Q. 2. Describe various modes of locmotion in protozoan types studied by you. *(Gorakhpur 1992; Avadh 91; Vikram 91; Jabalpur 92, 96)*

Describe the process of locomotion in *Amoeba, Euglena, Paramecium* and *Monocystis*. *(Kumaon 1990)*

How does locomotion take place in Protozoa? Make a labelled diagram of the ultrastructure of pseudopodium and cilium. Explain briefly the amoeboid and ciliary movement. *(Kanpur 1989, 92)*

Describe locomotion in Amboea giving various theories connected with amoeboid movements. *(Meerut 1989)*

The individuals belonging to phylum Protozoa exhibit four different modes of locomotion :

1. Amoeboid movement

2. Flagellar movement
3. Ciliary movement
4. Metabolic movement

1. Amoeboid Movement (Locomotion In Amoeba)

It is characteristic of all the Sarcodina and certain Mastigophores and Sporozoans. The amoeboid movement is demonstrated by *Amoeba* and *Entamoeba*. The pseudopodia are formed by the streaming flow of the cytoplasm in the direction of movement.

Pseudopodia are formed by two different methods :

1. **By profluent method**–In this method, a number of pseudopodia are formed together in the same direction of movement. Such pseudopodia are called **lobosia type** or **lobopodia.** These are formed in *Amoeba.*

2. **By eruptive method**–In this method only one pseudopodium is formed at a time in the direction of movement. Pseudopodia formed by eruptive method are called **limax type.**

Theories of Amoeboid Movement

The following theories have been presented to explain formation of pseudopodia :

1. **Sol-Gel Theory of Mast and Patin**–The flow of protoplasm to form pseudopodia is explained by the **sol-gel theory** or **change of viscosity theory** propounded by **Patin** (1923-26) and **Mast** (1955). According to them the protoplasm of these forms can be distinguished into an outer layer of **plasmagel** and an inner mass of **plasmasol** and the movement is brought about by conversion of plasmagel to plasmasol and vice versa. The process can be distinguished into following steps :

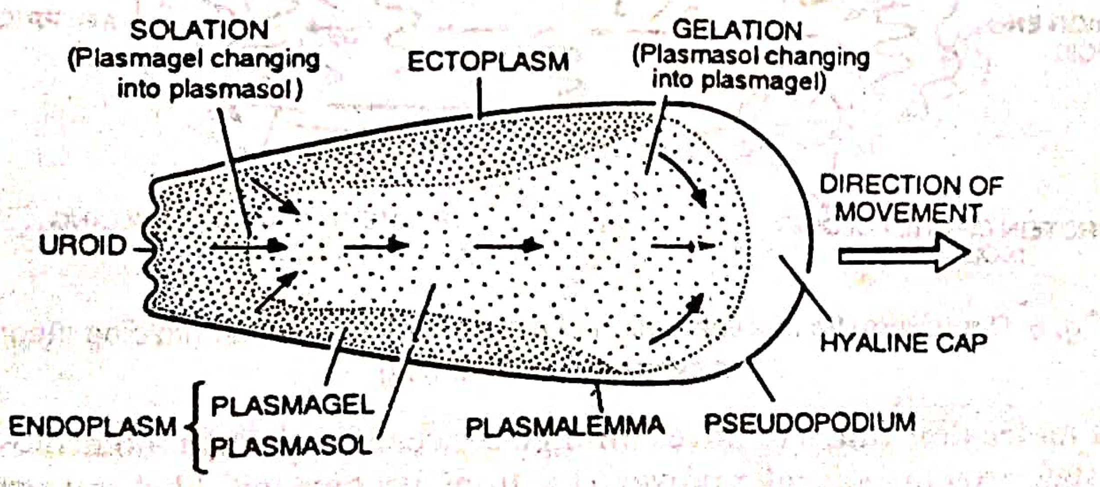

Fig. 5. Machanism of amoeboid movement as illustrated by sol-gel theory.

(a) The plasma membrane or **plasmalemma** adheres to the substratum.

(b) The **plasmasol** flows forward in the direction of movement through some weaker point of plasmalemma and a new pseudopodium is formed. Inside this new pseudopodium plasmasol changes into plasmagel and forms a stiff gelatinised tube.

(c) Simultaneously, the **plasmagel** at the posterior end gets converted into **plasmasol,** which maintains a continuous flow of plasmasol into the developing pseudopod.

The plasmagel tube contracts drawing the body forward. Later on, a new pseudopodium is given out in the same direction. The same streaming movement is repeated again and again and animal progresses forward.

