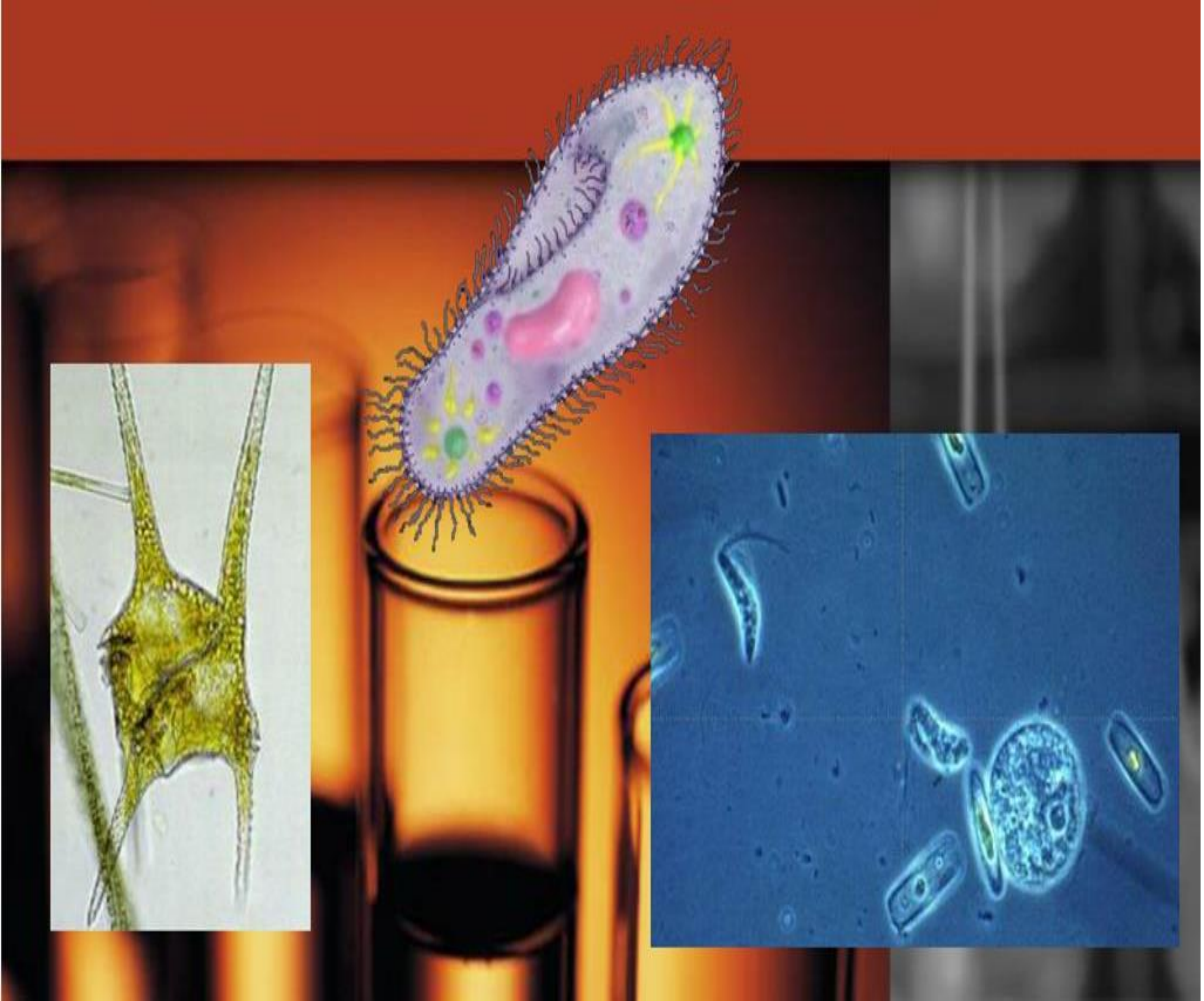

PROTISTA

Locomotory Organelles & Locomotion Methods

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Protista are unicellular eukaryotic microorganisms found in nearly every habitat on Earth, from freshwater ponds to marine environments, from soil to animal digestive tracts.

Diameters ranging from **1 to 100 micrometres**, with some larger species reaching lengths of **several millimetres.**

They are known for their morphology, physiology, behaviour, and ecological diversity.

One of the most fascinating aspects of Protista is their locomotory organelles and the various methods of locomotion they employ.

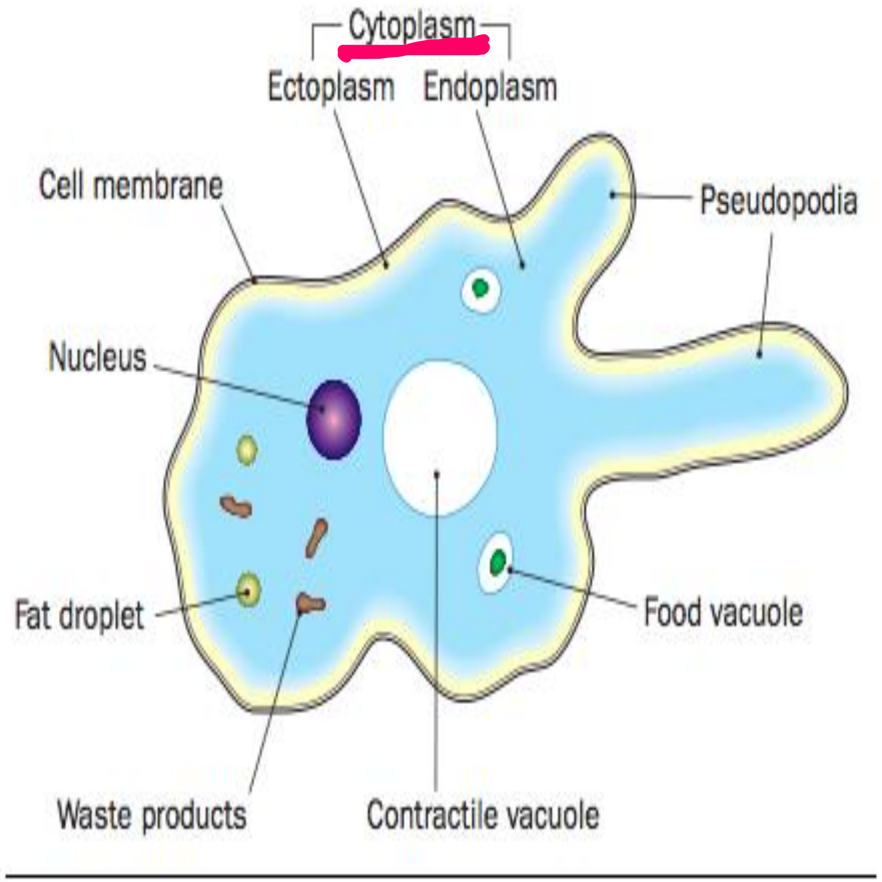
LOCOMOTOR ORGANELLES IN PROTISTA

Locomotion is a process of moving from one place to another.

As per the structure main types of locomotory organs in protista are – **Pseudopodia, Flagella, Cilia and Myomeres.**

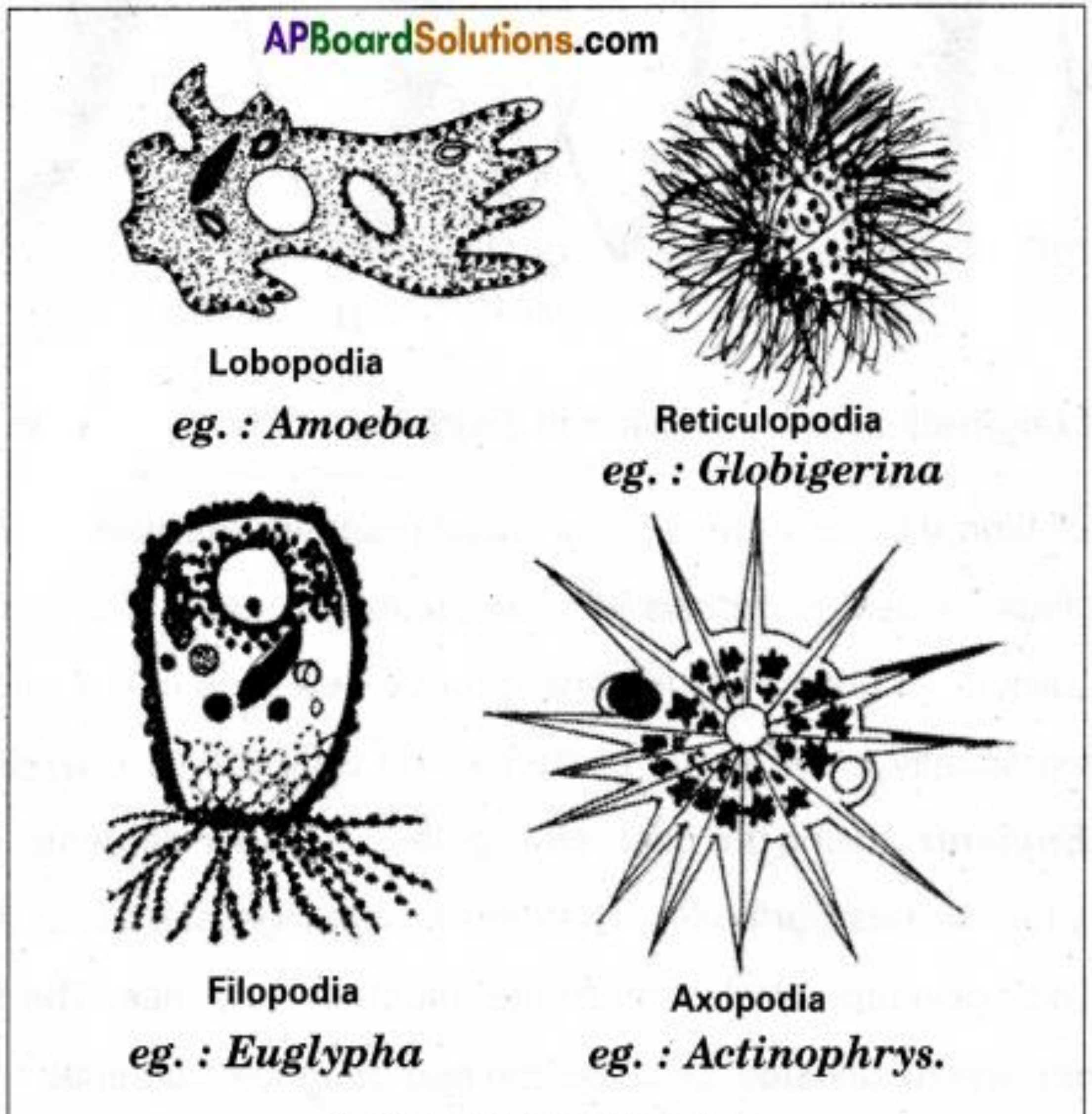
PSEUDOPODIA

1. Pseudopodia: These are the temporary projections or outgrowth of cytoplasm that can arise from any part of the body. They are mainly found in rhizopoda.



