BIOL 4640 Mol Micro
Lecture 15 9/28/26
Cell Structures Part 1

- Assignment 9 due on 9/25/26
- Assignment 10 due on 9/28/26
- New Assignment 11 – due on 10/7/26

- Exam 1 on Monday, October 5
  - A study guide and an old exam is posted

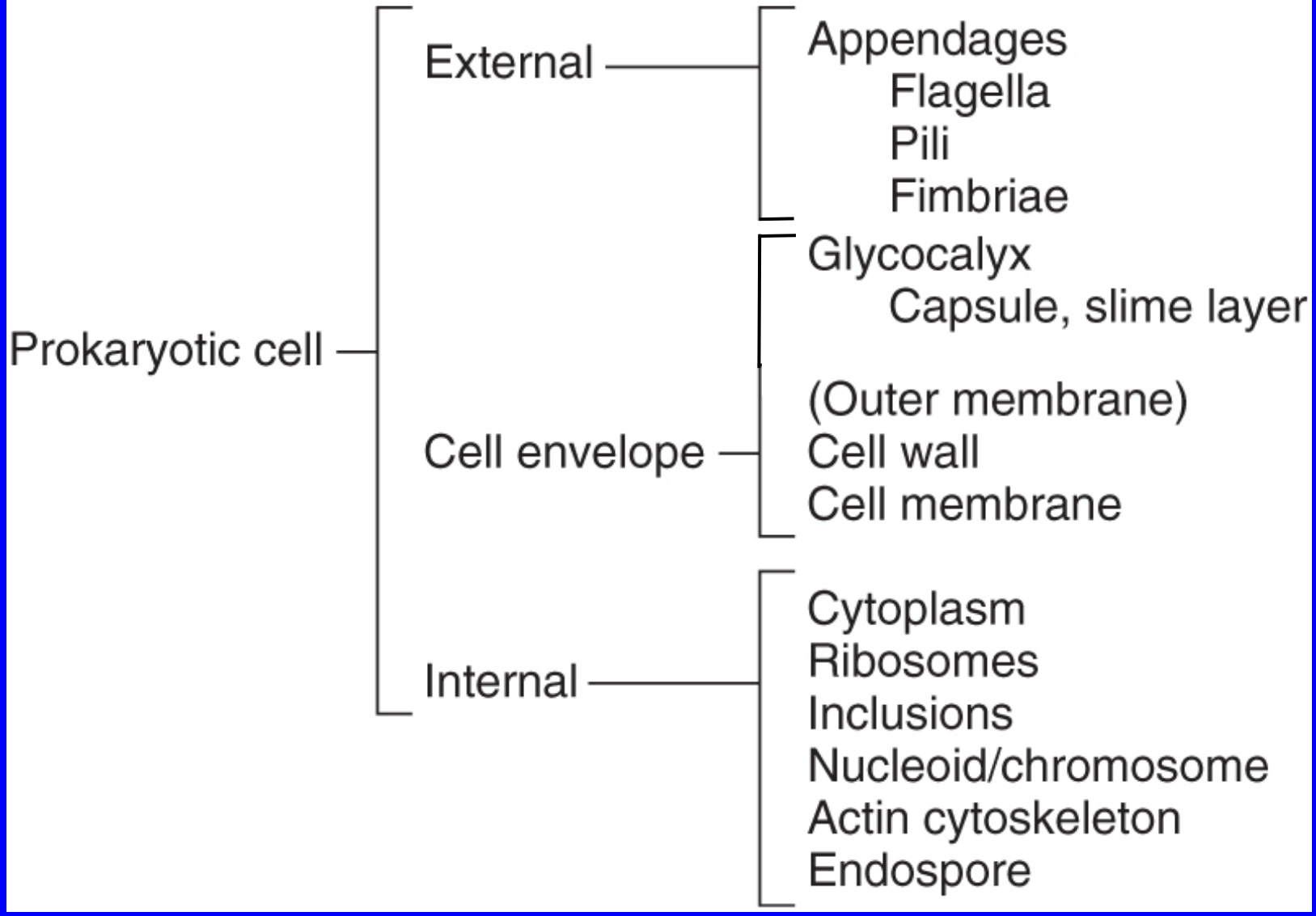
Unit 3. Features and Structures of Microbial Cells and Viruses

A. Size and Shape of bacteria
B. Specialized External Structures of bacteria
C. Cell envelope of bacteria
D. Internal structures of bacteria
E. Cell Division in Bacteria
F. Viruses – Chapter 6
G. Atypical bacteria and viruses

Mostly Chapter 3 in book

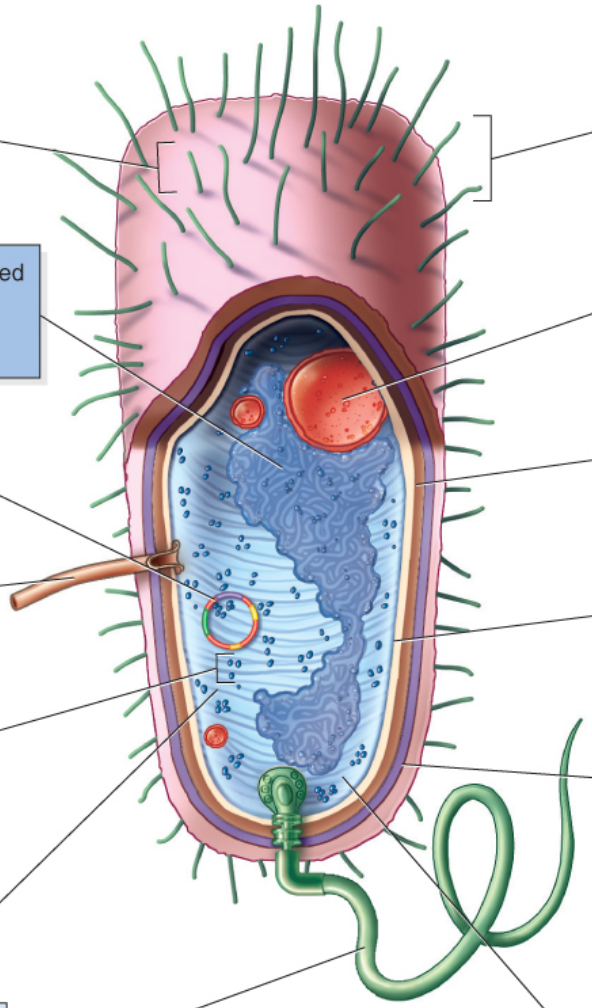
Unit 3. Structures of Bacterial Cells

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Structures in a Prokaryotic Cell

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Glycocalyx (pink coating)—A coating or layer of molecules external to the cell wall. It serves protective, adhesive, and receptor functions. It may fit tightly or be very loose and diffuse.

