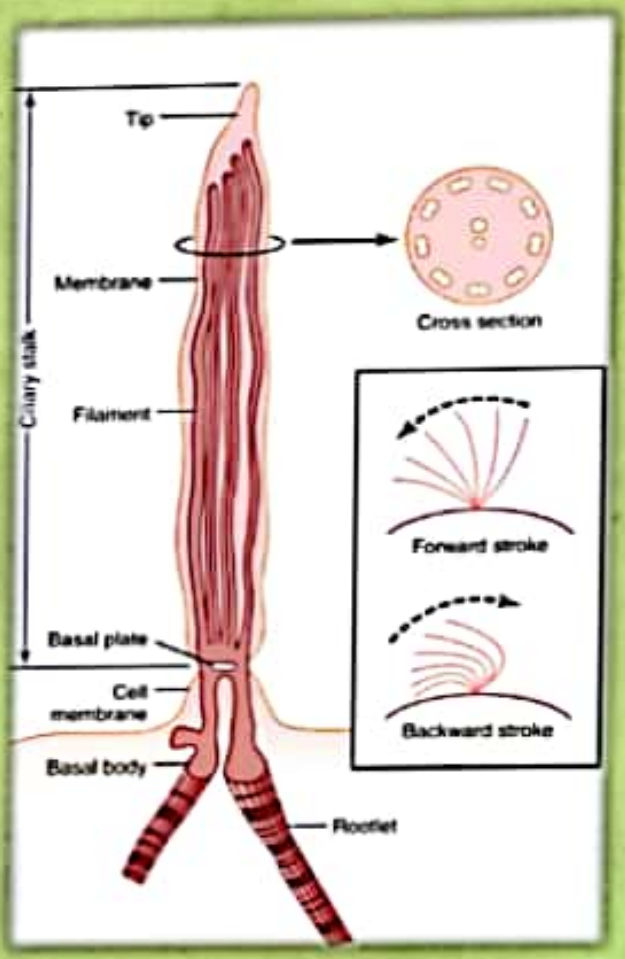
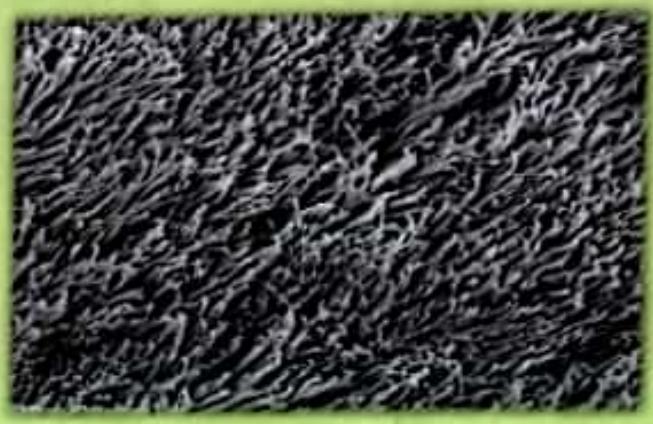
CILIA MOVEMENT

- The cilium moves forward with a sudden, rapid whiplike stroke 10 to 20 times per second, bending sharply where it projects from the surface of the cell.
- Then it moves backward slowly to its initial position.
- The rapid forward-thrusting, whiplike movement pushes the fluid lying adjacent to the cell in the direction that the cilium moves; the slow, dragging movement in the backward direction has almost no effect on fluid movement. As a result, the fluid is continually propelled in the direction of the fast-forward stroke.
- Because most ciliated cells have large numbers of cilia on their surfaces and because all the cilia are oriented in the same direction, this is an effective means for moving fluids from one part of the surface to another.

STRUCTURE OF CILIUM

- Cilium has the appearance of a sharp-pointed straight or curved hair
- projects 2 to 4 micrometers from the surface of the cell.
- Many cilia often project from a single cell—for instance, as many as 200 cilia on the surface of each epithelial cell inside the respiratory passageways.
- The cilium is covered by an outcropping of the cell membrane
- It is supported by 11 microtubules—9 double tubules located around the periphery of the cilium and 2 single tubules down the center, as demonstrated in the cross section
- Each cilium is an outgrowth of a structure that lies immediately beneath the cell membrane, called the *basal body* of the cilium.





