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ELECTIVE 2



UNIT:1 KINGDOM PROTISTA
GENERAL CHARACTERS AND CLASSIFICATION UPTO CLASSES
LOCOMOTORY ORGANELLES AND LOCOMOTION IN
PROTOZOA

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PROTISTA

GENERAL CHARACTERS AND CLASSIFICATION UPTO CLASSES

- What are Protists?
- Protists are simple eukaryotic organisms that are neither plants nor animals or fungi. Protists are unicellular in nature but can also be found as a colony of cells. Most protists live in water, damp terrestrial environments, or even as parasites.
- The term ‘Protista’ is derived from the Greek word “protistos”, meaning “the very first”. These organisms are usually unicellular and the cell of these organisms contain a nucleus which is bound to the organelles. Some of them even possess structures that aid locomotion like flagella or cilia.

Characteristics of Kingdom Protista

- The primary feature of all protists is that they are eukaryotic organisms. This means that they have a membrane-enclosed nucleus. Other characteristic features of Kingdom Protista are as follows:
- These are usually aquatic, present in the soil or in areas with moisture.
- Most protist species are unicellular organisms, however, there are a few multicellular protists such as kelp. Some species of kelp grow so large that they exceed over 100 feet in height. (Giant Kelp).
- Just like any other eukaryotes, the cells of these species have a nucleus and membrane-bound organelles.
- They may be autotrophic or heterotrophic in nature. An autotrophic organism can create their own food and survive. A heterotrophic organism, on the other hand, has to derive nutrition from other organisms such as plants or animals to survive

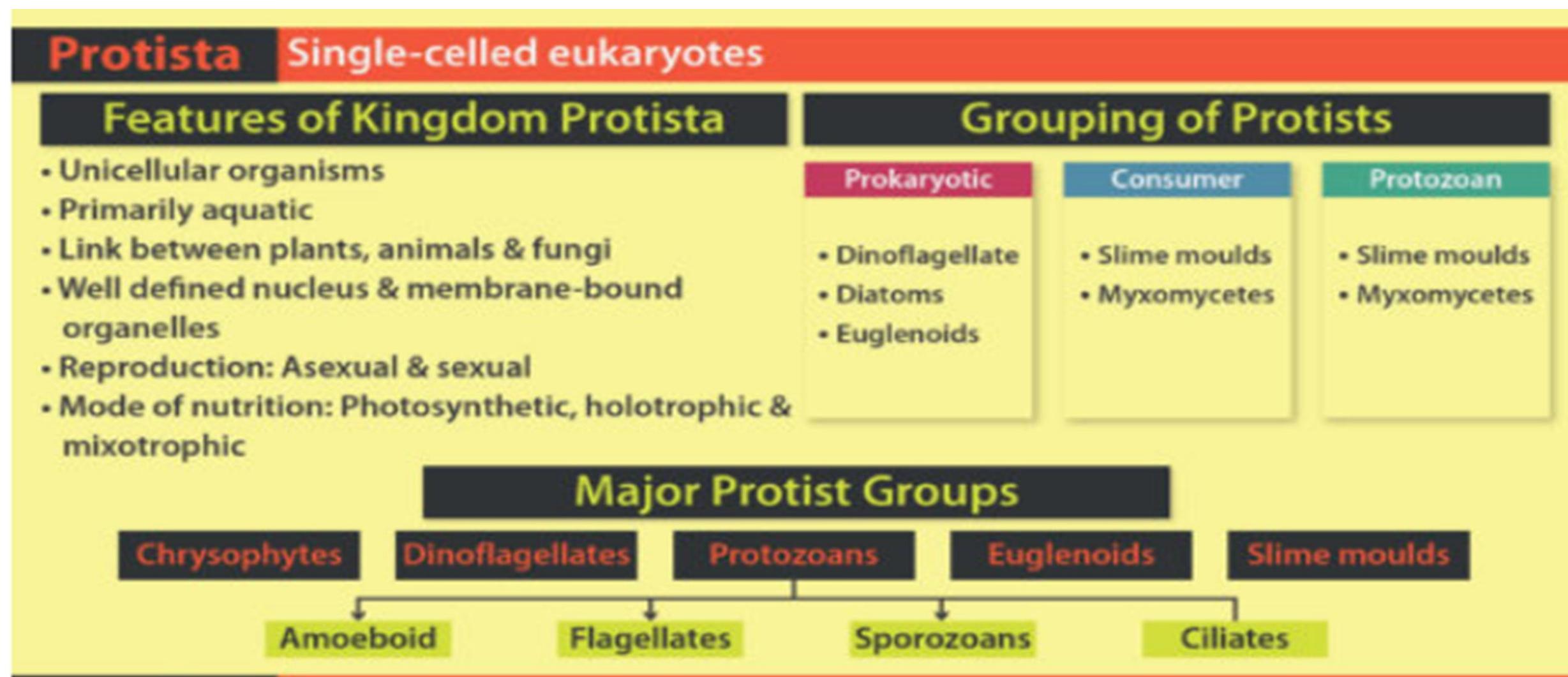
- **Symbiosis is observed in the members of this class. For instance, kelp (seaweed) is a multicellular protist that provides otters, protection from predators amidst its thick kelp. In turn, the otters eat sea urchins that tend to feed on kelp.**
- **Parasitism is also observed in protists. Species such as Trypanosoma protozoa can cause sleeping sickness in humans.**
- **Protists exhibit locomotion through cilia and flagella. A few organisms belonging to kingdom Protista have pseudopodia that help them to move.**
- **Protista reproduces by asexual means. The sexual method of reproduction is extremely rare and occurs only during times of stress.**