Bacterial chromosome or nucleoid—Composed of condensed DNA molecules. DNA directs all genetics and heredity of the cell and codes for all proteins.

Plasmid—Double-stranded DNA circle containing extra genes.

Pilus—An elongate, hollow appendage used in transfers of DNA to other cells.

Ribosomes—Tiny particles composed of protein and RNA that are the sites of protein synthesis.

Actin cytoskeleton—Long fibers of proteins that encircle the cell just inside the cell membrane and contribute to the shape of the cell.

Flagellum—Specialized appendage attached to the cell by a basal body that holds a long, rotating filament. The movement pushes the cell forward and provides motility.

Fimbriae—Fine, hairlike bristles extending from the cell surface that help in adhesion to other cells and surfaces.

Inclusion/Granule—Stored nutrients such as fat, phosphate, or glycogen deposited in dense crystals or particles that can be tapped into when needed.

Cell wall—A semirigid casing that provides structural support and shape for the cell.

Cell (cytoplasmic) membrane—A thin sheet of lipid and protein that surrounds the cytoplasm and controls the flow of materials into and out of the cell pool.

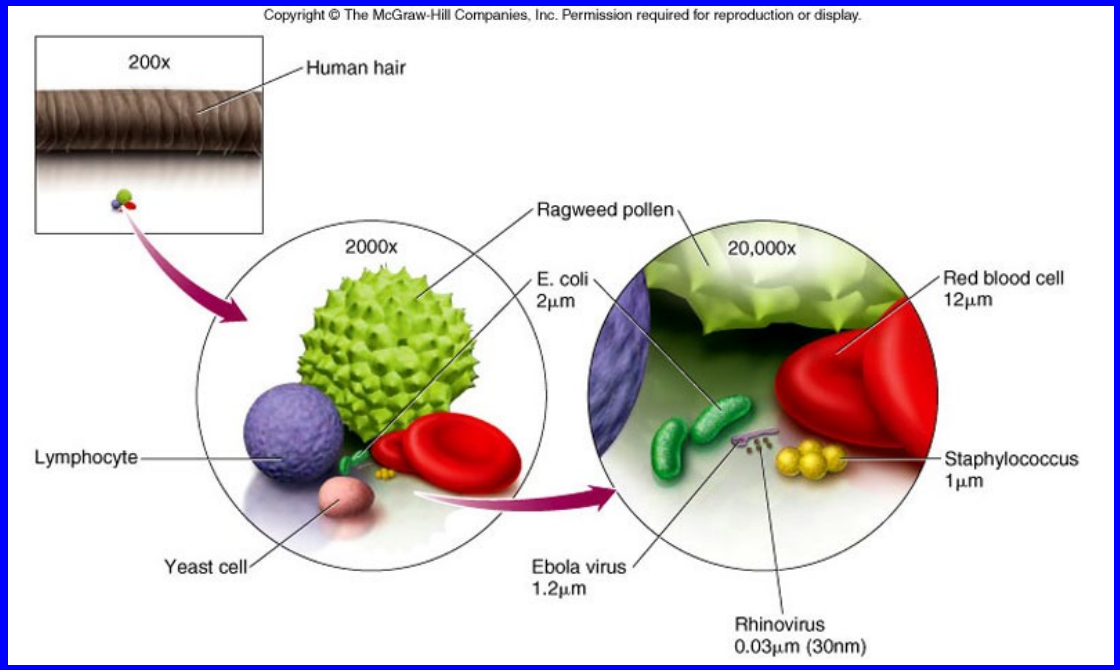
Outer membrane—Extra membrane similar to cell membrane but also containing lipopoly saccharide. Controls flow of materials and portions of it are toxic to mammals when released.

Endospore (not shown)—Dormant body formed within some bacteria that allows for their survival in adverse conditions.

Cytoplasm—Water-based solution filling the entire cell.

A. Size and Shapes

1. Sizes of Microbes
   - Eukaryotic microbes : 10-100 micrometer (μm) or micron (10^{-6} m) wide
   - Bacteria: 0.4-10 μm
   - Viruses:
     0.01 – 0.1 μm
     or 10-100 nm



2. Shapes of Bacteria



Shapes
Cocci
Bacillus
Vibro
Spiral

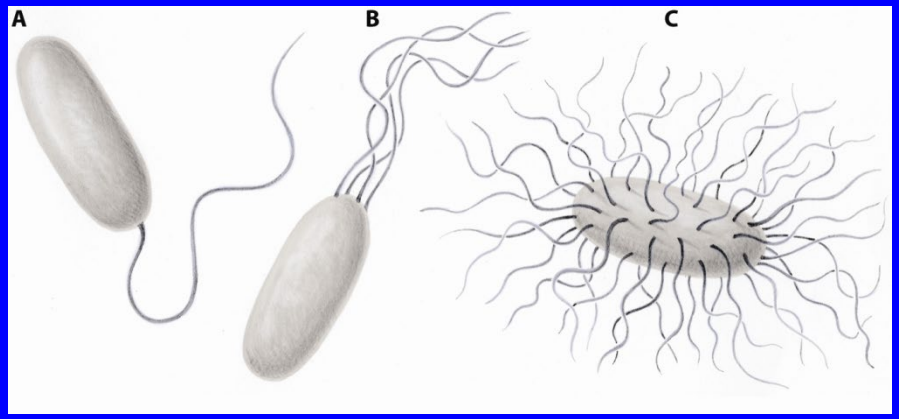
Note: Some grow in clusters or filaments

