Skills to Develop

After completing this section you should be able to perform the following objectives.

1. State the difference between eukaryotic flagella and cilia.
2. Briefly describe and state the function of eukaryotic flagella and cilia.

Flagellar arrangement schemes

Different species of bacteria have different numbers and arrangements of flagella (Figure 7.7.1).

- Monotrichous bacteria have a single flagellum (e.g., *Vibrio cholerae*).
- Lophotrichous bacteria have multiple flagella located at the same spot on the bacteria’s surfaces which act in concert to drive the bacteria in a single direction. In many cases, the bases of multiple flagella are surrounded by a specialized region of the cell membrane, the so-called *polar organelle*.
- Amphitrichous bacteria have a single flagellum on each of two opposite ends (only one flagellum operates at a time, allowing the bacteria to reverse course rapidly by switching which flagellum is active).
- Peritrichous bacteria have flagella projecting in all directions (e.g., *E. coli*).

In certain large forms of *Selenomonas*, more than 30 individual flagella are organized outside the cell body, helically twining about each other to form a thick structure (easily visible with the light microscope) called a "fascicle". Other bacteria, such as most *Spirochetes*, have two or more specialized flagella (endoflagella) arising from opposite poles of the cell, which together constitute the so-called "axial filament" that is located within the periplasmic space between the flexible cell wall and an outer sheath. The rotation of the axial filament relative to the cell body causes the entire...
bacterium to move forward in a corkscrew-like motion, even through material viscous enough to prevent the passage of normally flagellated bacteria.

**Figure 7.7.1**: Examples of bacterial flagella arrangement schemes. A-Monotrichous; B-Lophotrichous; C-Amphitrichous; D-Peritrichous.

**Internal Structure**

Flagella are long and few in number whereas cilia are short and numerous. Both consist of 9 fused pairs of protein microtubules with side arms of the motor molecule dynein that originate from a centriole. These form a ring around an inner central pair of microtubules that arise from a plate near the cell surface (Figure 7.2). The arrangement of microtubules is known as a 2X9+2 arrangement. This complex of microtubules is surrounded by a sheath continuous with the cytoplasmic membrane.
Figure 7.7.2: The "9+2" structure is visible in this cross-section micrograph of axoneme. *Chlamydomonas reinhardtii* is a unicellular flagellate used as a model system in molecular genetics work and flagellar motility studies. This image is a thin x-section cut through the isolated axoneme. *Chlamydomonas* flagella have the "9+2" structure characteristic of all eukaryotic cells. The axoneme has a central unit containing two single microtubules and nine peripheral doublet microtubules (known as the "9+2"). Dynein sidearms project from the A tubule of each doublet. Also visible in this image are the radial spokes and the inner sheath. Both figures are courtesy of Dartmouth Electron Microscope Facility, Dartmouth College.

In the presence of ATP, the dynein side arms of the microtubules in the outer ring elongate and attempt to move along the neighboring pair, causing the flagellum or the cilium to bend. Flagella and cilia function in locomotion. Cilia also function to move various materials that may surround a cell.

Figure 7.7.3: A cilium (plural cilia) is an organelle found in eukaryotic cells. Cilia are slender protuberances typically extending some 5–10 micrometers outwards from the cell body. There are two types of cilia: motile cilia, which constantly beat directionally, and non-motile—or primary—cilia, which typically serve as sensory organelles.
Example 7.7.1

Briefly describe the structure of eukaryotic flagella and cilia.

Solution

Flagella and cilia consist of 9 fused pairs of protein microtubules with side arms of the motor molecule dynein that originate from a centriole. These form a ring around an inner central pair of microtubules that arise from a plate near the cell surface. The arrangement of microtubules is known as a 2X9+2 arrangement. This complex of microtubules is surrounded by a sheath continuous with the cytoplasmic membrane.

Summary

1. Flagella are long and few in number whereas cilia are short and numerous.
2. Both flagella and cilia consist of 9 fused pairs of protein microtubules with side arms of the motor molecule dynein that originate from a centriole. These form a ring around an inner central pair of microtubules that arise from a plate near the cell surface. This complex of microtubules is surrounded by a sheath continuous with the cytoplasmic membrane.
3. Flagella and cilia function in locomotion. Cilia also function to move various materials that may surround a cell.

Contributors

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