Based on the structure pseudopodia are of 4 kinds

1. **Lobopodium-** They are lobe like in shape- short finger like structures having distinct ectoplasm and endoplasm. In most of the animals they are formed from the body surface. **Eg. *Amoeba***.
2. **Filopodium-** These are fine, long thread like or filamentous like structure which are exclusively made up of ectoplasm**. Filaments arises from the base of the individual**. In some animals-**branched**. **Eg. *Euglypha***
3. **Reticulopodium-** It is also known as myxopodium. Pseudopodias are **branched, filamentous and form network like structure** and mainly useful for food capturing. **Eg. *Elphidium, Globigerina***
4. **Axopodium-** These are **long stiff & spiny structures produced from nucleus or ectoplasm and endoplasm**. It has cytoplasmic envelope. These are useful for food capturing. **Eg. *Actinophyrs*.**



Types of Pseudopodia

FLAGELLA

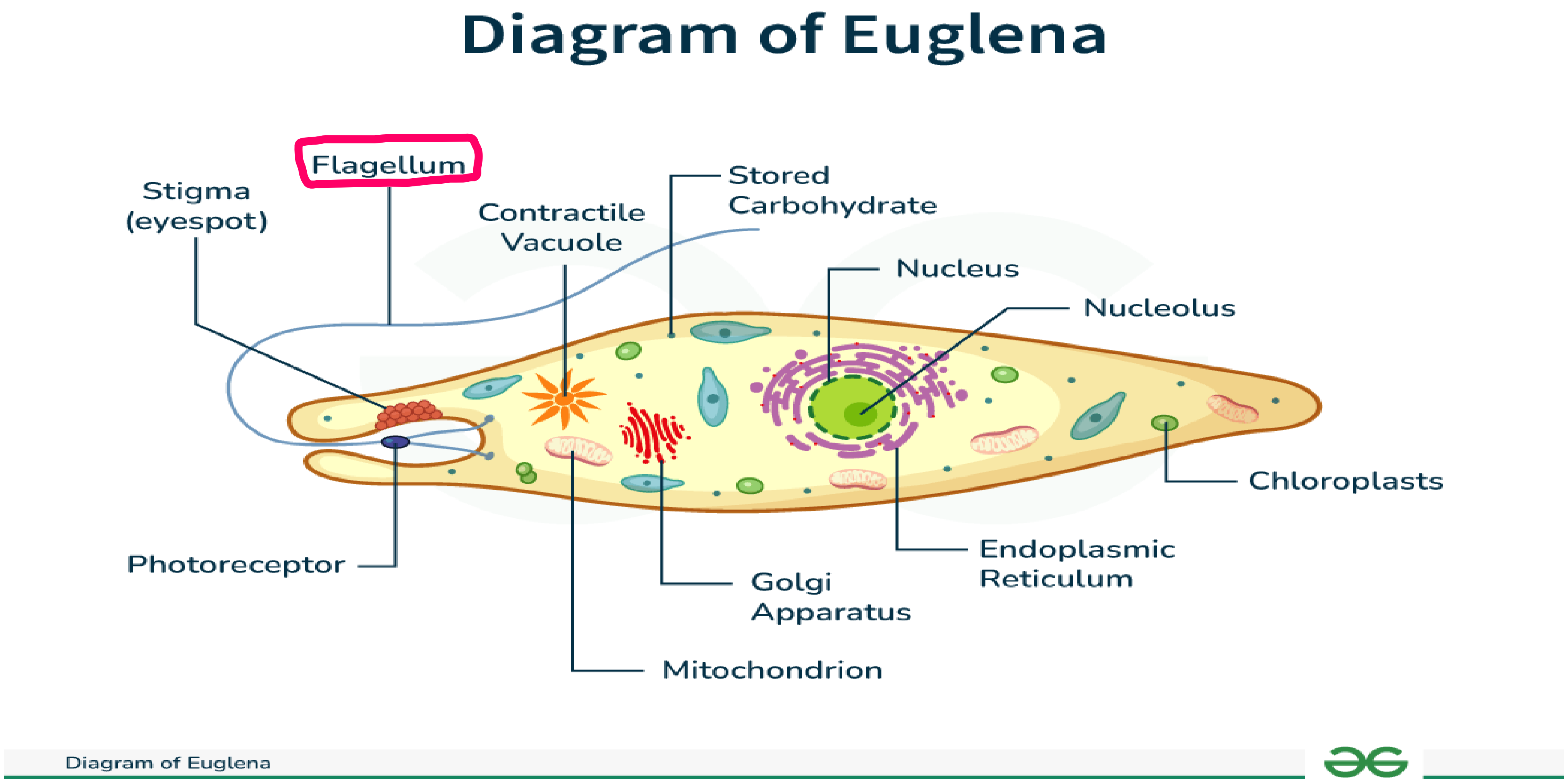


Diagram of Euglena
Flagellum
Stigma
(eyespot)
Contractile
Vacuole
Stored
Carbohydrate
Nucleus
Nucleolus
Chloroplasts
Photoreceptor
Endoplasmic
Reticulum
Golgi
Apparatus
Mitochondrion
Diagram of Euglena

FLAGELLA

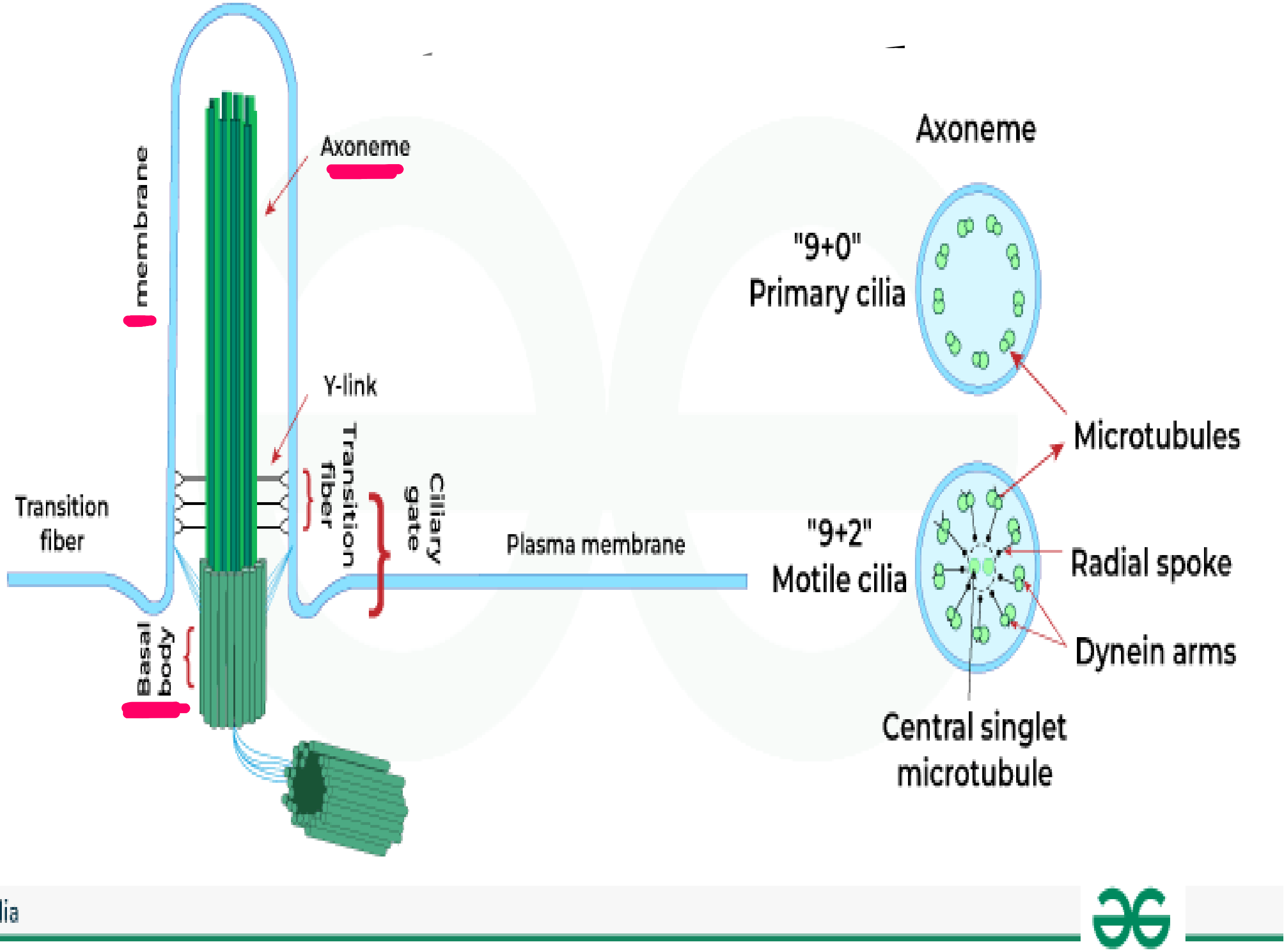
FLAGELLUM:

It is an extreme **filamentous or thread like extension of cytoplasm of the plasma membrane**. It is highly **vibratile.**

Flagella arises from the basal body called blepharoplast

Core of the flagella is called Axonema- elastic, straight [OR] spiral filaments

Outer covering of the flagellum is called Protoplasmic sheath.