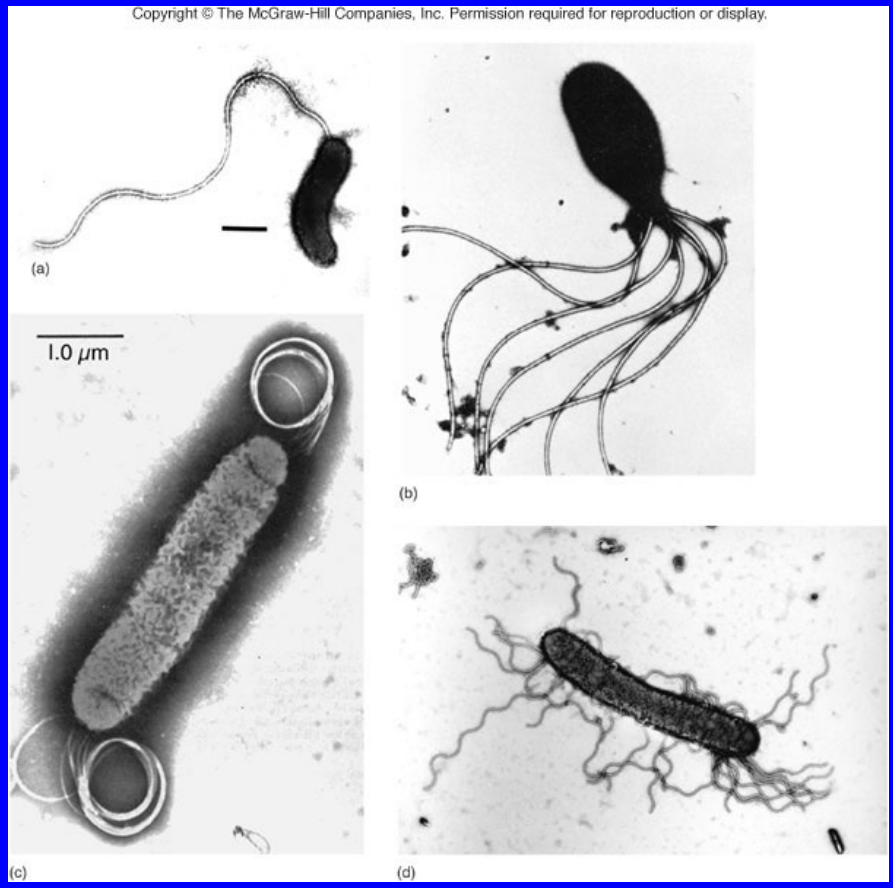
B. Specialized External Structures

- Protein filaments that project out from cell (Not enclosed by cell membrane or cell wall)
- Two main types
  1. Flagella – motility
     - Section 3.6
  2. Pili and fimbriae – adherence
     - Section 3.6 and 25.2 (6e)
  3. Others
     - section 3.5 6e

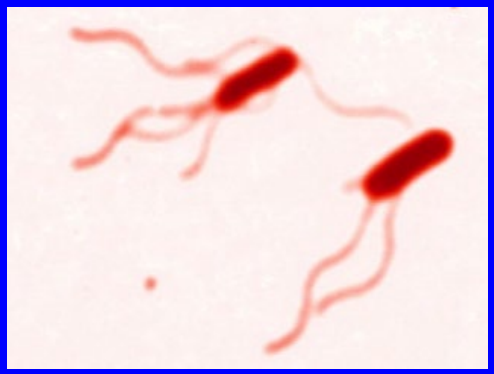
1. Flagella - a

a. Number of bacteria flagella per cell:
   - Number and location is a characteristic of a species
   - Some can lose and regain their flagella



