sexually through gametic fusion and asexually through regeneration. Fertilization is external.
13. The development is indirect.
14. They possess the power of regeneration.
15. They have poorly developed sense organs. These include chemoreceptors, tactile organs, terminal tentacles, etc.

Classification of Echinodermata

Asteroidea

- They have a flattened, star-shaped body with five arms.
- They have tube feet with suckers.
- They respire through papulae.
- The body comprises of calcareous plates and movable spines.
- Pedicellaria is present.
- Eg., Asterias, Zoroaster

Ophiuroidea

- The body is flat with pentamerous discs.
- The tube feet are devoid of suckers.
- They respire through Bursae.
- The long arms are demarcated from the central disc.
- Eg., Ophiderma, Amphuria

Echinoidea

- The body is hemispherical.
- The tube feet contains suckers.
- The body does not have arms.
- The body has a compact skeleton and movable spines.
- Eg., Echinus, Cidaris

Holothuroidea

- The body is long and cylindrical.
- The arms, spines, and pedicellariae are absent.
- They respire through the cloacal respiratory tree.
- They possess tube feet with suckers.
- Eg., Cucumaria, Holothuria

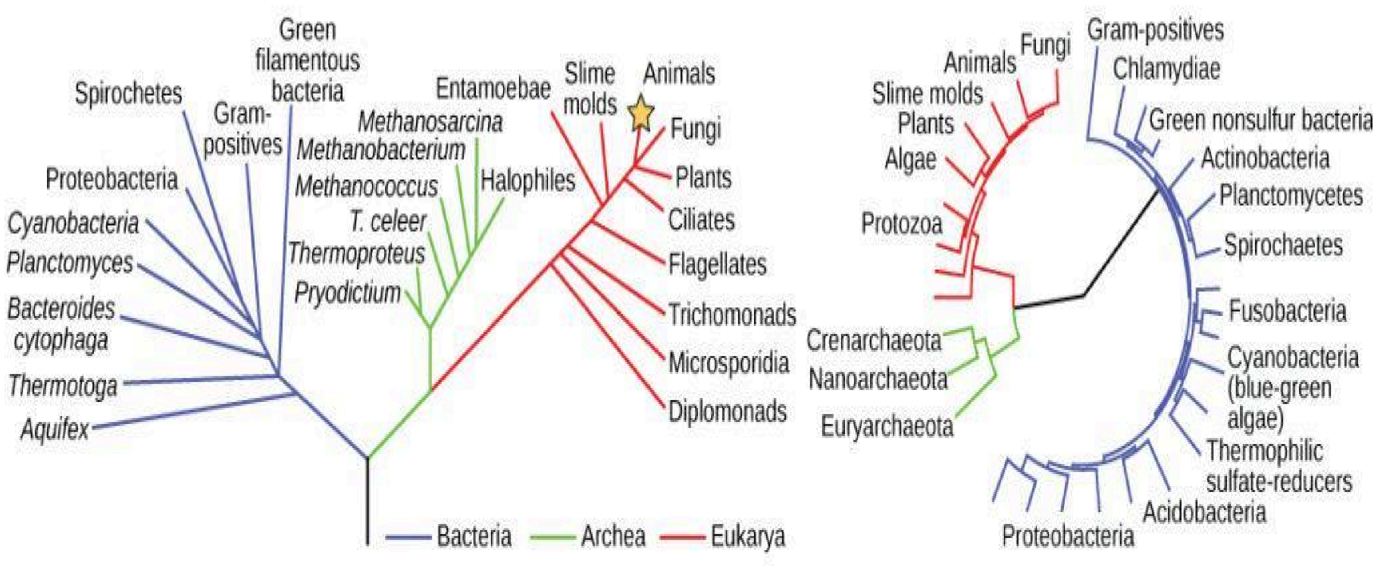
Crinoidea

- The body is star-shaped.
- The tube feet have no suckers.
- The arms are bifurcated.
- Spines and pedicellariae are absent.
- Eg., Neometra, Antedon

Q. 5 Give comprehensive explanation of Phylogenetic relationship of fishes.

In scientific terms, the evolutionary history and relationship of an organism or group of organisms is called phylogeny. **Phylogeny** describes the relationships of one organism to others—such as which organisms it is thought to have evolved from, which species it is most closely related to, and so forth. Phylogenetic relationships provide information on shared ancestry but not necessarily on how organisms are similar or different.