Classification of Protista

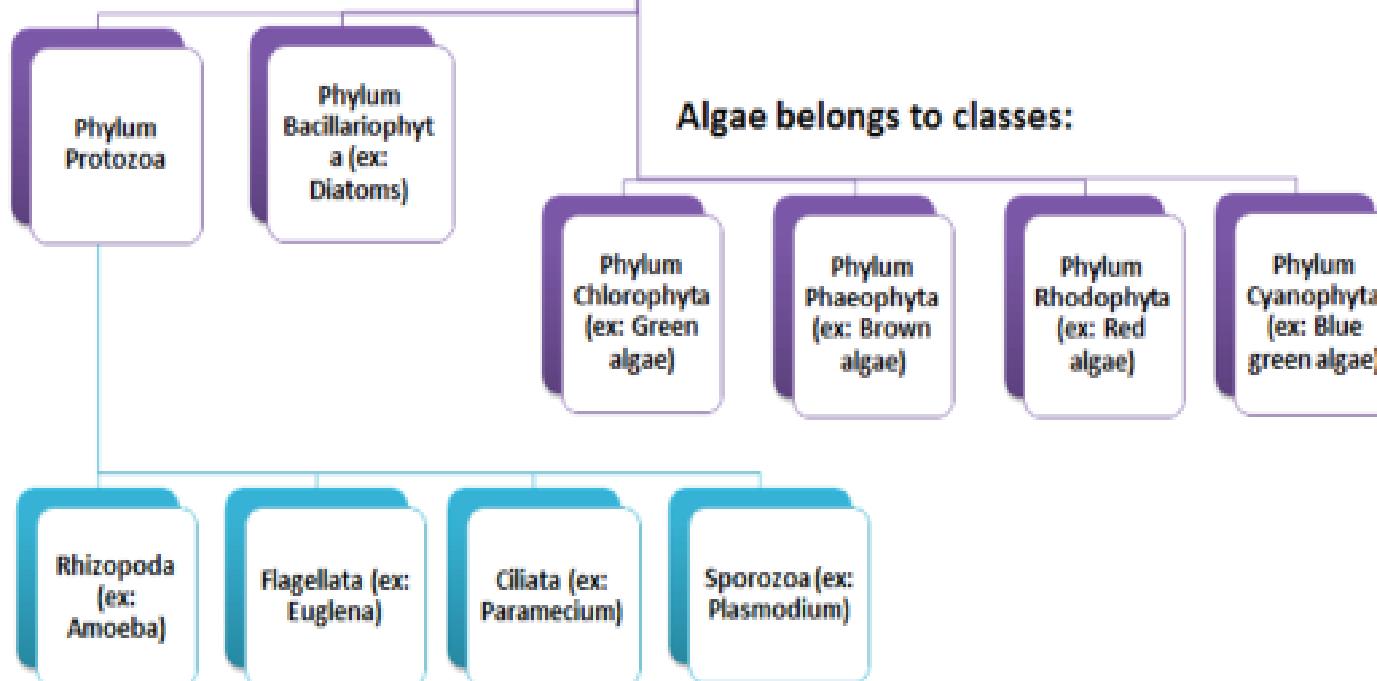
Kingdom Protista is classified into the following:

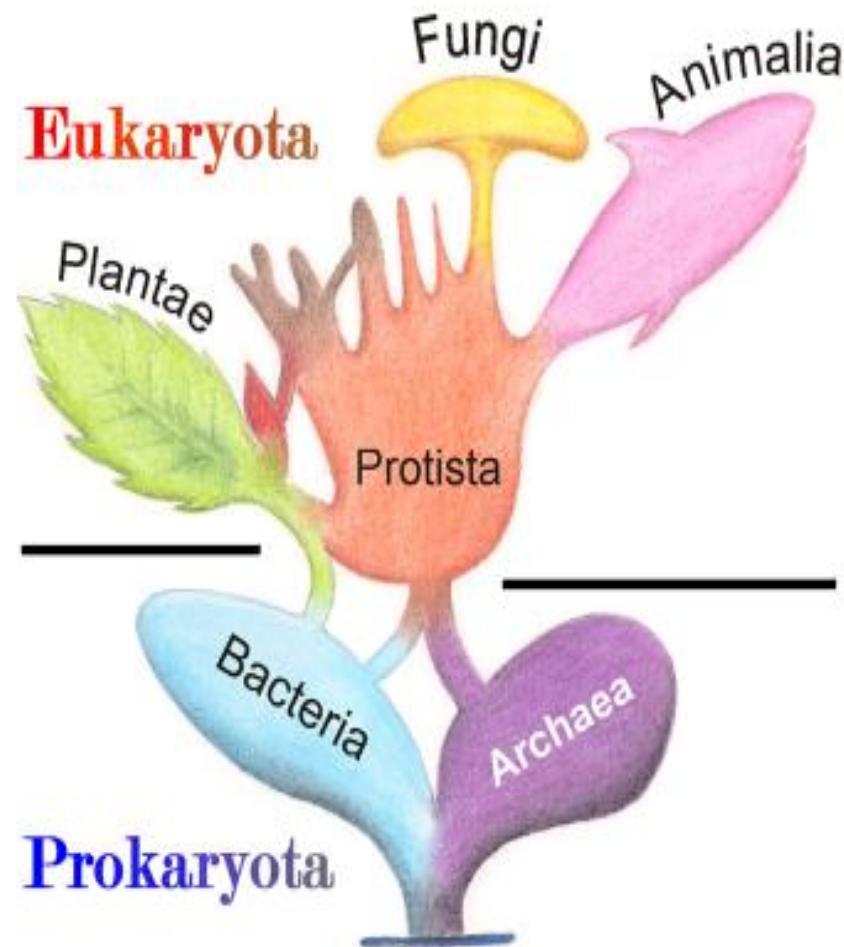
Protozoa

Protozoans are unicellular organisms. Historically, protozoans were called “animal” protists as they are heterotrophic, and showed animal-like behaviours