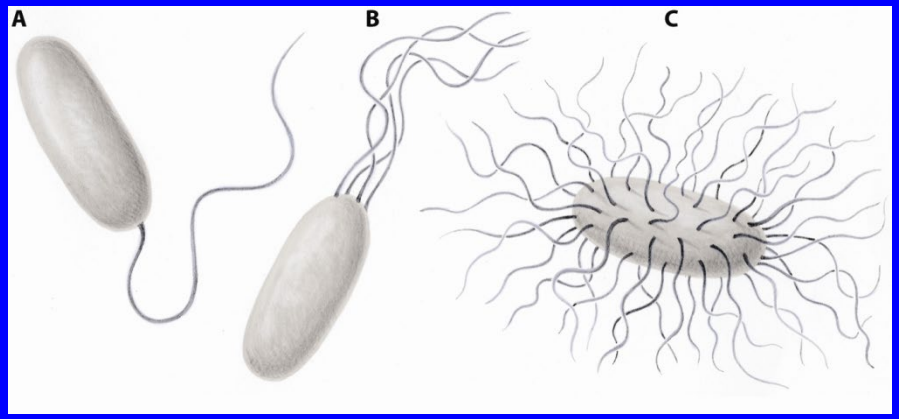


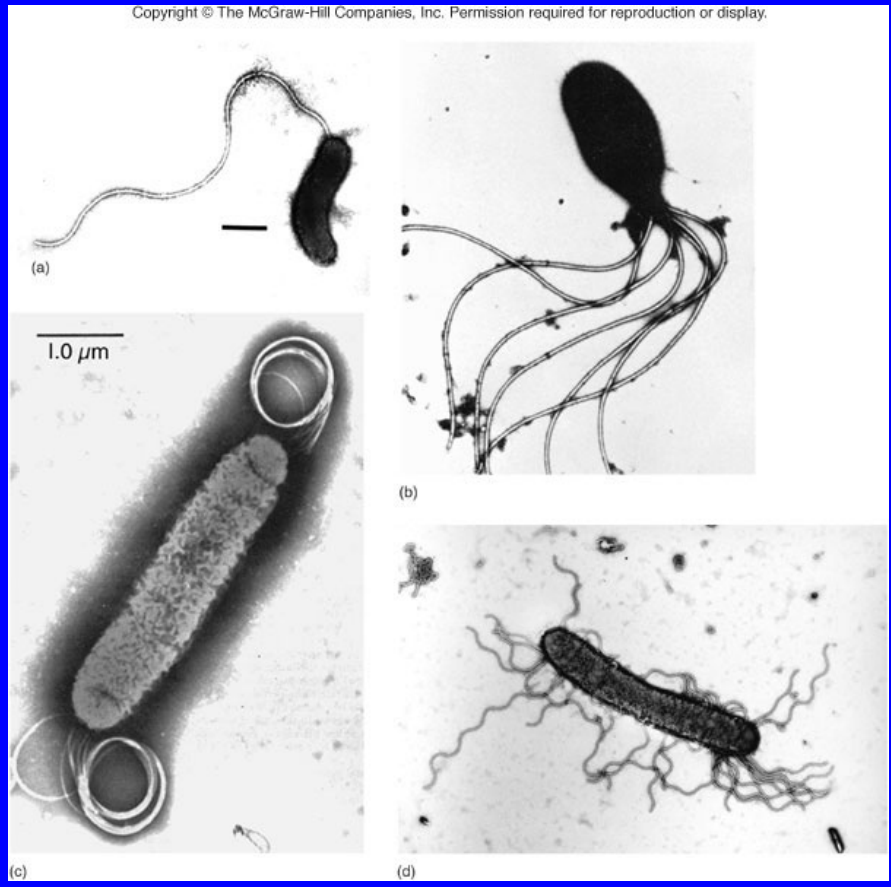
Flagellar Stain



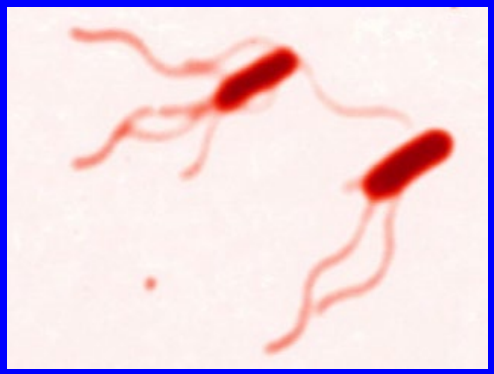
1. Flagella - a

a. Number of bacteria flagella per cell: 0-many
   - Number and location is a characteristic of a species
   - Some can lose and regain their flagella