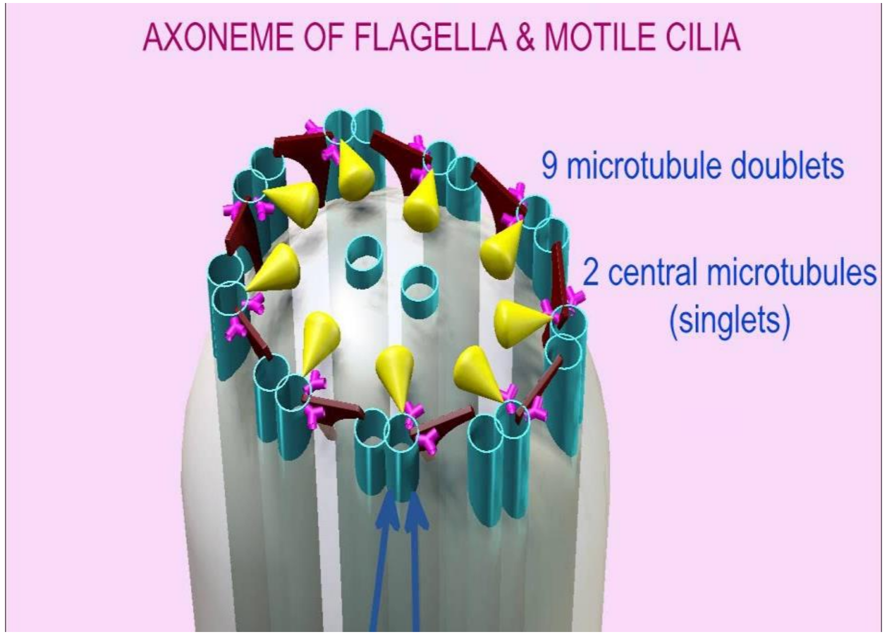
CROSS SECTION OF THE FLAGELLUM

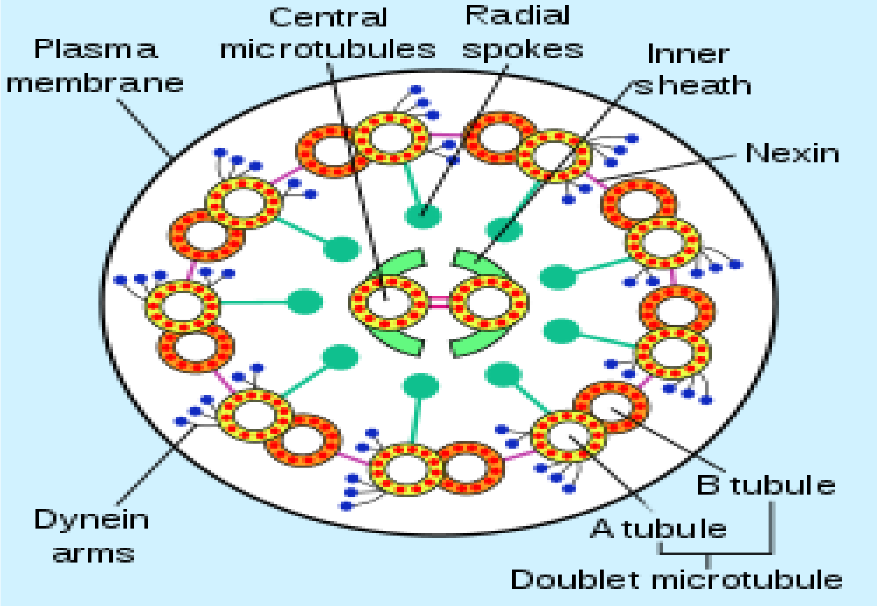
An Axonema contains 2 central fibrils and 9 pairs of peripheral fibrils. Hence, they arrange in [9+2] order .

At centre- 2 rings are present in singlet form (ie 2 circles)

At periphery- 9 rings are present but in doublet form which are fused together. One ring seen overlapping the other

The protein that joins all the doublets is **DYNEIN** which helps in bending properly .





STRUCTURE OF AXONEMA

Rings are called microtubules (2 types):

A microtubule (13 protofilaments)

B microtubule (10 protofilaments)

Protofilaments are the **linear arrangement of α and β tubules which are polymerized and fused in a rod like structure.**

Two microtubules are attached by **TECTIN** protein.

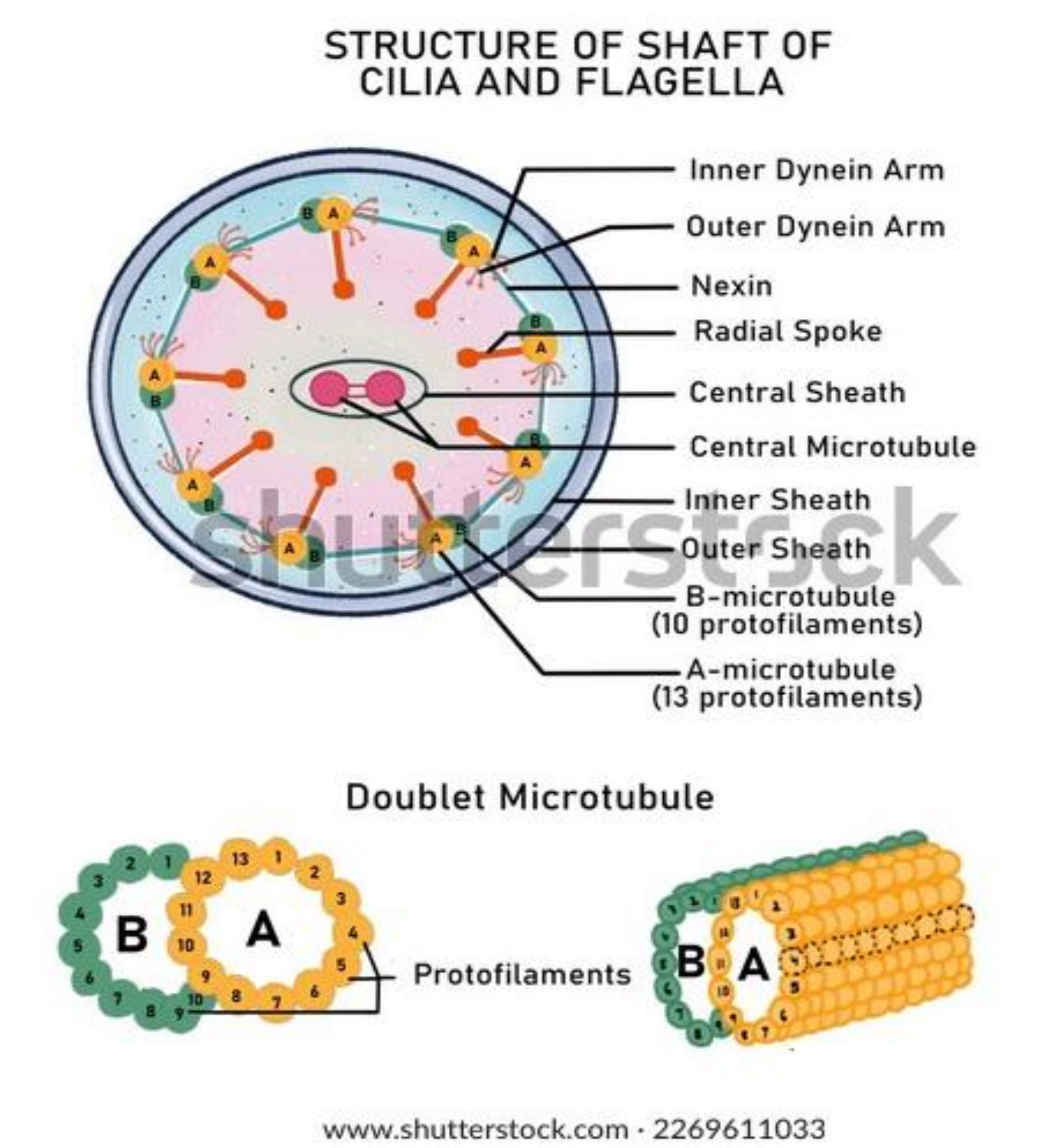
Central Rings or microtubules are also made up of protofilaments covered by central sheath.

In periphery rings, **Complete ring(A microtubule) has radial spoke** which attached them to central sheath and also **contain inner and outer dynein arms.**

Dyenin Arms convert the chemical energy released from adenosine triphosphate (ATP) hydrolysis into mechanical work by causing the doublets to slide with respect to each other (**Responsible for the oscillating movement of flagella**)

The doublet rings are connected to adjacent rings with the **NEXIN** protein

On the whip like flagella some have lateral fibrila called mastigonemes .



According to their Arrangement of Mastigonems,
flagella are classified into five types.

[1] Stichonematic : Single row of mastigonemes are present on one side of the flagella **E.g. *Euglena.***

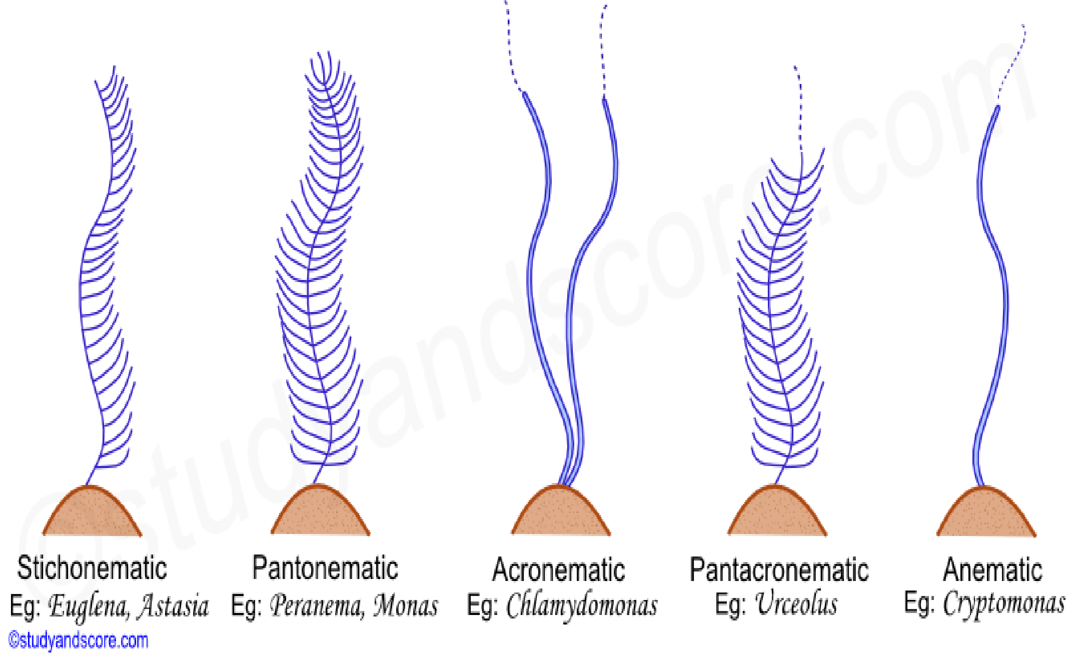
[2] **Pantonematic:** Two [or]more rows of mastigonemes are present on both side of flagella **e.g *Monas & Paramecium***