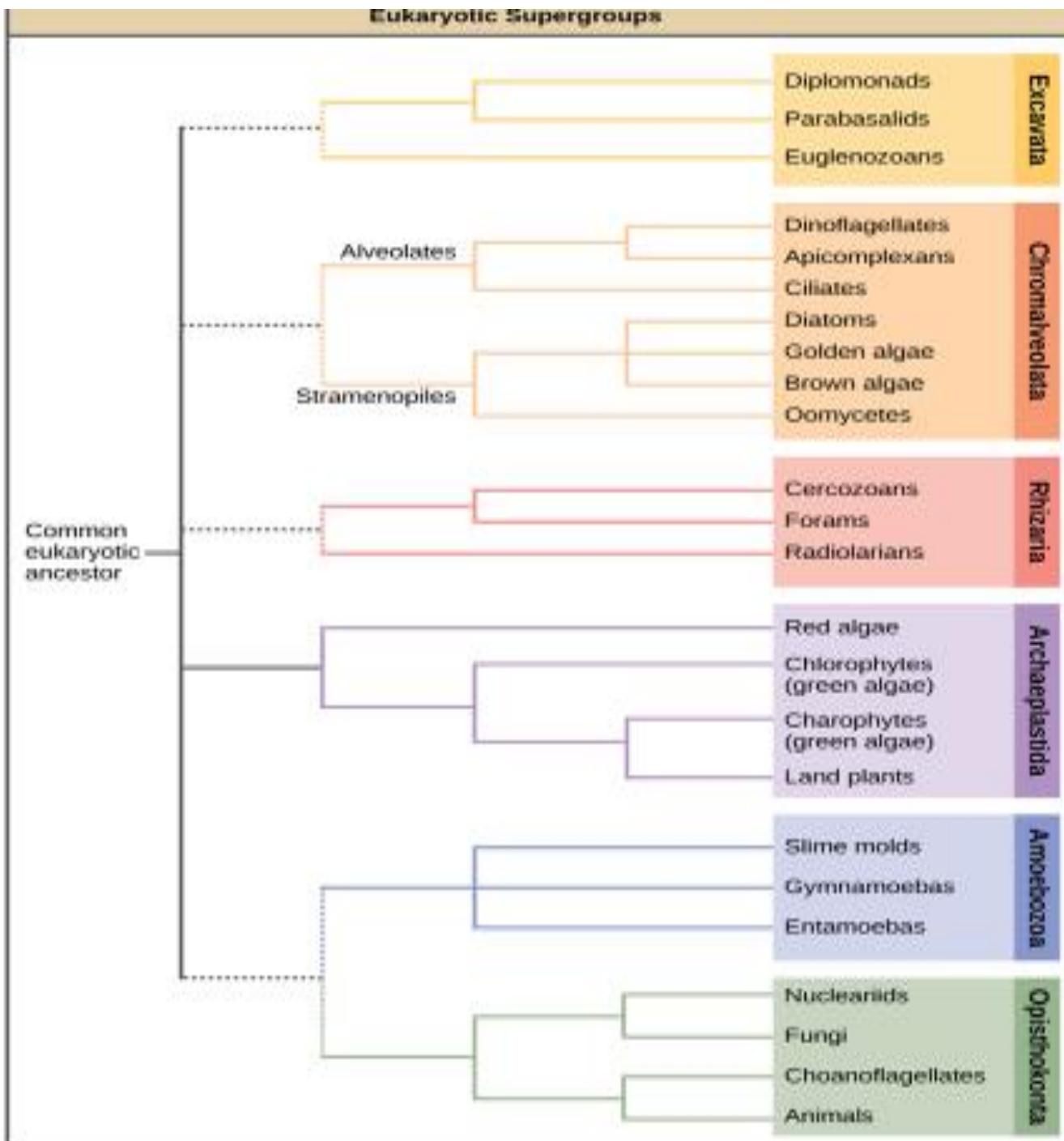


Classification of Protista





PHYLOGENETIC
AND SYMBIOTIC
TAXONOMIC
CLASSIFICATION
OF PROTIST



There are also parasitic protozoans which live in the cells of larger organisms. Most of the members do not have a predefined shape. For instance, an amoeba can change its shape indefinitely but a paramecium has a definite slipper-like shape.

The most well-known examples of protozoans are amoeba, paramecium, euglena. Unlike other members of this group, euglena is a free-living protozoan that has chlorophyll, which means it can make its own food. The protozoans can be divided into four major groups:

Amoeboid protozoans – Mostly found in water bodies, either fresh or saline. They have pseudopodia (false feet) which help to change their shape and in capturing and engulfing food. E.g. Amoeba

Flagellated protozoans – As the name suggests, the members of this group have flagella. They can be free-living as well as parasitic. E.g. Euglena

Ciliated protozoans – They have cilia all over their body which help in locomotion as well as nutrition. They are always aquatic. E.g. Paramecium

Sporozoans – These organisms are so-called because their life cycle has a spore-like stage. For example, the malarial parasite, Plasmodium.

Slime Moulds - Slime moulds are saprophytic organisms (they feed on the dead and decaying matter). These are tiny organisms that have many nuclei. Usually, Slime moulds are characterized by the presence of aggregates called plasmodium and are even visible to the naked eye.

Chrysophytes, Dinoflagellates and Euglenoids: -These form another category under kingdom Protista. These are generally single-celled or multicellular organisms. These are photosynthetic, found mostly in freshwater sources or marine lakes. They are characterized by a stiff cell wall.

Example of chrysophytes include diatoms and golden algae. They are characterized by the presence of a hard siliceous cell wall.

Diatomaceous earth is formed due to the accumulation of cell wall deposits. They are photosynthetic organisms.

Dinoflagellates are photosynthetic and found in various different colours, according to the pigment present in them. They show bioluminescence and known to cause red tide. Euglenoids are the link between plants and animals. They lack a cell wall but

perform photosynthesis. In the absence of sunlight, they act as a heterotroph and feed on small organisms. The outer body covering is a protein-rich layer known as a pellicle. E.g. Euglena, Trachelomonas, etc.

Economic Importance of Protists

1. Protists serve as the foundation of the food chain.
2. Protists are symbionts – having a close relationship between two species in which, one is benefited.
3. Some protists also produce oxygen and may be used to produce biofuel.
4. Protists are the primary sources of food for many animals.
5. In some rare cases, Protists are harvested by humans for food and other industrial applications.
6. Phytoplankton is one of the sole food sources for whales
7. Seaweed is an alga, which is considered a plant-like protist.
8. Zooplankton is fed on by various sea creatures including shrimp and larval crabs.

LOCOMOTORY ORGANELLES AND LOCOMOTION IN PROTOZOA

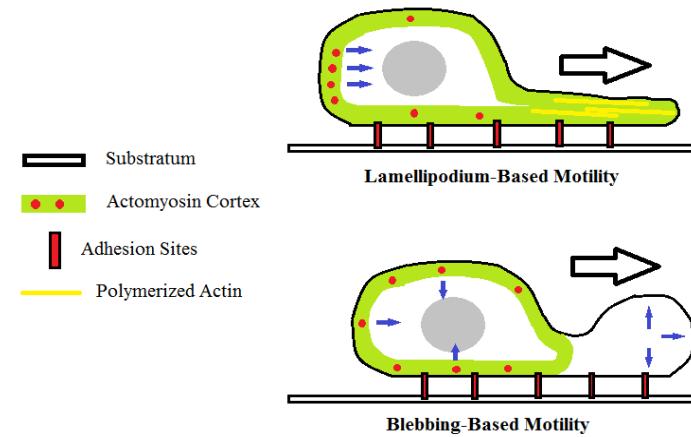
Four major types of locomotion organelles occur among protozoa; and usually each type of them is characterized by a class:

1. Pseudopodia are characteristics of Sarcodina
2. Flagella are characteristics of Flagellata (Mastigophora)
3. Cilia are characteristics of Ciliata
4. Myonemes are characteristics of Sporozoa.

Type # 1. Pseudopodia:

Pseudopodia are temporary extension of cytoplasm from any part of the body. They occur in those protozoa which are “naked” or have a very thin pellicle. Pseudopodia are formed from ectoplasm but also have a core of endoplasm.