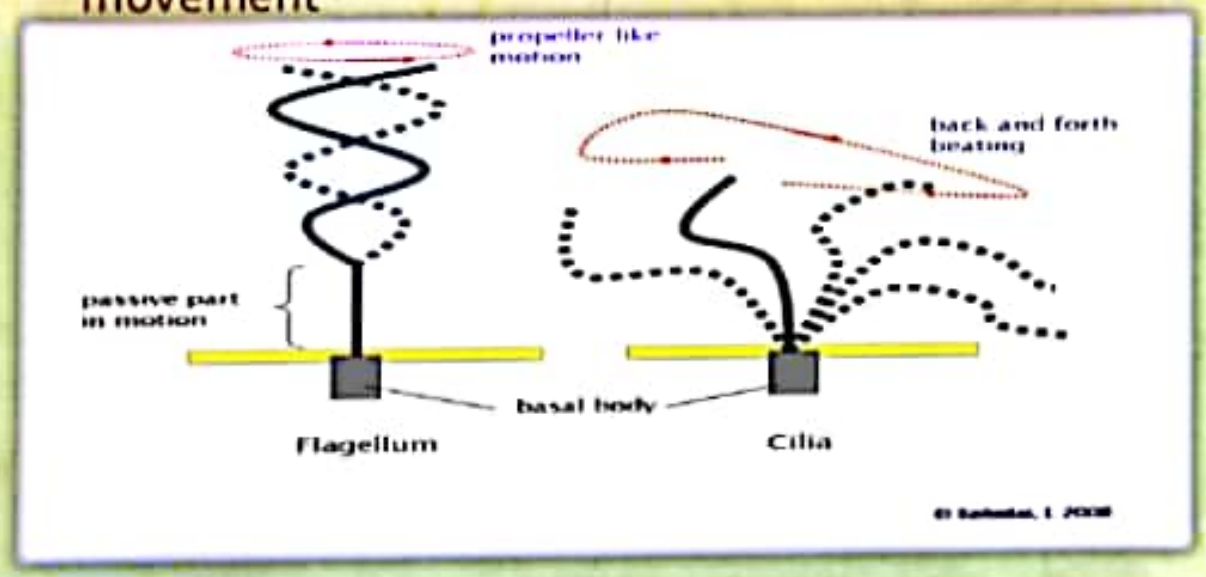
COMPARISON

FLAGELLUM

- Longer in size
- Quasi-sinosidal movement

CILIUM

- Shorter in size
- Whip like movement



MECHANISM OF CILIARY MOVEMENT

Although not all aspects of ciliary movement are clear, we do know the following:

- First, the nine double tubules and the two single tubules are all linked to one another by a complex of protein cross-linkages; this total complex of tubules and cross-linkages is called the *axoneme*.
- Second, even after removal of the membrane and destruction of other elements of the cilium besides the axoneme, the cilium can still beat under appropriate conditions.

CONTINUED...

- Third, there are two necessary conditions for continued beating of the axoneme after removal of the other structures of the cilium:
  (1) the availability of ATP and
  (2) appropriate ionic conditions, especially appropriate concentrations of magnesium and calcium.
- Fourth, during forward motion of the cilium, the double tubules on the front edge of the cilium slide outward toward the tip of the cilium, while those on the back edge remain in place.
- Fifth, multiple protein arms composed of the protein *dynein*, which has ATPase enzymatic activity, project from each double tubule toward an adjacent double tubule.

ATPase DYNEIN

- the release of energy from ATP in contact with the ATPase dynein arms causes the heads of these arms to "crawl" rapidly along the surface of the adjacent double tubule.
- If the front tubules crawl outward while the back tubules remain stationary, this will cause bending.

ABNORMALITIES

- The way in which cilia contraction is controlled is not understood.
- The cilia of some genetically abnormal cells do not have the two central single tubules, and these cilia fail to beat.
- Therefore, it is presumed that some signal, perhaps an electrochemical signal, is transmitted along these two central tubules to activate the dynein arms.