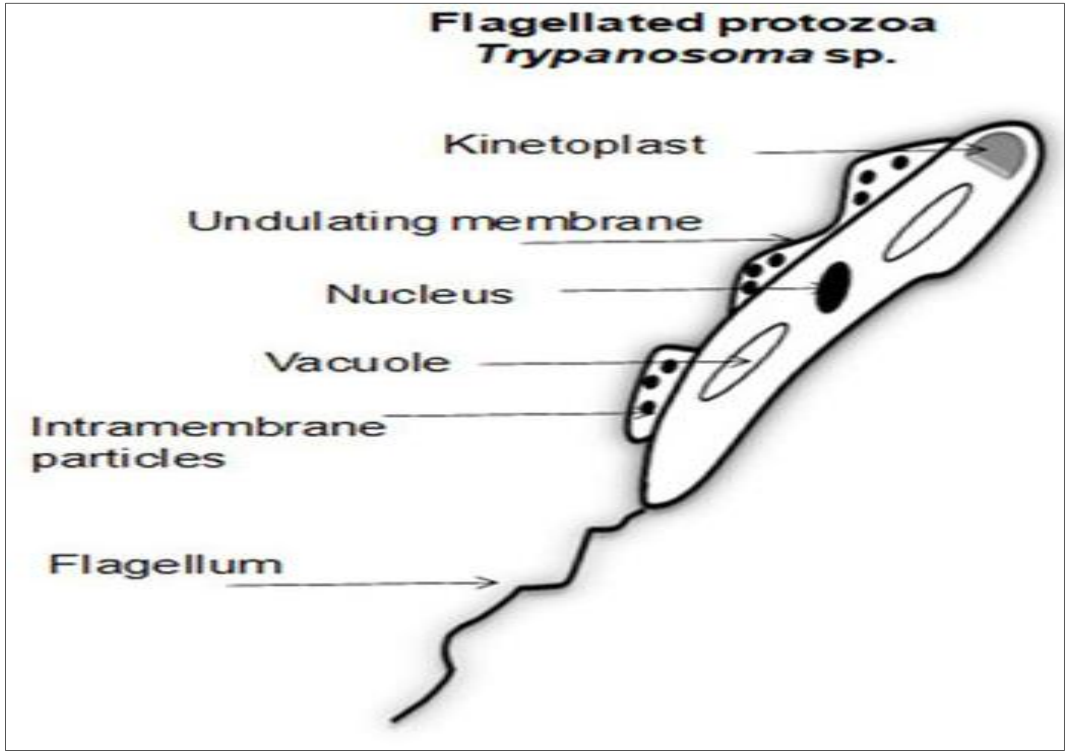
[3] Acronematic:Mastigonems are absent. Both of the **flagellum is wide** and ends in a filament Eg: ***Volvox,***

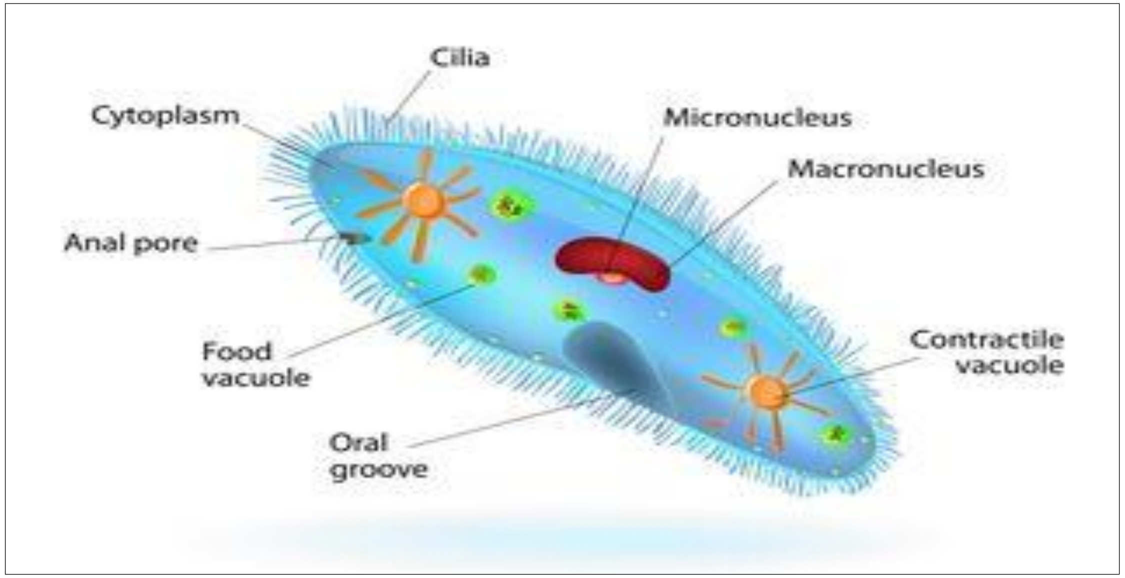
[4] Pentachronematic: Matigonems present on both side but **ends with a terminal filament**. **Eg: *Urcoelus***

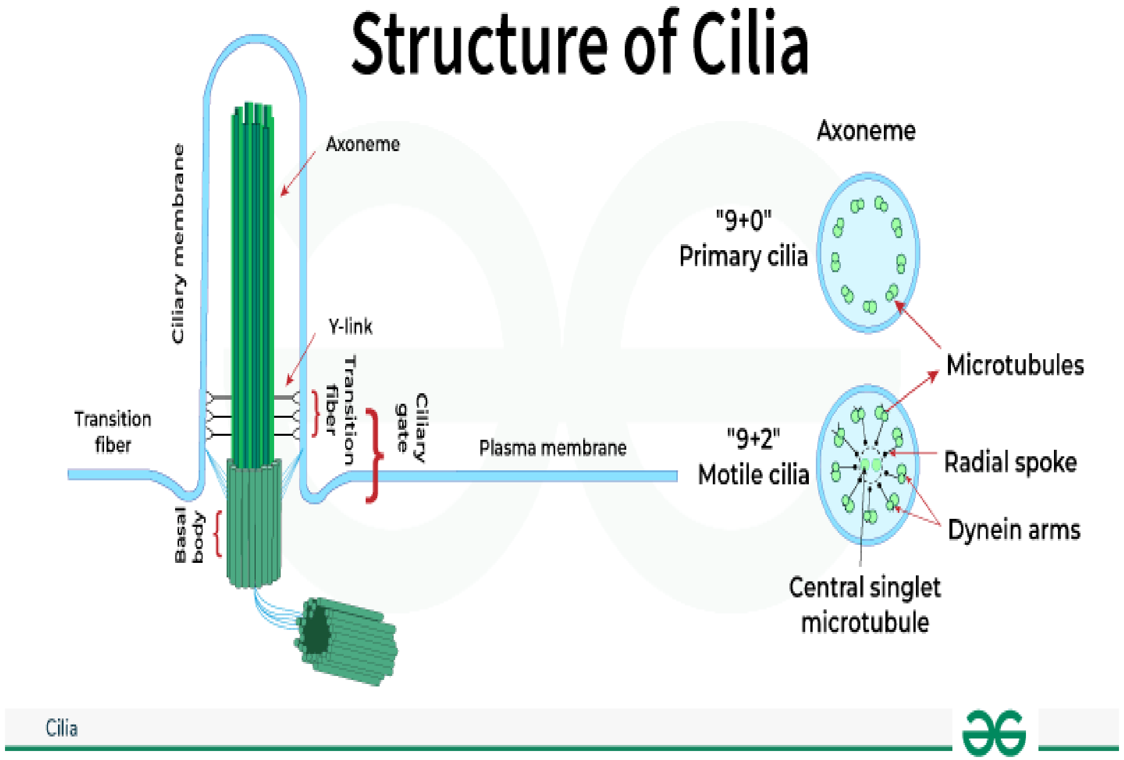
[5]Anematic: **T**ype of flagellum that are simple and lack mastigonomes Eg: ***Cryptomonas***

[6]Flagella with undulating membrane: Flagella remains attached with the undulating membrane at the base and free at the tip. **Eg: *Trypanosoma***









III) Cilia:

Structure of cilia and flagella are same but differs in number and size.