Movement occurs when the cytoplasm slides and forms a pseudopodium in front to pull the cell forward. This type of movement has been linked to changes in action potential, though the exact mechanism is still unknown. Some examples of organisms that exhibit this type of locomotion are amoebae (such as *Amoeba proteus* and *Naegleria gruberi*) and slime molds, as well as some cells in humans such as leukocytes.



Two common modes of amoeboid motility

Among Sarcodina, the following kinds of pseudopodia are found:

(i) Lobopodia:

These are relatively broad, finger like or lobe like and sometimes branched pseudopodia, typically with rounded tips. They are usually composed of both the ectoplasm and the endoplasm. They are quickly formed and equally quickly withdrawn.

Lobopodia are characteristic of amoeba, although they are also formed by certain flagellates and testaceans (Arcella). Several lobopodia may be given out from the body surface in different directions, as in *Amoeba proteus*. But in others, like *A. limax*, the whole body flows into a single lobopodium.

ii) Filopodia:

It is filamentous and tapering at the tip. It is formed of only ectoplasm. Sometimes they may be branched. Example- Euglypha.

(iii) Reticulopodia (Rhizopodia or Myxopodia):

These are also filamentous, branching and anastomosing in form a network. Reticulopodia are formed of ectoplasm. Example, Foraminifers.

(iv) Axopodia:

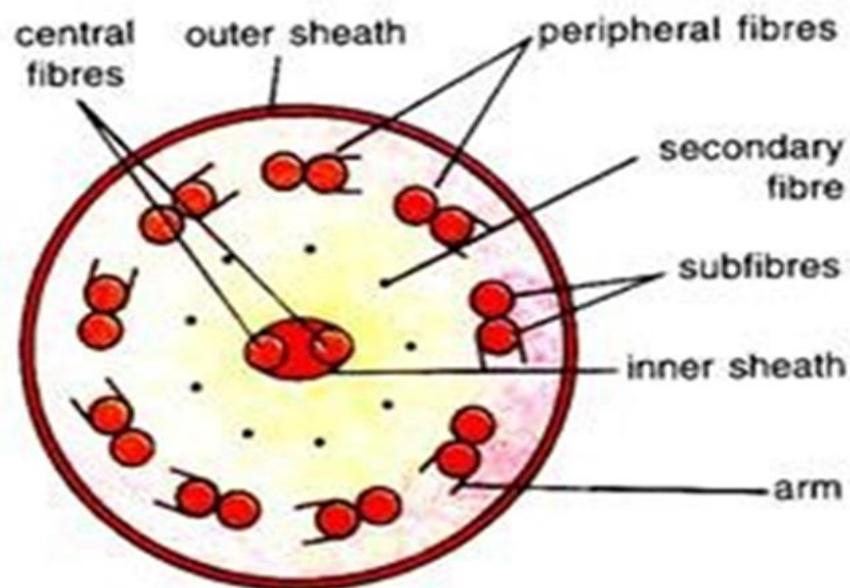
These are long and single radiating pseudopodia. These are formed of an axial filament surrounded by cytoplasmic sheath. Cytoplasm is fluid in nature. Example, Actinophrys and Actinosphaerium.

Type # 2. Flagella

Structure:

A flagellum is a thread-like cylindrical or flattened, band-like structure typically consisting of a stiff, elastic axial filament or axoneme, surrounded by a protective contractile outer sheath. The axoneme may be straight or spirally coiled. It consists of nine longitudinal paired peripheral fibres, at equal distance from each other, forming a cylinder and two longitudinal central fibres enclosed by a membranous inner sheath. Each peripheral pair bears a double row of short arms.

All the fibres remain embedded in a fluid matrix. Nine accessory fibres mostly occur between the central and peripheral fibres.



**Fig. 12.2. *Euglena*. T.S. flagellum
(diagrammatic).**

The kinetosome may be joined to the nucleus by a rhizoplast. The basal granule is often synonymous with a centriole because it initiates nuclear divisions. If it does not act as a centriole then it is connected by a rhizoplast to a centriole or to the nucleus.

Flagellar Movement:

Vickerman and Cox (1967) have suggested that the flagellum makes direct contribution to locomotion.

However, several theories have been put forth to explain the mechanism of flagellar movement. Butschli observed that the flagellum undergoes a series of lateral movements and in doing so, a pressure is exerted on the water at ripressure is exerted on the water at right angles to its surface.

