Cilia:

The entire body is covered with numerous, small, hair like projections called cilia. Cilia occur in longitudinal rows all over the body, this condition is known as holotrichous in which the body cilia are equal. Cilia have the same structure as flagella, they have an outer protoplasmic sheath or plasma membrane with nine double longitudinal fibrils in a peripheral ring. In some cilia the nine outer fibrils are not paired.

There are two central longitudinal fibrils which are thinner than the outer fibrils. Each cilium arises from a basal granule or kinetosome. The nine pairs of peripheral fibrils fuse together to form the wall of the kinetosome, thus, kinetosome is a tube which is either open or closed at its lower end, the two central fibrils stop at the level of the pellicle in most ciliates.

Arising from the kinetosome is a thin rhizoplast which does not join the nucleus. Many Metazoa also have cilia, their structure is the same, except that the basal granule is different and it has fine filaments or rooting fibres extending down into the cytoplasm. But cilia differ from flagella in being generally more numerous and shorter in size.

The ciliature may be conveniently divided into body or somatic cilia which are found on the body surface, and into oral ciliature which is associated with the mouth region. The body cilia are equal but they are longer at the posterior end, hence, the name caudatum. The cilia are organelles of locomotion and food collection, they also act as sensory receptors and detect the stimuli of the external environment.

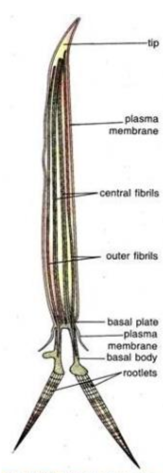
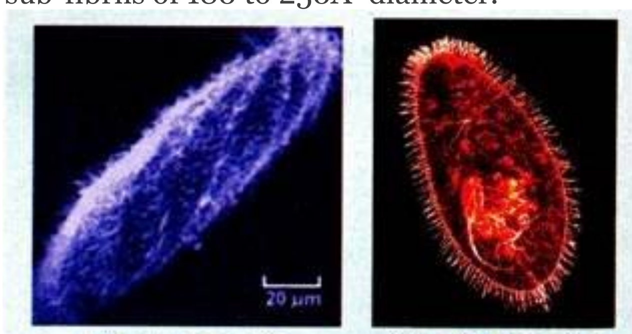


Fig. 20.3. Ultrastructure of a cilium.

Ultra Structure of Cilia:

The cilia and flagella have a fibrillar composition. At the base the cilium has the diameter of about 0.2 micron or 2,000 A° which may be up to 10 microns above the cell surface. The cilia are bounded by a unit membrane of 90 A° thickness which resembles and remains continuous with the plasma membrane. The bounded space of the cilium contains a watery substance known as the matrix.

In the matrix, there remain embedded eleven longitudinal fibrils or microtubules. Out of the eleven fibrils, two are located in the centre, while the remaining nine fibrils remain arranged peripherally around the central fibrils. Each of the nine outer fibrils is 360A° in diameter and composed of two sub-fibrils of 180 to 250A° diameter.



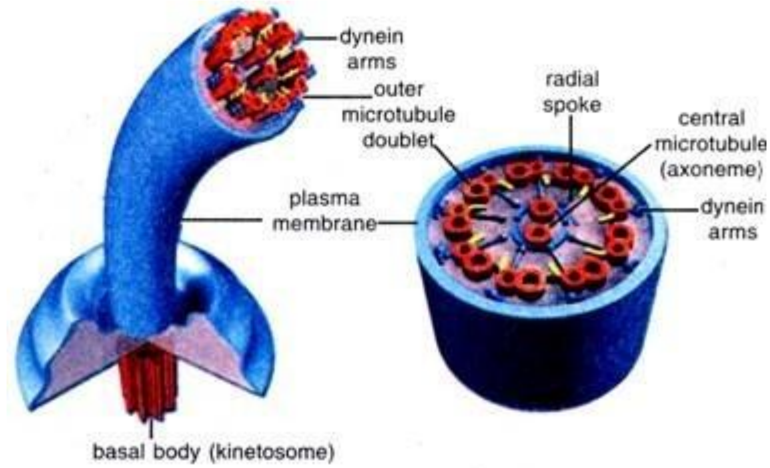
Holotrichous cilia. Cilia of *Paramecium.*

These sub-fibrils are designated as the sub-fibril A and sub-fibril B.