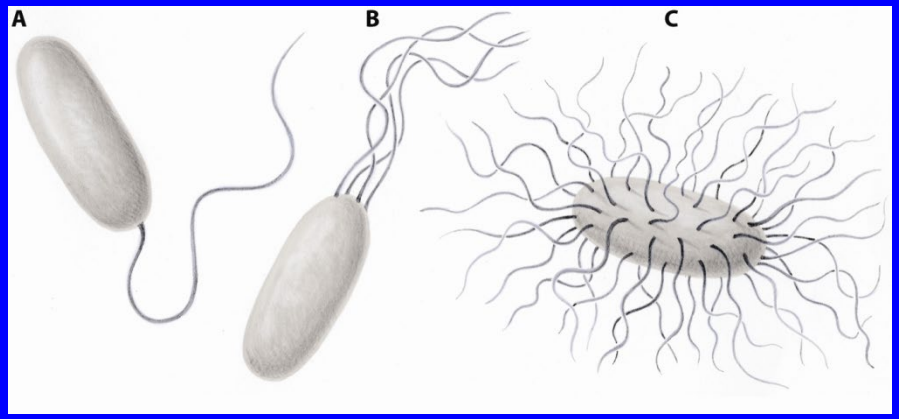
Flagellar Stain

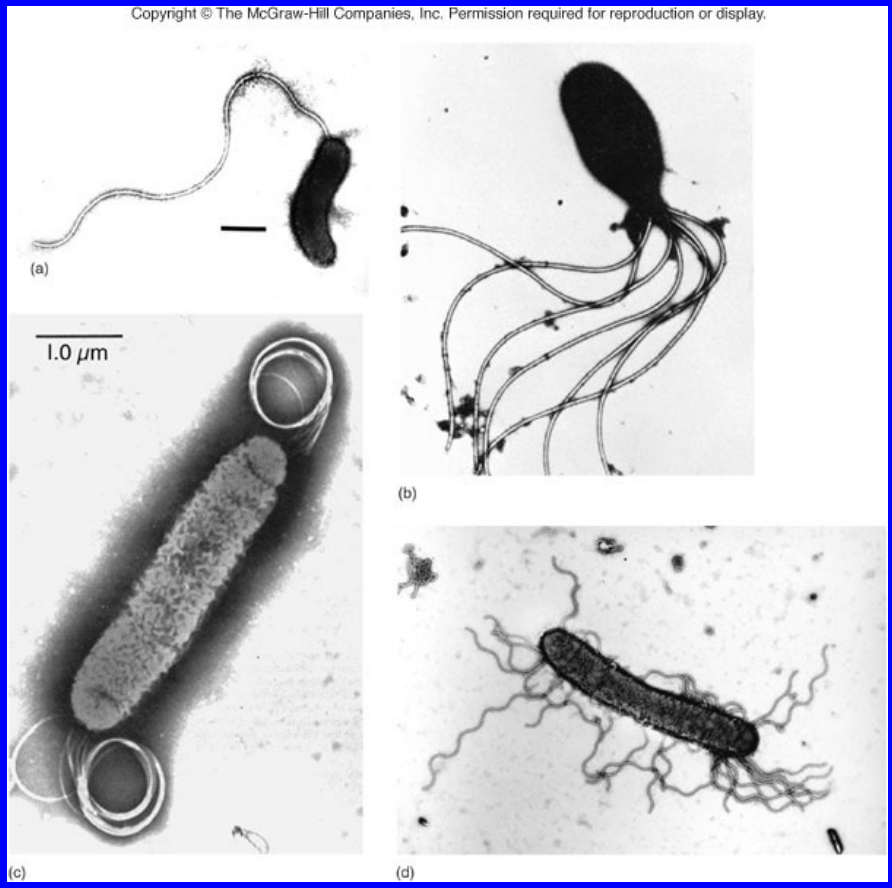


1. Flagella - b

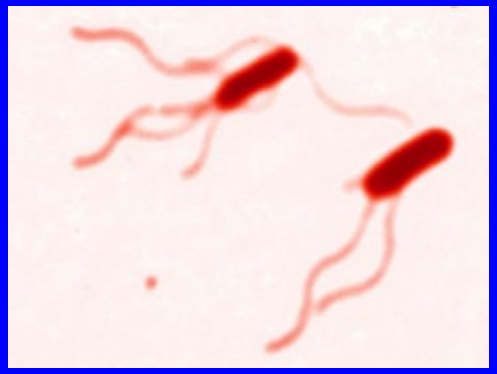
b. Location of flagella:

one end, both ends or all over





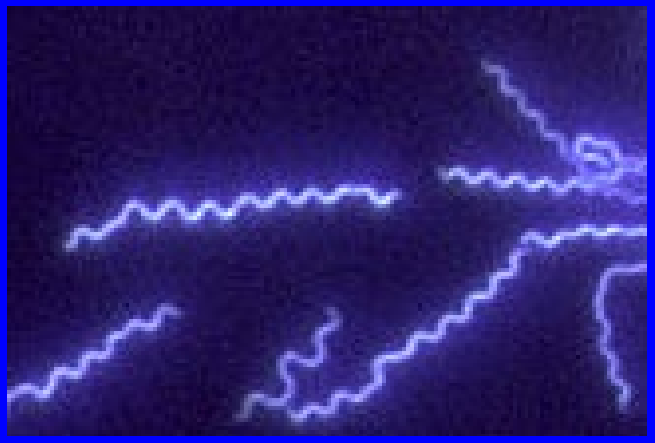
Flagellar Stain

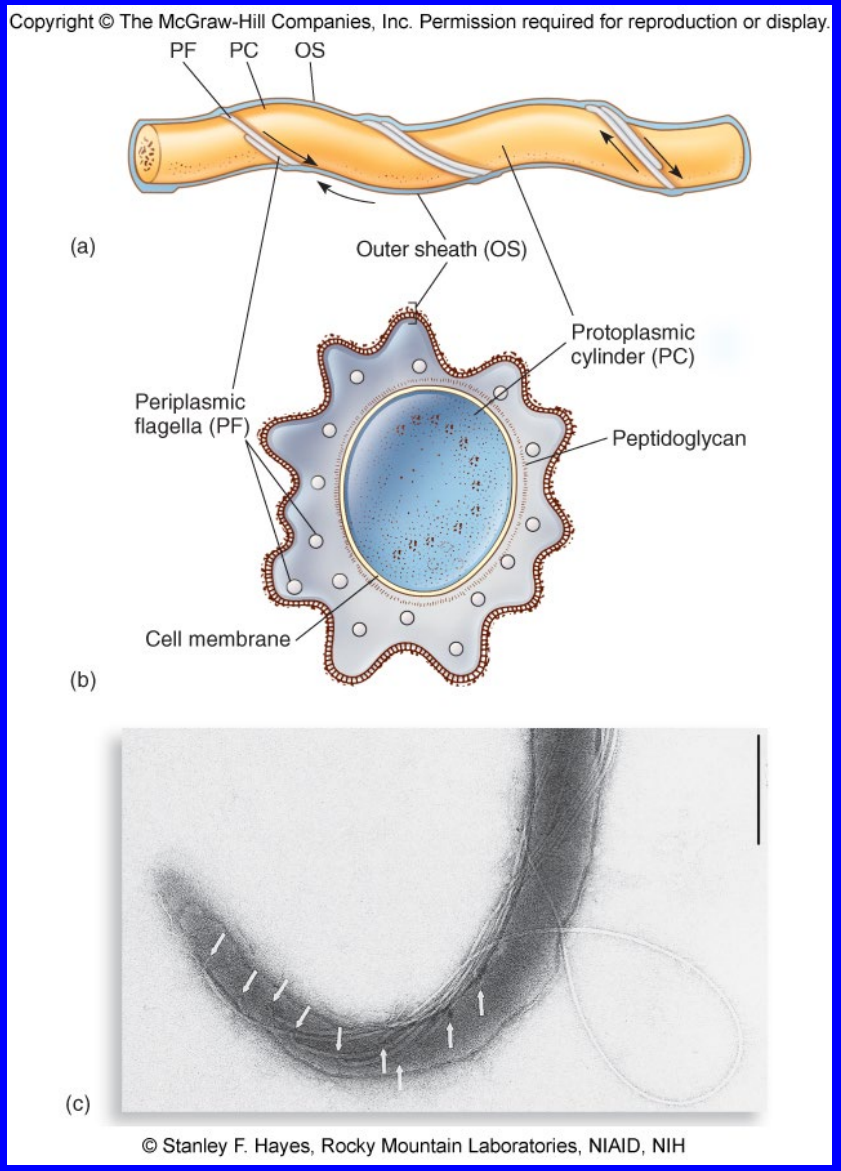


1. Flagella - b2

b. Location Part 2:

- Some are located in the periplasm - Spirochetes
- Flagella extend out from each pole and wrap around cell





1. Flagella - c

c. Complex structure of ~ 40 proteins
   - Some section in membrane
   - Filament portion sticks out from cell