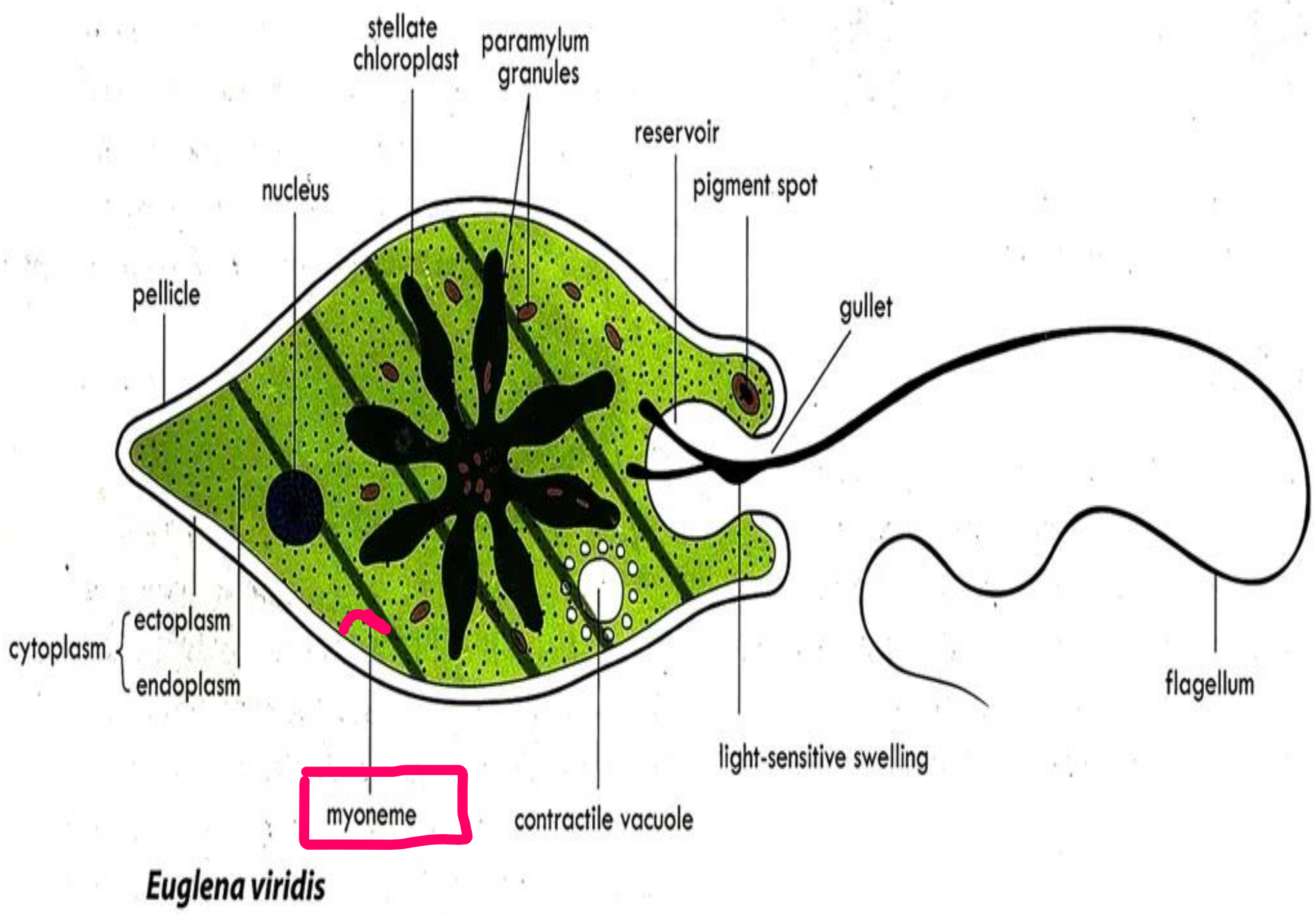
Found in class Ciliata **(ex: *Paramecium*)**

These are **shorter, more numerous in no.**

They **cover all body surface of the organism and beat in coordination.**

Cilia are devoid of Mastigonems.

PELLICULAR CONTRACTILE STRUCTURES OR MYONEMS



Myonemes are contractile structures found in the cells of some eukaryotic organisms, especially protozoans

STRUCTURE

Myonemes are made up of protein filaments that are **3-6 nanometers in diameter.**

FUNCTION

Myonemes help organisms move by contracting and relaxing. They can contract the entire cell body or just parts of it.

METHODS OF LOCOMOTION

Locomotion is a directional movement that enables animal to move from one location to another with the help of Locomotory Organelles

Basically 4 known methods, by which Protista Move

1. AMOEBOID MOVEMENT– 0.24 μ to 3 μ /second
2. FLAGELLAR MOVEMNET- 15 μ to 300 μ/ second
3. CILIARY MOVEMENT– 400 μ to 2000 μ / second
4. METABOLIC MOVEMENT

1. AMOEBOID MOVEMENT

- This type of locomotion is also called as **pseudopodial locomotion**. Here locomotion is brought about by the **pseudopodia** which is finger like projection structures. These are broad with a round tip and are called lobopodia. **They are formed by the flow of cytoplasm (ectoplasm & endoplasm) in forward direction.**
- It is the characteristic of **rhizopod protozoans** like *Amoeba proteus* and *Entamoeba histolytica.* Also, such movement is exhibited by amoeboid cells, macrophages and phagocytic leucocytes like monocytes and neutrophils of metazoans.

Various theories have been proposed to explain the amoeboid locomotion.

Name of theory	Proposed by
Contraction theory	Schultuz
Walking theory	Dellinger
Rolling movement theory	Jenning
Surface tension theory	Berthold
Adhesion theory	Jenning
Fountain zone theory	Allen
Folding and unfolding theory	Goldacre and Lorch
Hydraulic pressure theory	Renoldi and Jaun
Sol-gel theory	Hyman

SOL GEL THEORY

Sol Gel theory convincingly explains the mechanism involved in the formation of pseudopodia. **This theory, also known as Change in viscosity theory was advocated by Hyman in 1971. Later, Pantin and Mast supported this theory**.

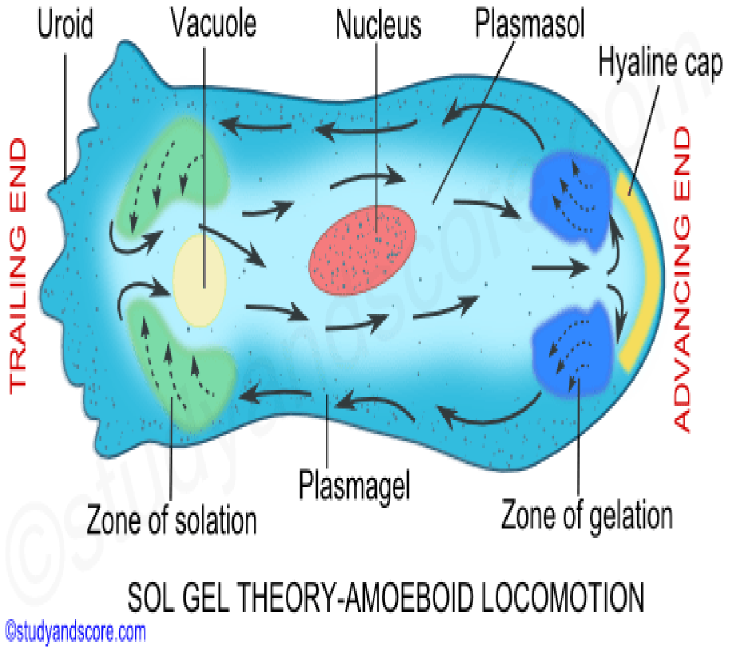
According to this theory, **the cytoplasm of amoeba can be distinguished into outer ectoplasm/Plasmagel and the inner endoplasm/Plasmasol.**

The **plasmagel which forms the outer layer of the cytoplasm is thick (like gel), less in quantity, non-granular and contractile.**

The plasmasol which forms the inner layer of the cytoplasm is more in quantity, less viscous, fluid like & more granular

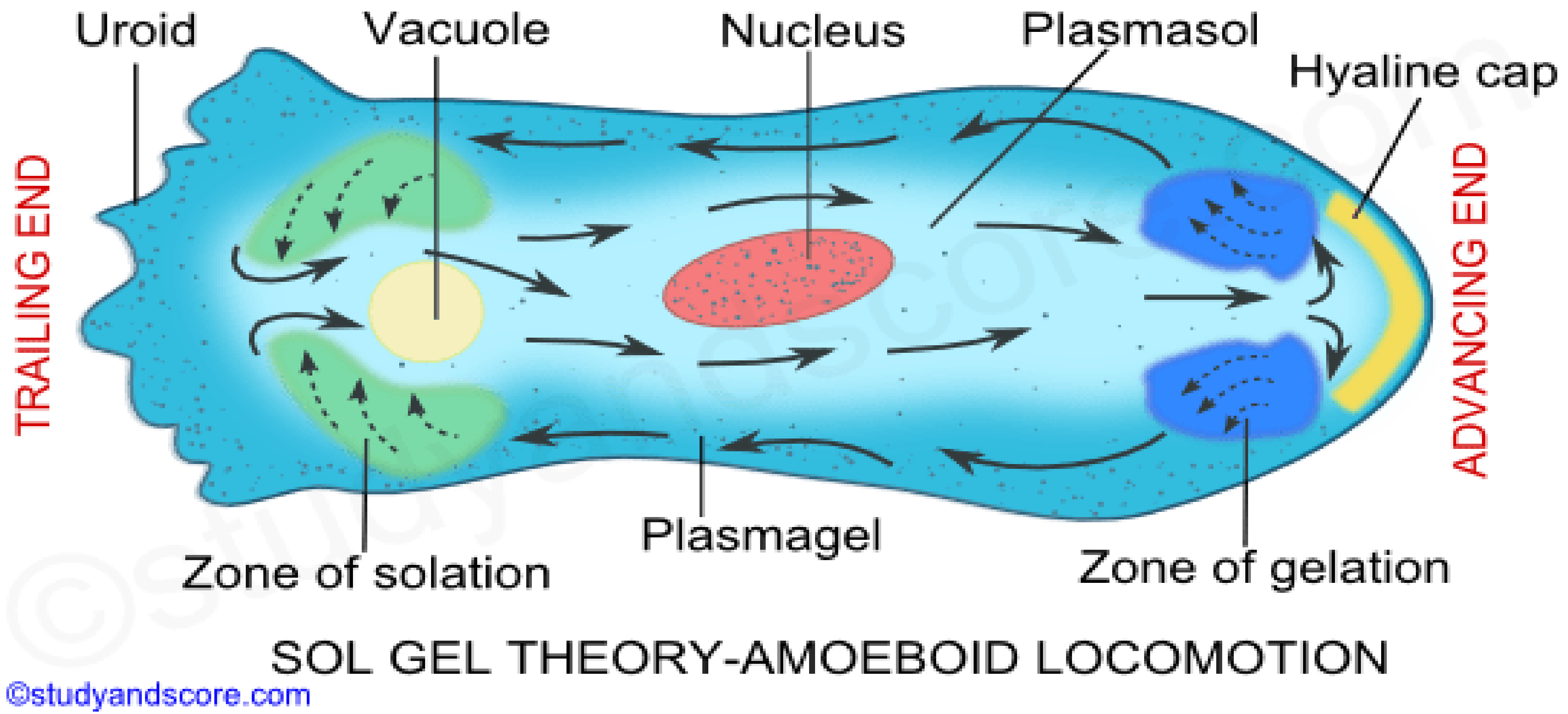
Due to change in the viscosity, the plasmagel and plasmosol inter-convert and consequently the pseudopodia form and disappear causing the movement of Amoeba.