This pressure creates two forces one directed parallel, and the other at right angles, to the main axis of the body. The parallel force will drive the animal forward and the force acting at right angles would rotate the animal on its own axis

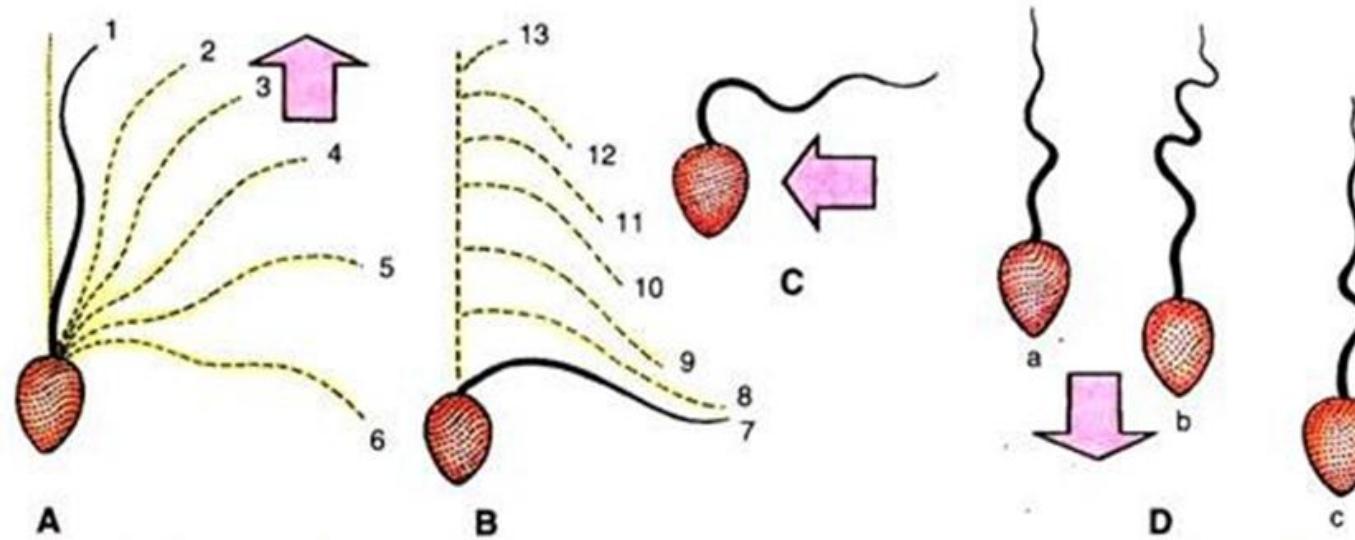


Fig. 12.5. Action of flagellum. A—Recovery stroke, successive stages from 1 to 7; B—Effective stroke, successive stages 8 to 13.

Gray (1928) suggested that a series of waves pass from one end of the flagellum to the other. These waves create two types of forces, one in the direction of the movement and the other in the circular direction with the main axis of the body. The former will drive the animal forward and the latter would rotate the animal.

For quite a long time it was generally presumed that the flagellum is directed forwards during flagellar movement but now it is generally agreed that the flagellum is straight and turgid in effective stroke and dropped backwards in the recovery stroke.

Recently Lowndes (1941-43) has pointed out that the flagellum is directed backwards during locomotion. According to Lowndes, a series of spiral waves pass successively from the base to the tip of the backwardly directed flagellum at about 12 per second with increasing velocity and amplitude.

The waves proceed along the flagellum in a spiral manner and cause the body of Euglena to rotate once in a second. Thus, in its locomotion, it traces a spiral path about a straight line and moves forward. The rate of movement is 3 mm per minute.