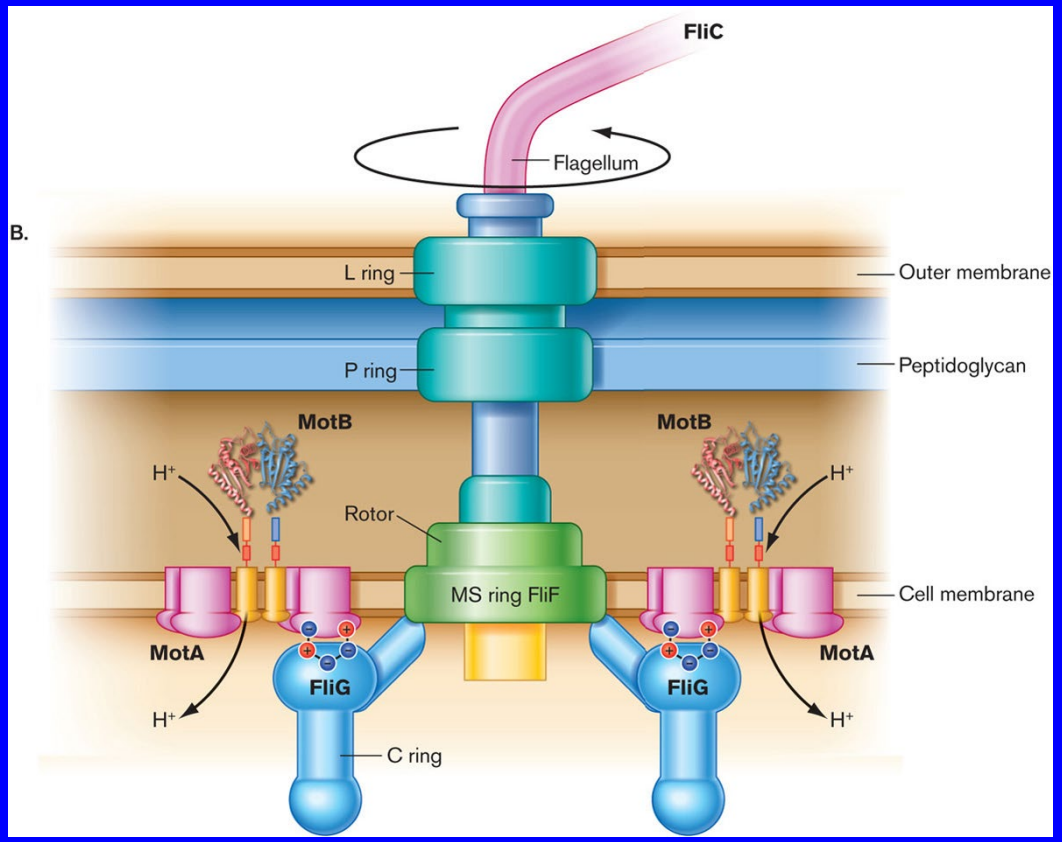
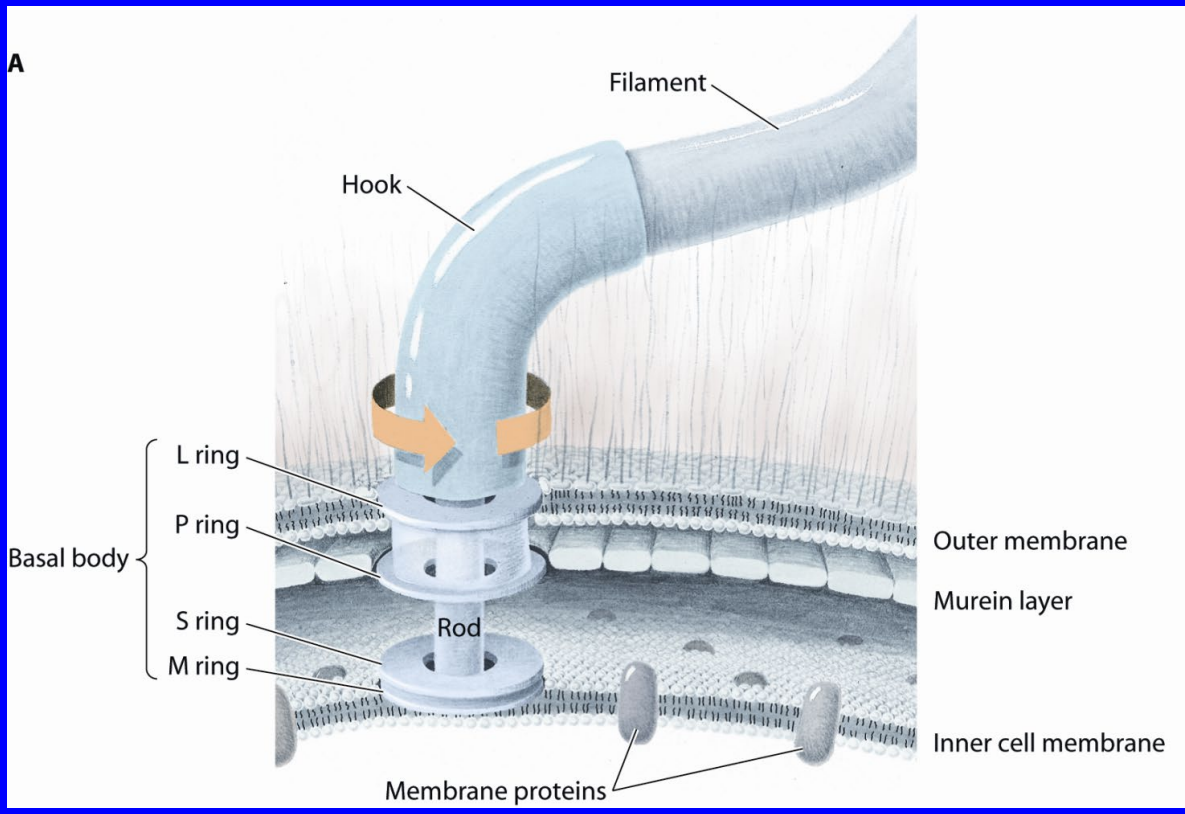