Scientists use a tool called a phylogenetic tree to show the evolutionary pathways and connections among organisms. A **phylogenetic tree** is a diagram used to reflect evolutionary relationships among organisms or groups of organisms. Scientists consider phylogenetic trees to be a hypothesis of the evolutionary past since one cannot go back to confirm the proposed relationships. In other words, a "tree of life" can be constructed to illustrate when different organisms evolved and to show the relationships among different organisms.



(a) Rooted phylogenetic tree (b) Unrooted phylogenetic tree

A phylogenetic tree can be read like a map of evolutionary history. Many phylogenetic trees have a single lineage at the base representing a common ancestor. Scientists call such trees rooted, which means there is a single ancestral lineage (typically drawn from the bottom or left) to which all organisms represented in the diagram relate. Notice in the rooted phylogenetic tree that the three domains—Bacteria, Archaea, and Eukarya—diverge from a single point and branch off. The small branch that plants and animals (including humans) occupy in this diagram shows how recent and minuscule these groups are compared with other organisms. Unrooted trees don't show a common ancestor but do show relationships among species.

In the past, biologists grouped living organisms into five kingdoms: animals, plants, fungi, protists, and bacteria. The organizational scheme was based mainly on physical features, as opposed to physiology, biochemistry, or molecular biology, all of which are used by modern systematics. The pioneering work of American microbiologist Carl Woese in the early 1970s has shown, however, that life on Earth has evolved along three lineages, now called domains—Bacteria, Archaea, and Eukarya. The first two are prokaryotic groups of microbes that lack membrane-enclosed nuclei and organelles. The third domain contains the eukaryotes and includes unicellular microorganisms together with the four original kingdoms (excluding bacteria). Woese defined Archaea as a new domain, and this resulted in a new taxonomic tree. Many organisms belonging to the Archaea domain live under extreme conditions and are called extremophiles. To construct his tree, Woese used genetic relationships rather than similarities based on morphology (shape).

Woese's tree was constructed from comparative sequencing of the genes that are universally distributed, present in every organism, and conserved (meaning that these genes have remained essentially unchanged throughout evolution). Woese's approach was revolutionary because comparisons of physical features are insufficient to differentiate between the prokaryotes that appear fairly similar in spite of their tremendous biochemical diversity and genetic variability. The comparison of homologous DNA and RNA sequences provided Woese with a sensitive device that revealed the extensive variability of prokaryotes, and which justified the separation of the prokaryotes into two domains: bacteria and archaea.

Advantages of phylogenetic classification

Phylogenetic classification has two main advantages over the Linnaean system. First, phylogenetic classification tells you something important about the organism: its evolutionary history. Second, phylogenetic classification does not attempt to "rank" organisms. Linnaean classification "ranks" groups of organisms artificially into kingdoms, phyla, orders, etc. This can be misleading as it seems to suggest that different groupings with the same rank are equivalent. For example, the cats (Felidae) and the orchids (Orchidaceae) are both family level groups in Linnaean classification. However, the two groups are not comparable:

- One has a longer history than the other. The first representatives of the cat family Felidae probably lived about 30 million years ago, while the first orchids may have lived more than 100 million years ago.
- The have different levels of diversity. There are about 35 cat species and 20,000 orchid species.

- They have different degrees of biological differentiation. Many orchids belonging to different genera are able to hybridize. But the same is not true of cats — house cats (belonging to the genus Felis) and lions (belonging to the genus Panthera) cannot form hybrids.