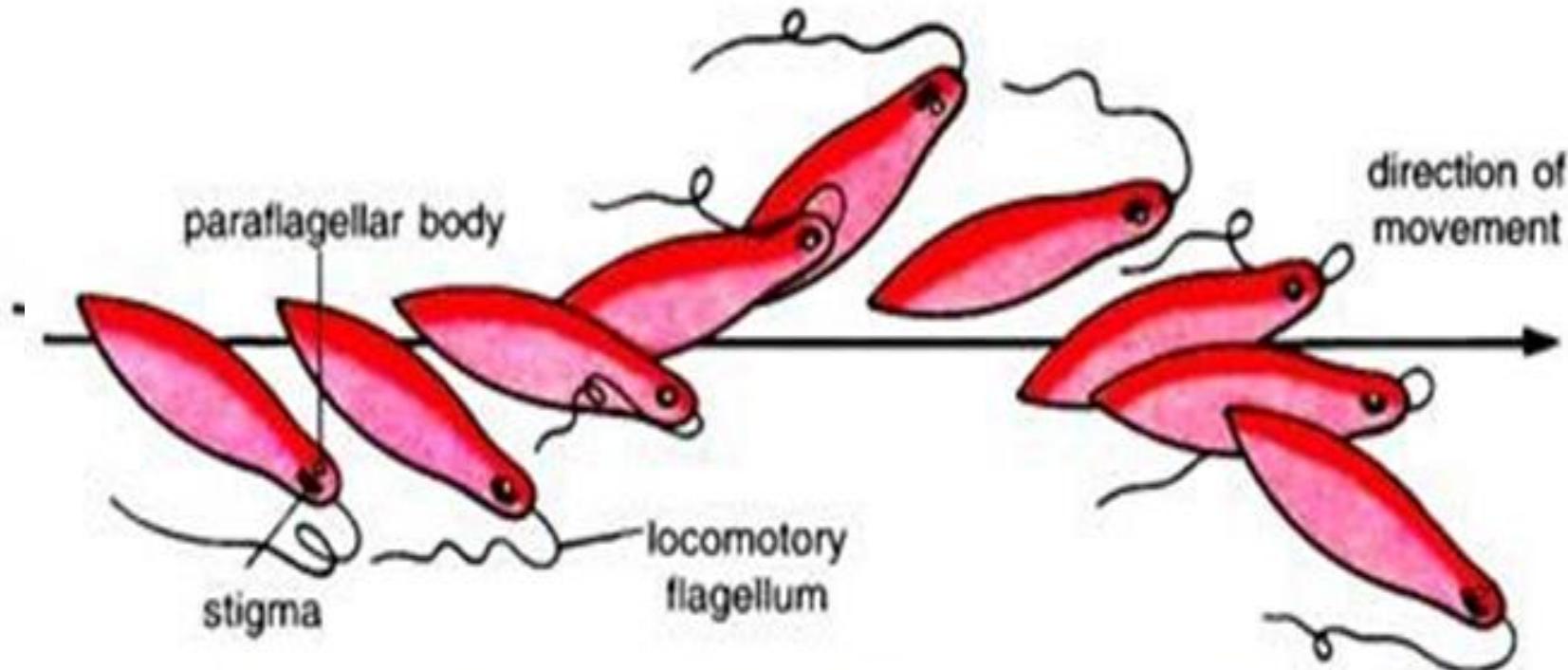
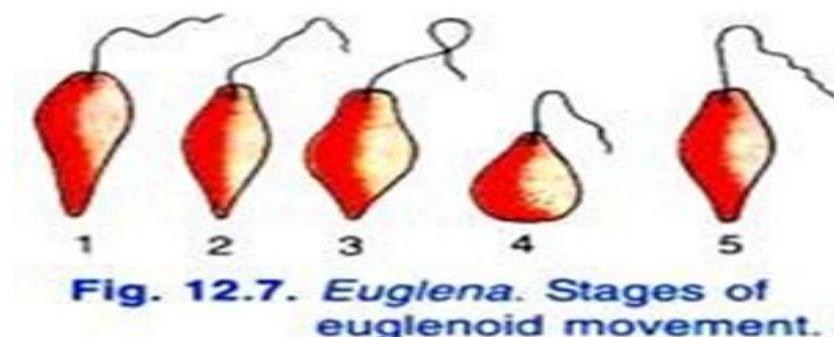


Fig. 12.6. *Euplotes*. Successive stages in flagellar movement.

However, movement of flagellum is related to the contraction of its all fibrils. The energy for the contraction of these fibrils is derived from ATPs formed in the mitochondria of blepharoplasts.

Euglenoid Movement or Metaboly:

Euglena sometimes shows a very peculiar slow wriggling movements. A peristaltic wave of contraction and expansion passes over the entire body from the anterior to the posterior end and the animal moves forward. The body becomes shorter and wider first at the anterior end, then in the middle and later at the posterior end. This type of movement is called euglenoid movement by which slow and limited movement occurs. Euglenoid movements are brought about by the contractions of cytoplasm or by the contractions of myonemes present in the cytoplasm below the pellicle.



Mastigonemes:

In some flagella, the outer sheath may also contain fibrils which become frayed out laterally under certain conditions. These fibrils are known as mastigonemes or Flimmer. But their real nature is uncertain. Their arrangement seems to be constant within various groups and may prove helpful in studies on taxonomy and phylogeny.

On the basis of mastigonemes, flagella may be of— Stichonematic, Pantonematic, Acronematic, Pentachronematic, and Simple type. Stichonematic type flagella bear a single row of lateral mastigonemes (e.g., *Astasia*, *Euglena*) while Pantonematic type flagella bears neither terminal filament nor mastigonemes.

Flagellar Attachment:

Flagellar attachments are generally complex. A flagellum commonly springs from the anterior body-end, either directly (Trichomonas, Eudorina) or from a groove, pit or cytopharynx (Euglena). The axoneme of each flagellum arises from a basal granule or blepharoplast or kinetosome.

It is a cylindrical body formed by the bases of the peripheral fibres. It may occur in the cytostome, attached to the nuclear membrane or inside the nucleus. The basal granule is usually connected to the nucleus by fibrils, called rhizoplast, which may also connect it with a parabasal body of unknown function, especially in some parasitic flagellates (Trichomonas, Giardia, Trypanosoma, etc.).

Number of Flagella:

The number and arrangement of flagella varies greatly in **Mastigophora**. They may be one to eight in number; several flagella occur in parasite forms (e.g., *Giardia intestinalis*). Free-living forms (e.g., *Euglena*) are usually with one to two flagella. Flagella are often divided into two types – tractella and pulsella. The tractellum is situated at the end that is anterior when the organism is in motion and drags the body along; the pulsellum is generally situated posteriorly and pushes or propels the body forward.

In *Bodo* and *Aesonema* there are two flagella. One is directed forward, drags the body and is called tractellum, while the other is directed backwards along the side of the body and acts as an organ of propulsion, it is known as trailing flagellum.