Figure 3.40 6th edition Flagellum of Gram-negative bacteria

c. Structure of Flagella – 1

- Four major sections
  1) Basal body – spans membrane
  2) Hook –
  3) Filament
  4) Motor



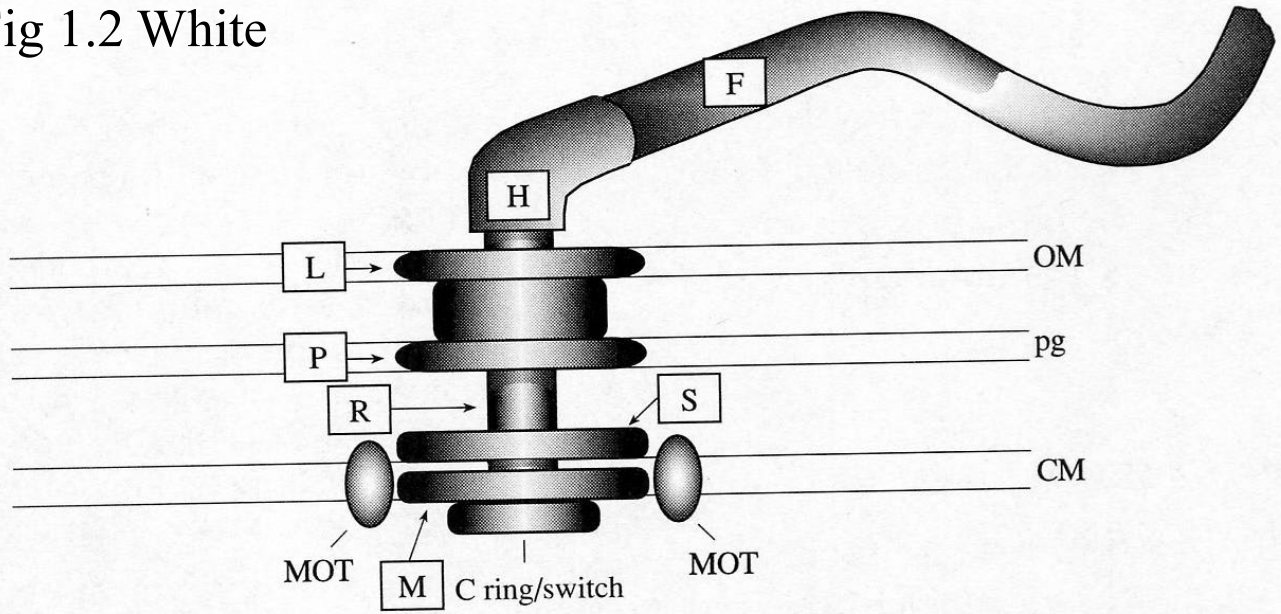
c. Structure of Flagella - 2

1) Basal body – ~ 15 different proteins
   - 1-4 rings in membranes and cell wall)
   - (L, P, S, M in Fig 1.2)

   Central rod (R)

2) Hook – hook protein and 2 HAPs

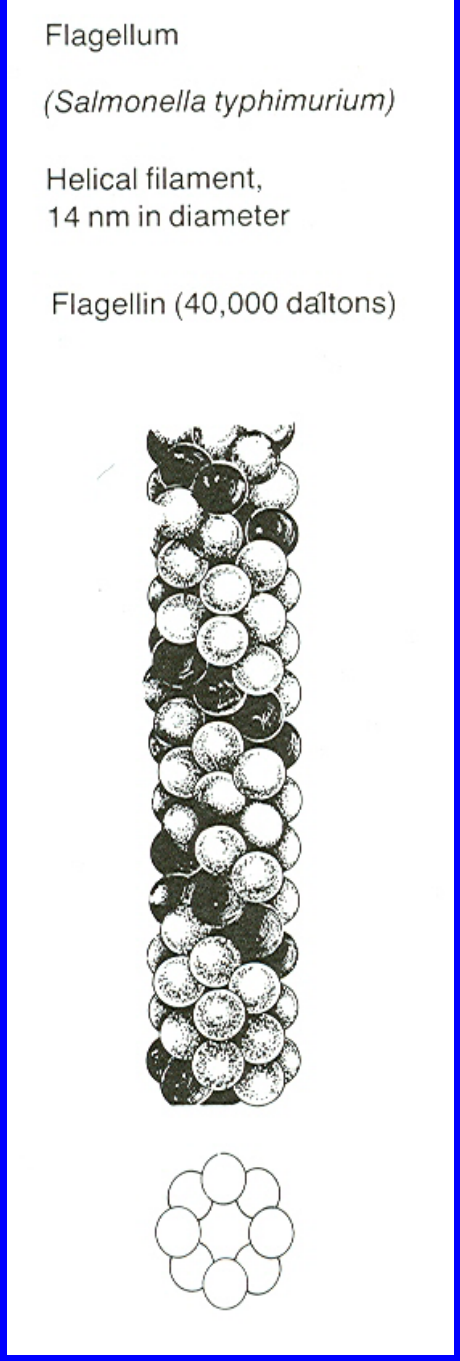
Fig 1.2 White



c. Structure of Flagella - 3

3) Filament

- 14-20 nm wide
- Up to 5-10 μm long
- Usually composed of a single protein called flagellin
- May have a different protein on tip (cap protein)
- Cell may have several different flagellin genes and can change one used
- Flagellin subunits self polymerize in a helical/spiral arrangement
- Form a hollow tube



c. Structure of Flagella - 4

4) Motor –

– Composed of rotor section and Mot proteins.