The sub-fibril A is slightly larger than the sub-fibril B. The sub-fibril A gives out two thick projections or arms from its one side. The arms of the sub-fibril A of all the outer fibrils remain directed in clockwise direction. Further, the sub-fibril A occurs more closely to the centre of the cilium than the sub-fibril B. Both the sub-fibrils have a common wall of 50A° thickness.

The two central fibrils do not have paired sub-fibrils like the peripheral nine fibrils but each contains only a single tubule. Each central fibril has a diameter of about 250A° and is composed of 60A° thick wall.

Both the central fibrils remain separated by a space of 350A° and remain enveloped in a common sheath. Gibbnos (1967) has reported that the sheath of the central fibrils gives out nine radially oriented links or spokes to each sub-fibril A.



Ultrastructure of cilia.

The high resolution electron microscopy has revealed that each of the peripheral and central fibrils of the cilia and flagella is composed of ten to twelve filaments of 40A◦ thickness. Each filament is beaded. Each bead remains arranged in the lattices of 40 by 50A◦ in the plane of the wall of the tubule. These beads are considered as the basic subunit of the tubule structure.

Infra-Ciliary System:

The infra-ciliary system is located just below the pellicular alveoli. It consists of the kinetosome or basal body and kinetodesma. The cilia arise from kinetosomes and from each kinetosome arises a delicate cytoplasmic fibril called kinetodesma, (Fig. 20.2).

Lying below the pellicle slightly to the right, but joined to all kinetosomes of one longitudinal row, is a longitudinal bundle of several kinetodesmata, a kinetodesmata of each kinetosome extends for a distance anteriorly into its own bundle of kinetodesmata.

A longitudinal row of kinetosomes with their kinetodesmata forms a longitudinal unit called a kinety. All the kineties or kinetia make the infra-ciliary system of a ciliate. The kinetia lie in the cortex below the pellicle, their number is fairly constant for each ciliate.

The infra-ciliary system controls and coordinates the movements of the cilia, and it brings about formation of organelles in cell division, e.g., some kinetia form the mouth. In binary fission of ciliates the kinetia are cut transversely into two, each going to one daughter cell, this is called perikinetal fission.

3. Locomotion of Paramecium Caudatum:

Paramecium Caudatum performs locomotion by two methods, viz., metaboly or body contortions and by cilia.

(i) Metaboly or Body Contortions:

The body of Paramecium Caudatum possesses elasticity, it can squeeze itself through a passage narrower than its body, after which the body assumes its normal shape. This temporary change of body shape is metaboly, it is brought about in Paramecium by the protoplasm.

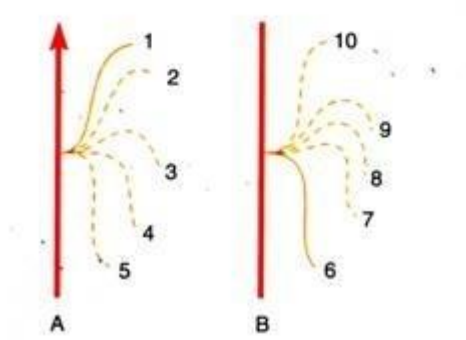


Fig. 20.12. Diagrams illustrating ciliary movement of a single cilium. A—Effective stroke; B—Recovery stroke.

(ii) Ciliary Locomotion:

Locomotion brought about by cilia is the main method. The cilia can beat forwards or backwards enabling the animal to swim anteriorly or posteriorly.

Normally the animal swims forwards, the cilia beating backwards but obliquely, the cilia stiffen and bend backwards rapidly to almost touch the body surface, this is called the effective stroke; then the cilia become limp and return slowly to the original vertical position, this is , called recovery stroke.