2. Ectoplasm contraction theory–According to this theory the cytoplasm of *Amoeba* is differentiated into outer gel portion (ectoplasm) and inner sol portion (endoplasm). The movement is brought about by the contraction of the ectoplasmic tube of plasmagel. According to **Goldacre,** the gel portion contracts at the rear end of the body and squeezes the sol portion (endoplasm) forward. On reaching the anterior end the sol is converted into gel.

3. Fountain zone or front contraction theory–According to **Allen,** the streaming semiliquid endoplasm in the centre of the cell is pulled forward by the contraction of cortical gel in the front part of the body which has been described as **fountain zone** by **Allen.** On being pulled, it is converted into plasmagel. The solation occurs at the rear end in the **recruitment zone.**

Mechanism of contraction of gel–Two different theories have been put forward :

(i) Molecular folding and unfolding theory–**Goldacre** and **Lorch** have suggested that protein molecules in the cytoplasm form elongated chains. The ectoplasm contracts at the rear end of the body by the folding of interlinked (gelated) protein molecules. The solation of ectoplasm is due to the super-folding

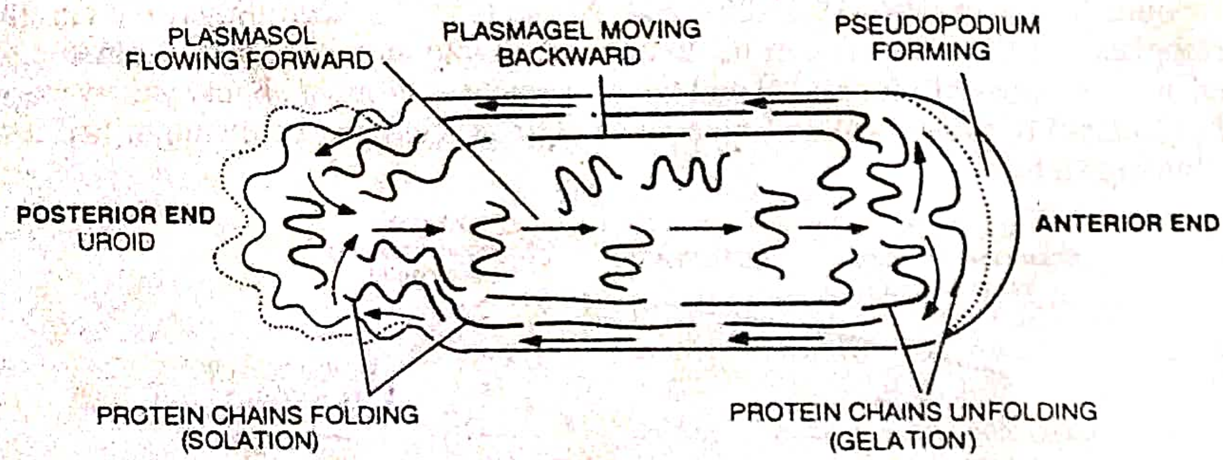

Fig. 6. Diagrammatic representation of molecular folding and unfolding theory of cytoplasmic streaming.

of these molecules, which removes **linkage** between the protein molecules. In this folded state protein molecules move to the front, become unfolded and again form linkage and thereby, sol is converted into gel at the front end of *Amoeba.*

(ii) Gel endoplasm shearing or sliding theory–According to this theory, mechanism of contraction in *Amoeba* is the same as in the muscles of higher forms. **Huxley** (1954) suggested the mechanism of sliding of actin-myosin filaments and made and break ratchet which bring about crawling of one set of filaments over the other. Accordingly, it is presumed that chemical ratchets are present on the inner edge of the gel ectoplasm. These ratchets push the molecules of endoplasm forward.

2. Flagellar Movement (Locomotion in *Euglena*)

It is characteristic of Mastigophores or flagellated protozoans. e.g. *Euglena.* Flagellar movement is produced by continuous beating of long, elastic flagella. Following types of flagellar movements have been explained :

(a) **Screw propeller theory**–According to **Butschlii** the lateral or spiral movements of flagellum are like a screw that exerts propelling action. It is produced by repeated spiral waves arising from the base of flagellum one after the other and moving towards the tip and draws the animal forward.

(b) **Circular beat theory–Metzner** suggested that the flagellum beats in a circle tracing a cone and produces sufficient current to pull the animal forward.

(c) **Sideways lashing movement**–According to **Ulehla** and **Krijsman** (1925) the flagellum beats in a side-ways lash, consisting of an effective **downstroke** or bending and a relaxed **recovery stroke** or straightening. In the **effective stroke** the flagellum is held out rigidly with slight concavity in the direction of stroke, while in the recovery stroke the flagellum is relaxed, strongly curved and is brought forward again. This draws the body forward. Usually the flagellum beats obliquely so that during forward movement, the animal also rotates on its longitudinal axis.