This inter-convertibility of plasmagel and plasmosol is physicochemical change. **Gel becomes sol by taking water** and **sol becomes gel by losing water.**

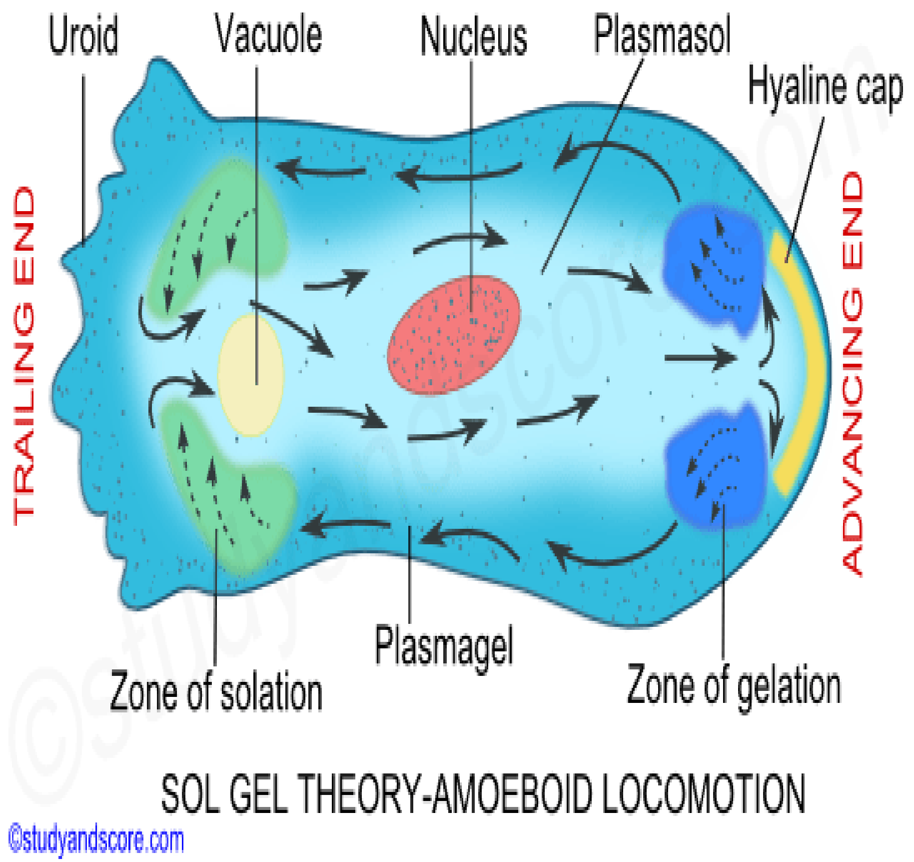


SOL GEL THEORY-AMOEBOID LOCOMOTION

SOL GEL THEORY



Step 1: Initially Amoeba **attaches itself to the solid substratum by the plasma lemma** at the temporary anterior end. Then **the hyaline layer of the ectoplasm** at the anterior end **forms a thickened hyaline cap**. It is the first stage in the **formation of the pseudopodium.**



Step 2: Behind the hyaline cap, a **point of weakness in the elasticity of plasmagel is formed**. Hence the inner plasmosol flows forward, forming a pseudopodium.

Step 3: The **plasmasol that flows outward** behind the hyaline cap changes its colloidal state from **sol to gel and joins the ectoplasm.**

Step 4: The outer region of the plasmasol, which is flowing forward undergoes gelation and produces a rigid plasmagel tube. The gelation of plasmasol extends the plasmagel tube forward.

Step 5: **Two ends appear in Amoeba at this stage**. **The anterior end is smooth** with the rounded surface which the retractile end also called as **Uroid has a wrinkled surface**.

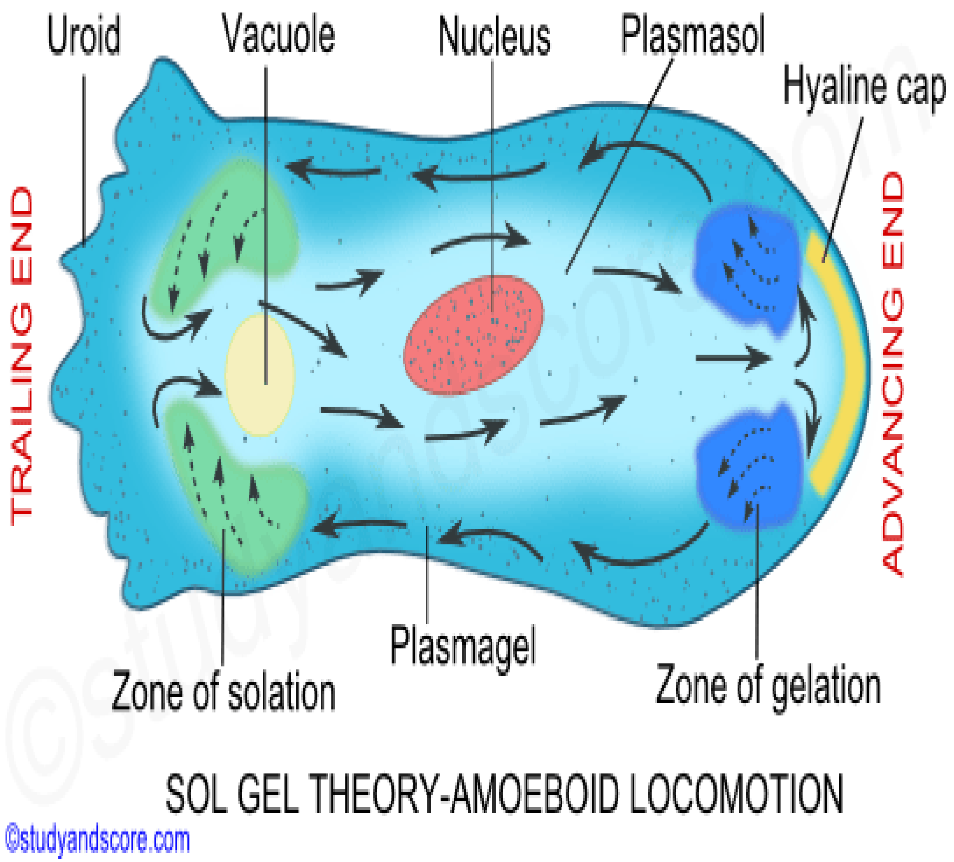
Step 6: **Around the region of the hyaline cap**, an annular region of **sol to gel transformation is formed**. It is called the zone of gelation. **At the uroid end** a region where gel transforms into sol is called as zone of solation.

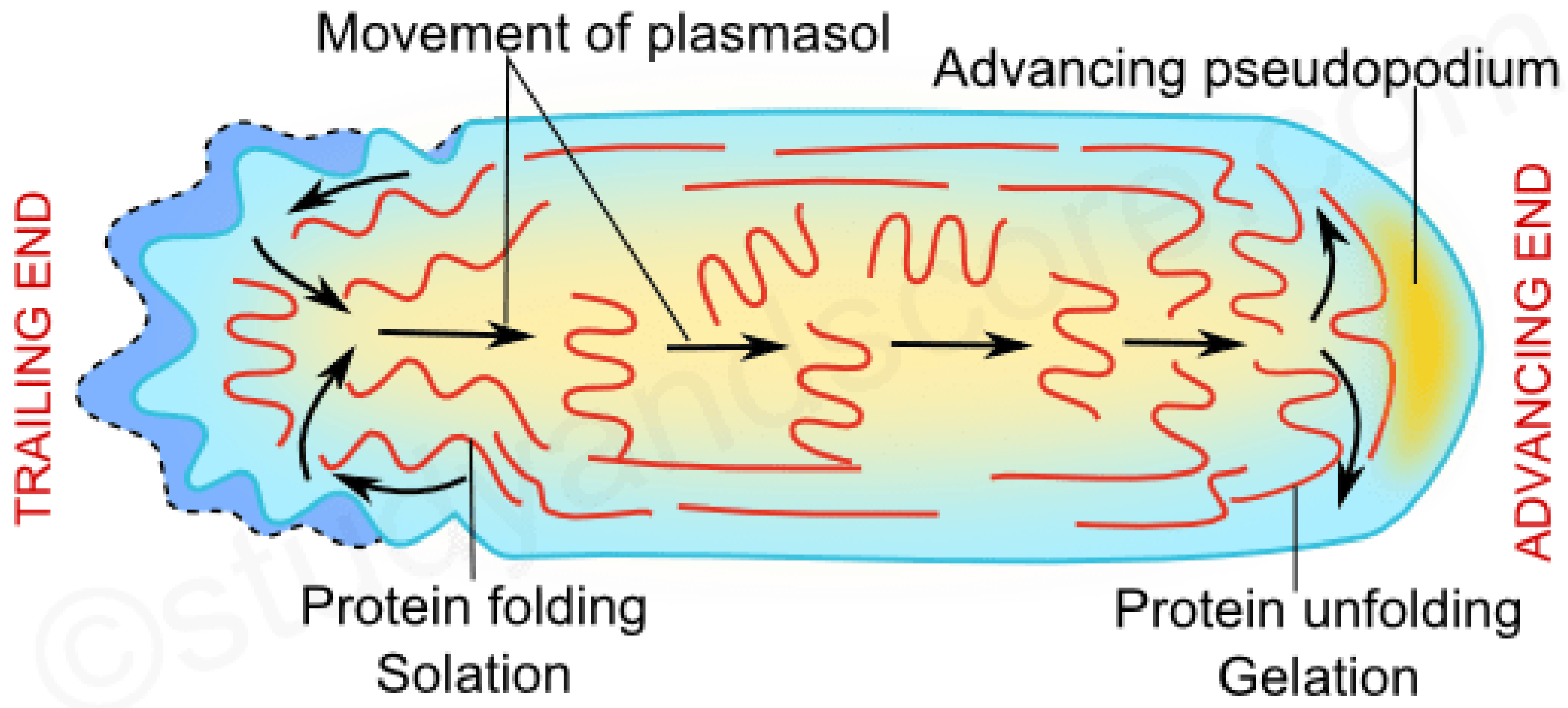
Step 7: Plasmagel at the uroid end changes into sol and flows forward continuously through the gelatinized tube. **As the plasmasol flows forward, the pseudopodium elongates further and the body of amoeba moves in that direction.**

Step 8: The gelation at the advancing end and the solation at the trailing end **occur simultaneously** and at the same rate thus making the forward movement of amoeba continuous.