Type # 3. Cilia:

The cilia are highly vibratile small ectoplasmic processes. They arise from the basal granules (or blepheroplasts or kinetosomes) in the ectoplasm. Cilia form a characteristic feature of ciliates but they are also found in the larval stages of Suctoria. In primitive forms (e.g., Opalina, Paramecium etc.) cilia cover the entire body, but in more specialized forms (e.g., Vorticella) cilia are restricted to certain regions of body only.

They are commonly arranged in longitudinal, diagonal or spiral rows. Cilia may be of equal length all over the body or may be longer at definite spots (e.g., cilia of caudal tuft of Paramecium are longer than other body cilia

The infraciliary system of ciliates differs from that of flagellates in the following respects:

- (i) Cilia are shorter and numerous than flagella.**
- (ii) In case of ciliates, the infraciliature is not joined to the nucleus nor are kinetia inter-connected. In flagellates rhizoplasts join the kinetosomes to the nucleus and the kinetia may be inter-connected.**
- (iii) In case of ciliates, during cell division the cleavage is perkinetal because it cuts across all kinetia. The upper halves go to one daughter cell and the lower halves to the other. Such type of division is known as homothetogenic in which the daughter cells are duplicates of each-other. In cell division of flagellates the cleavage is interkinetal because it is longitudinal and parallel to kinetia**

So that kinetia are not cut but are shared by daughter cells. Such type of division is known as symmetrigenic in which the daughter cells are not duplicated for mirror images of each other. The normal number of kinetia of an animal is restored by division of kinetosomes.

(iv) Like Flagella, cilia have no mastigonemes. Usually the cilia remain arranged in longitudinal diagonal or spiral rows, springing from either ridges or furrows. The manner of arrangement is rather constant within a species. The cilia may be found all over the body (like Opalins, Paramecium) or may be restricted to certain parts/of the body, referred to as ciliary fields or ciliary zones (like Vorticella). The term pectinella is sometimes used for such a small row of close-set cilia.

Structure:

A cilium is morphologically similar to a small flagellum and consists of an axial filament or axoneme surrounded by an elastic sheath continuous with the plasma membrane of the cell surface. Electron microscope shows that the axoneme consists of 9 paired peripheral fibres and 2 central fibres, the later enclosed within a delicate inner sheath, and all present in a fluid matrix.

One microfibre of each peripheral pair gives out a double row of short projections, called arms, all pointing in the same direction. In between the outer and inner fibre rings is present, nine spoke-like radial lamella. The cilium arises from a basal granule or bleplaroplast situated deep in the ectoplasm.

It is a tubular body formed by the basal ends of the 9 peripheral fibres, each made of a triplet of 3 microfibres arranged in a twisted fashion. According to Lenhssek and Henneguy (1898), the basal granules are centrioles or their derivatives. In Coleps, Stentor and many others, besides vibratile locomotory cilia, are also found stiff, motionless, sensory cilia, equipped with special fibrils and basal granules.

Specialized Organelles:

The cilia may form the following composite motile organelles which are found in several protozoan groups. These are membranelles of Ciliata (Paramecium), undulating membrane of Spirotricha and Peritricha and cirri of Hypotricha.

Cirri are tuft-like brushes of functionally fused somatic cilia. Their kinetosomes form a basal fibre plate. Undulating membranes are formed of a row of oral cilia. Membranelle is flat plate of oral cilia with a basal fibre plate. They are arranged in a longitudinal series and beat in a coordinated fashion.

Differences in Cilia and Flagella:

Cilia are similar to flagella in structure, and function but differ in following ways:

- i. They are short in length than flagella.**
- ii. They are larger in number.**
- iii. Cilia possess no mastigonemes as found in flagella.**
- iv. No connection of basal granule with nucleus in cilia. In flagella the rhizoplast join the basal granules to the nucleus.**

Type # 4. Myonemes:

The myonemes are extremely fine and highly contractile structures running in various directions in the pellicle or ectoplasm of various Protozoa. They serve chiefly to alter the shape of the body. Some Protozoa, like Amoeba, which do not possess myonemes, can also change their shape, but this is due to the general contractility of the protoplasm.

The myonemes may be in the form of ridges and grooves (e.g. Euglena), or microtubules (e.g. Trypanosoma), or myofibrils (e.g. ciliates). The myonemes find their greatest development in Ciliata. They are band-like and cross-striated in Stentor. In certain stalked ciliates (Vorticella) the longitudinal myonemes of the body proper converge, basally into the stalks forming the spasmoneme

In some ciliates (*Stentor*) and larger gregarines (*Monocystis agilis*), the myonemes lie inside individual hyaline ectoplasmic canals. In many Gregarinida, they are arranged longitudinally, transversely and spirally and apparently used in locomotion. In certain Radiolaria (*Acanthometron*) 10-30 short, thick myonemes (myophrisks) are connected basally to each radiating spicule. These serve as hydrostatic organelles since their contractions and expansions cause variations in the volume of the body, which is thus enabled to rise or sink in the water.