Cilia of the same transverse row beat together and those of the same longitudinal row beat one after the other from the anterior to the posterior end.

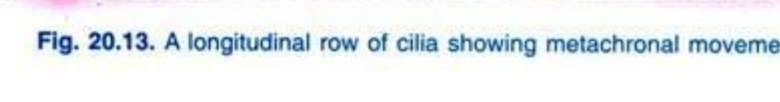


Fig. 20.13. A longitudinal row of cilia showing metachronal movement.

This coordinated movement of cilia is called metachronal rhythm, which is due to the infra-ciliary system; this causes swimming forward by the animal. But when the body cilia are beating obliquely backwards, then at the same time the longer cilia of the oral groove beat more vigorously which causes the anterior end to swerve to the left.

The action of cilia of body and oral groove makes the animal to rotate on its long axis. This rotation is always to the left (except in P. calkinsi which rotates in a right hand spiral).

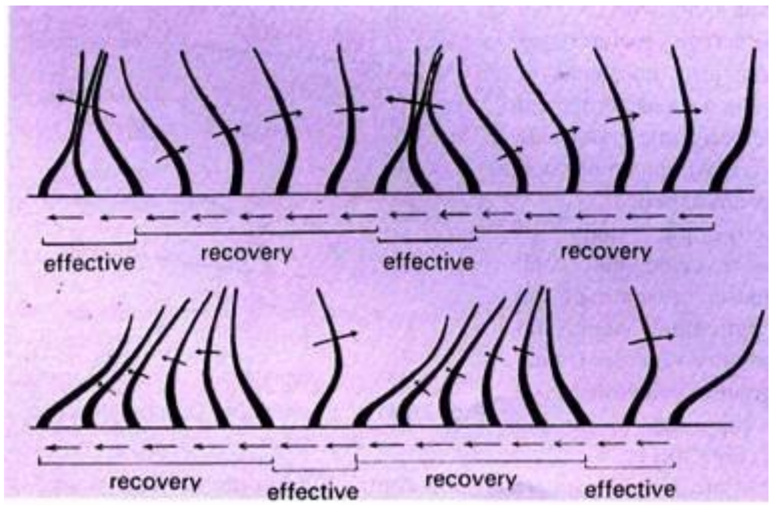


Fig. 20.14. Cilia indicating effective and recovery strokes.

This combination of forward motion, swerving and rotation makes the animal move forwards in a counter-clockwise spiral path. This path has a straight axis, and the same body surface of the animal remains towards the axis of the spiral path. But in swimming backwards, all species rotate to the right.

The ciliary beat can be reversed so that the cilia move obliquely forwards by which the animal swims backwards. By ciliary action, Paramecium moves with a speed of 1500 microns or even more per second.

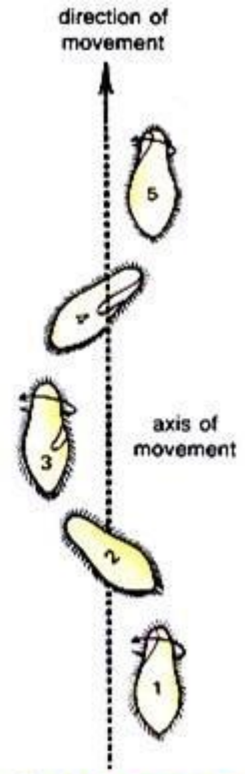


Fig. 20.15. *Paramecium.* Spiral path of movement.

Jennings contended that the spiralling of Paramecium is due to the fact that while the cilia strike chiefly backward they do so obliquely to the right thereby causing the animal to roll over to the left.

Also this swerving of the body toward the aboral surface is due largely to the greater power of the effective stroke of the oral cilia which strike more directly backward. The result—the rotation of Paramecium on its long axis—thereby enables the Paramecium to follow a more or less straight course in forming large spirals.