Step 9: The **contraction of the plasmagel** at the trailing end causes **hydraulic pressure** on the sol and makes the plasmasol flow forward continuously in the plasmagel tube.

Step 10: As the pseudopodium advances continuously in the direction of the movement the body of amoeba also moves.





FOLDING & UNFOLDING OF PROTEIN MOLECULES

Goldacre and Lorsch

Basis of action of protein molecules: Sol gel theory

- Amoeboid locomotion is brought about by **the protein molecules (actin and myosin)** present in the cytoplasm.
- **Goldacre and Lorsch explained** the phenomenon of gelation and solation based on the folding and unfolding of these protein molecules. According to them, the **cytoplasm gelates when the protein molecules unfold by losing water** and the **cytoplasm solates when the protein molecules folds by absorbing water.**
- Hence, **the proteins in the plasmasol are in folded state** and the **proteins in the plasmagel are in the unfolded state.**
- This folding and unfolding of the protein molecules lead to the formation of the pseudopodia and thus the amoeboid movement. The energy required for this process is made **available from the ATP.**

2. FLAGELLAR MOVEMENT

Flagellar Movement is a **characteristics of Mastigophora-** which bears 1 or more flagella. **For Flagellar movement, liquid medium is needed.**

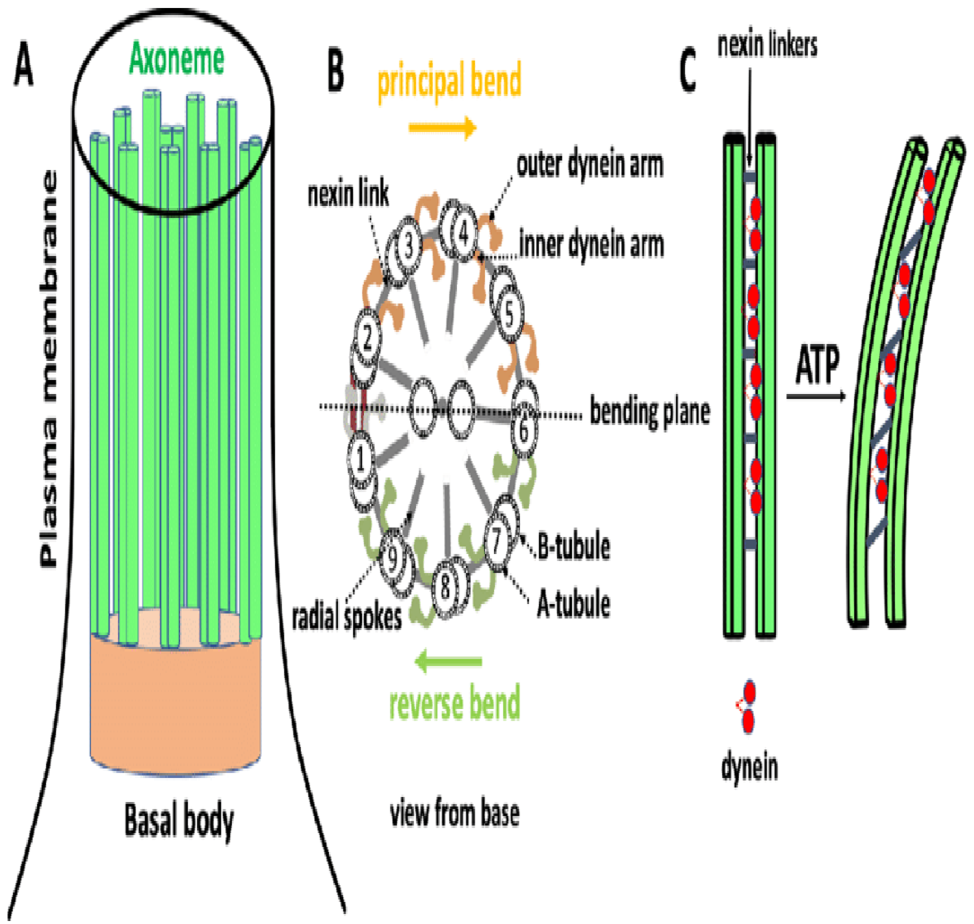
A flagellum **pushes the fluid medium at right angles to the surface of its** attachment, by its bending movement.

The bending movement of flagellum is made by the sliding of microtubules past each other with the help of **dynein arms.**

The doublets slide past each other in opposite direction. The arms release and attach a little farther on the adjacent doublet and again pull the neighboring doublet.

The doublets of the flagellum are **physically held in place by the radial spokes and thus the doublets cannot slide past much and their sliding is limited** by the radial spokes.

Instead the doublets can **curve causing a bend in the flagellum and this bending has an important role in the flagellar movement**.



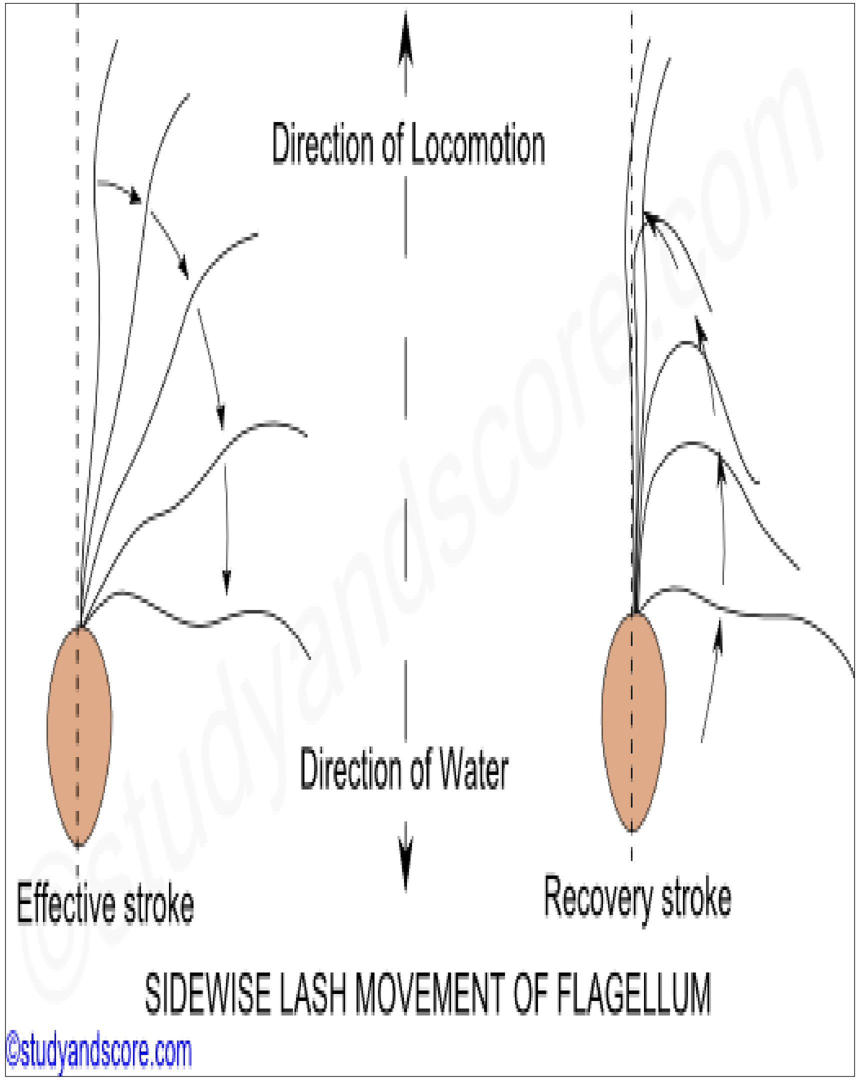
DIFFERENT TYPES OF FLAGELLAR MOVEMENTS HAVE BEEN RECOGNIZED

I) Paddle Stroke Or Sideways Lashing Movement

II) Undulating Movement

III) Simple conical gyration/ Screw propelling Theory

Sidewise lash movement



- Proposed by **Uleha & Kripisman (1925)** They observed that the most common Movement of flagellum is sideway lash movement consisting of strokes namely effective stroke and recovery stroke.
- **Effective stroke**-During effective stroke the flagellum becomes rigid and starts bending against the water. This beating in water at right angles to the longitudinal axis of the body causes the organism body to move forward and sending the water move backward.
- **Recovery stroke**- During recovery stroke, the flagellum becomes comparatively soft and will be less resistant to the water. This helps the flagellum move backwards and then to the original position.
- As a result of continuous effective and Recovery stroke, animal moves forward.

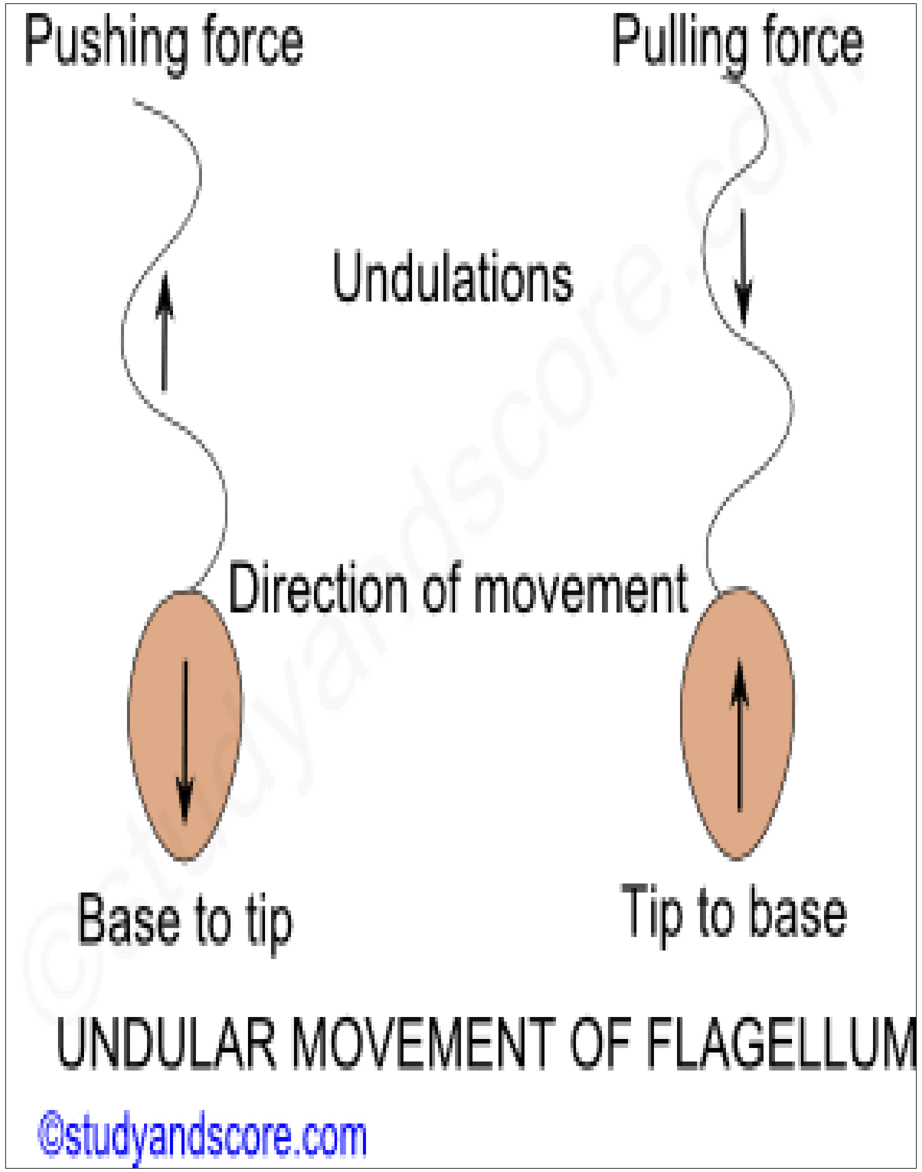
Undulation movement:

It is a characteristics of **certain Uniflagellate**. Waves in Flagellum originates which can **proceed from tip to base or base to tip.**

Undulation from the base to the tip causes pushing force and pushes the organism backwards.

Similarly undulation from the tip to the base causes **pulling force** and causes the organism to pull forward.

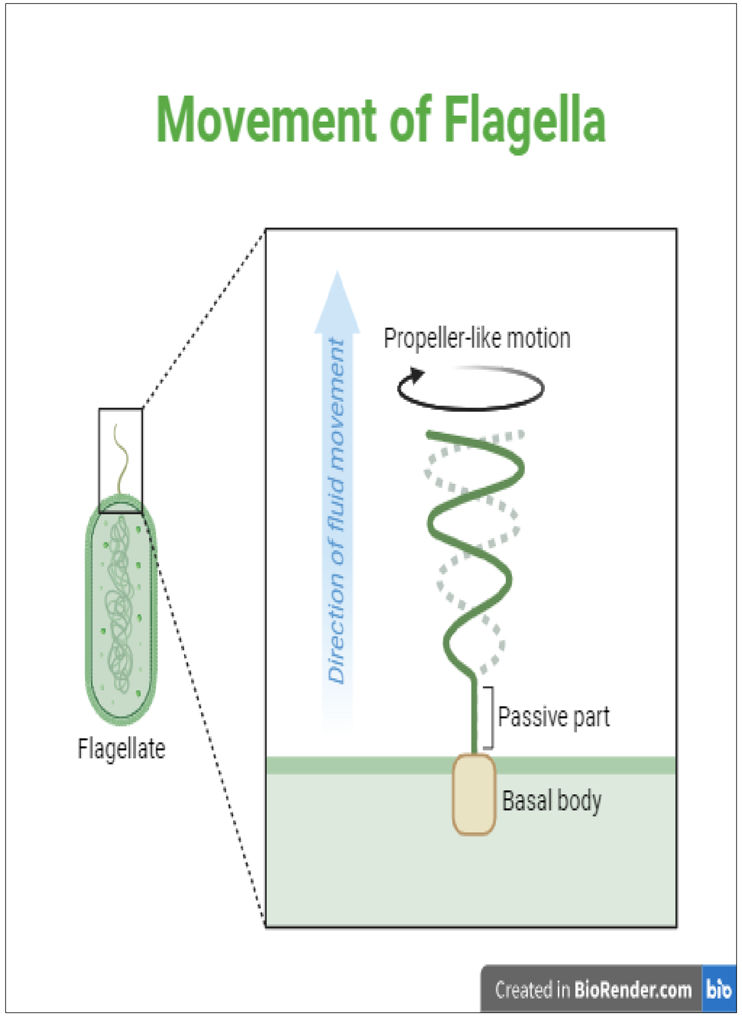
Also when the flagellum ends to one side and shows wave like movement from base to tip the organism moves in laterally in opposite direction.
Finally when the undulation is spiral, it causes rotation of the organism in the opposite direction and this is called as gyration.



Simple conical gyration movement or Screw Propelling Theory

Theory was proposed by **Butschli.** This theory postulates that there occurs a spiral turning of the flagellum like a screw ie., in this kind of movement the flagellum turns like a screw. This exerts a propelling action.

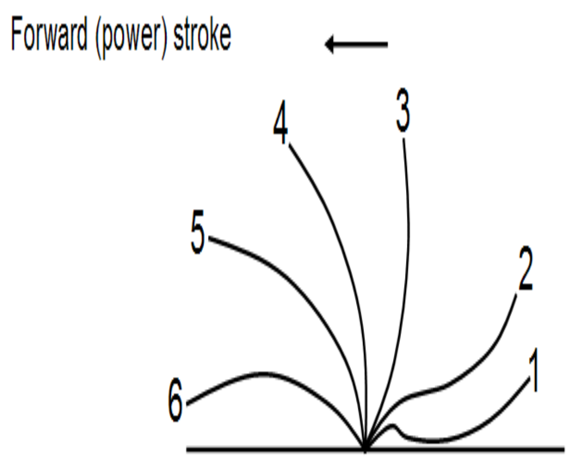
This **propelling action pulls the organism forward through the water** with a spiral rotation around the axis of movement.



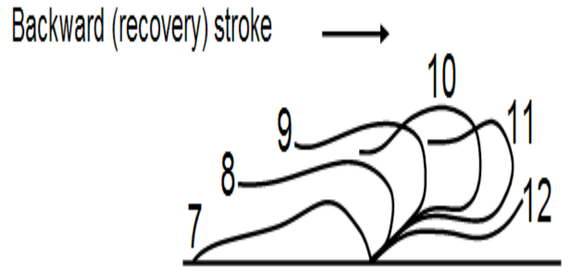
3. CILLIARY MOVEMENT

Paramecium has streamlined body which enable it swim about in water with a minimum amount of friction.

Just like the flagellum, the cilium also shows back and forth movements during the locomotion. These back and forth movements of the cilia are also called as effective and recovery strokes respectively.

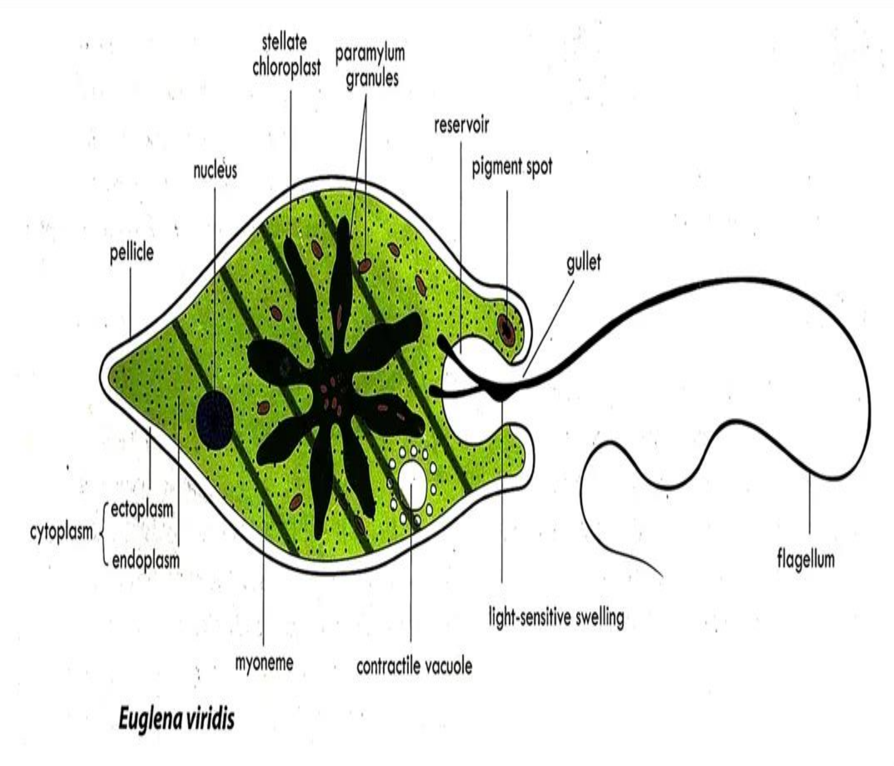


- **Effective stroke: During effective stroke, the cilium bends and beats against water thus bringing the body forward and sending the water backwards.**
- **Recovery stroke: During recovery stroke, the cilium comes back to original position by its backward movement without any resistance.**



- **Cilia shows two types of coordinated rhythms**
- **Synchronous rhythm**, where in the cilia beat simultaneously in a transverse row.
- **Metachronous rhythm**, where in cilia beat one after another in a longitudinal row. The metachronal waves pass from anterior to posterior end.
- The beating of the cilia can be reversed to move backwards when a Paramecium encounters any undesirable object in its path.
- The ciliary movement is coordinated by **infraciliary system** though neuromotor center called as motorium present near the cytopharynx in the ciliates like Paramecium.
- The infraciliary system together with motorium form neuromotor system which helps in coordination of the beating of the cilia.
- **Ciliary movement is the fastest locomotion in protozoans.**

4. Metabolic Movement:



- The Protista possessing myonemes move by contraction of the body. Some flagellate (Euglena) perform peristaltic movements by a wave of contraction and expansion passing over their body. Such movements have been termed euglenoid or metabolic movements. These occur due to the action of the myonemes. The mechanism and the physiology of myonemes are not understood well.
- **In protozoans a pellicle is present in the ectoplasm which is composed of proteinaceous strips supported by dorsal and ventral microtubules.**
- **In many protozoans these protein strips can slide past one another, causing wriggling motion. This wriggling motion is called as metaboly or metabolic movement.**
- **This movement is mainly caused by the change in the shape of the body.**

Thank you