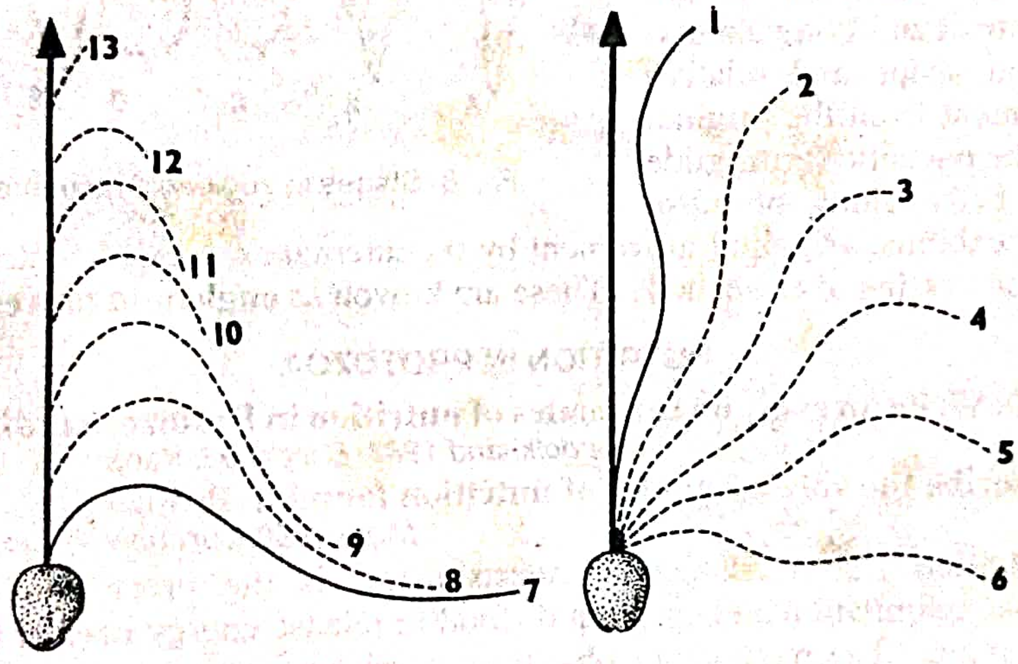

Fig. 7. Two stages in the lashing movement of flagellum.
A–Effective stroke; B–Recovery stroke.

(d) **Undulating movement**–The speedy progression of certain uniflagellates has been observed due to the wave-like **undulations** of the flagellum from tip to its base. These provide the force of propulsion and the animal moves forward. The backward movement is caused when the undulations proceed from base to tip.

3. Ciliary Movement (Locomotion in Paramecium)

Ciliary movement is accomplished by extremely fine and very small thread-like processes of ectoplasm in ciliates and larval suctorians. A very good example is *Paramecium.* The ciliary movement is very much similar to that of flagellar movement, consisting of the same effective stroke and recovery stroke, but the cilia bend throughout their length. The water moves in the direction of beat, while the animal moves in the opposite direction.

Every cilium of the body moves independently and slightly in advance of the cilium behind it. Thus the cilia of a longitudinal row do not move simultaneously but metachronously *i.e.* one after another, so that a wave of propulsion passes from one end of the body to the other, whereas cilia of a transverse row beat synchronously (all together). The animal follows spiral path and the speed of progression is 400 to 2,000μ per second. The movement of cilia is co-ordinated by a complicated and contractile system of myofibrils which constitute neuromotor system.

4. Metabolic Movements (Locomotion in Euglena and Monocystis)

These movements are typical of certain flagellates (e.g. *Euglena)* and in most sporozoans at certain stage of their life-cycles. Such organisms show gliding or wriggling movement. The contractile myonemes of the body contract and bring about a change in shape and relative displacement from the original place. The parasitic forms glide in the body fluid of host. *Euglena* exhibits wriggling movement by the alternate waves of contraction and expansion passing over the body. These are knwon as **euglenoid movements.**

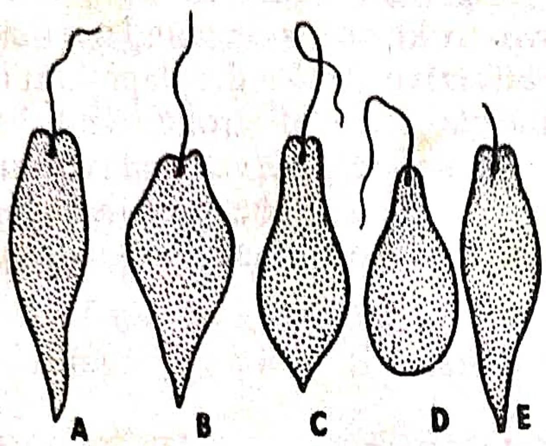

Fig. 8. Stages in euglenoid movement.