– Mediates movement of flagellum

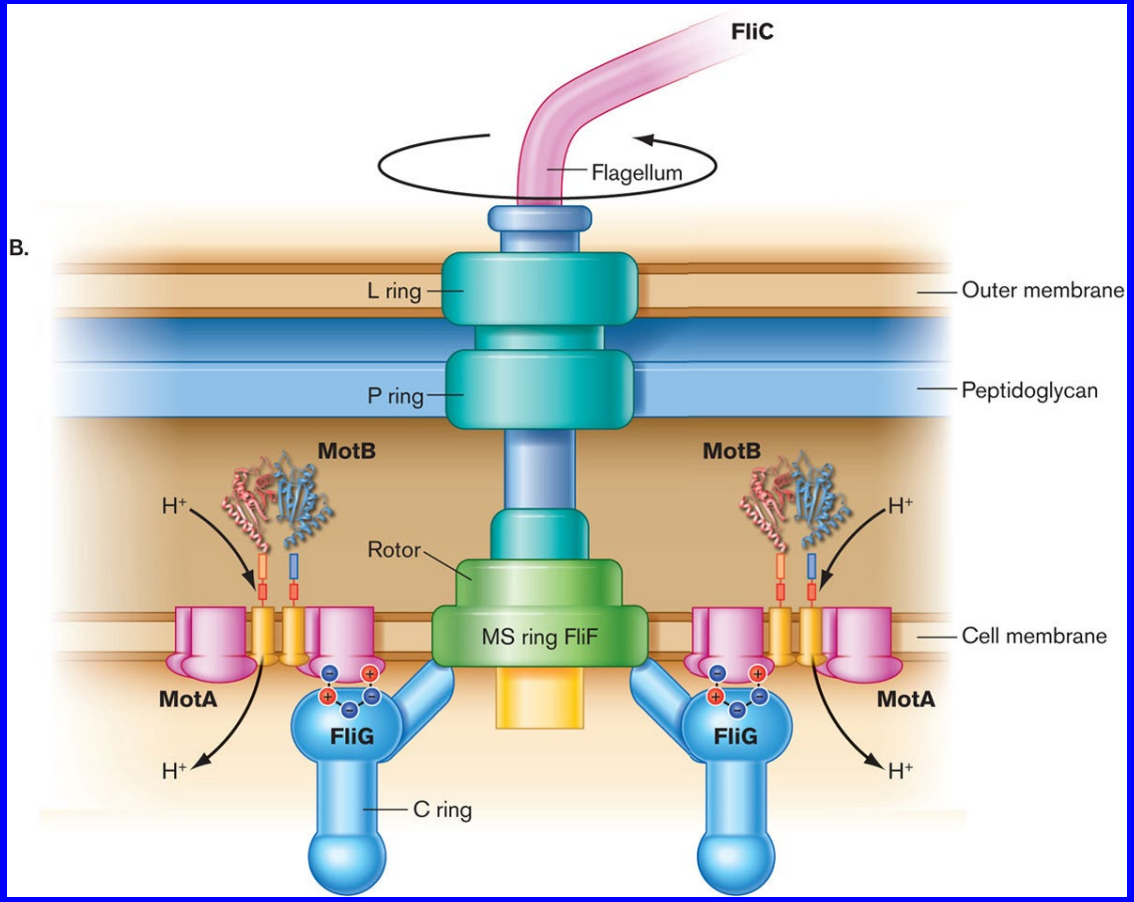
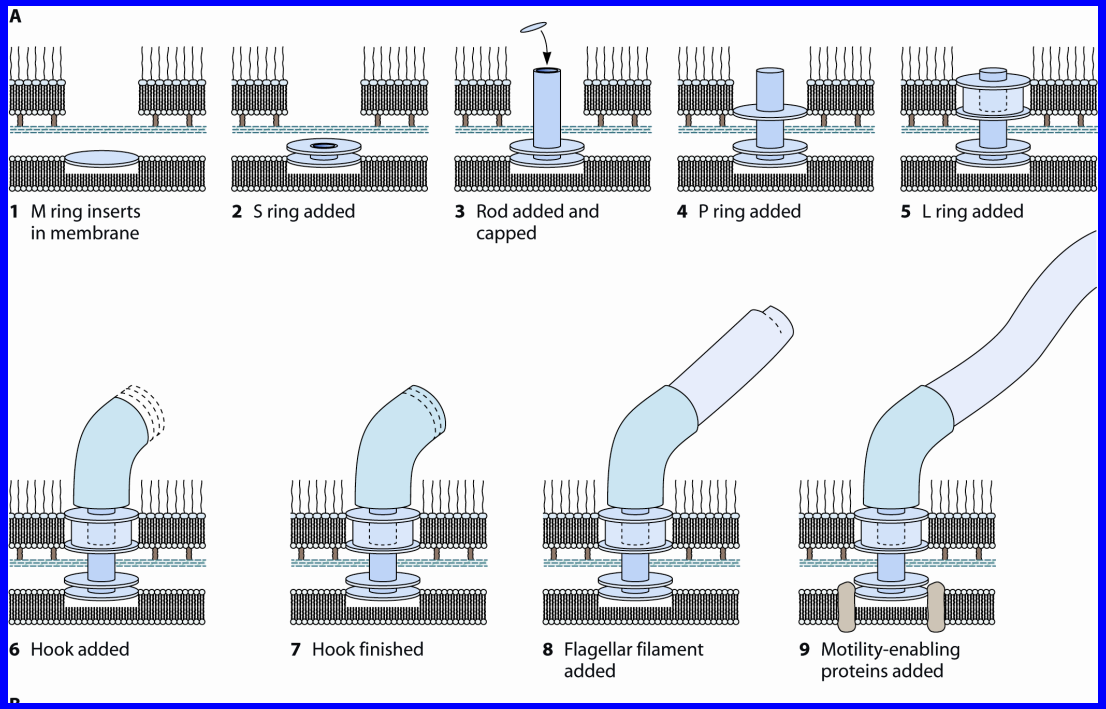


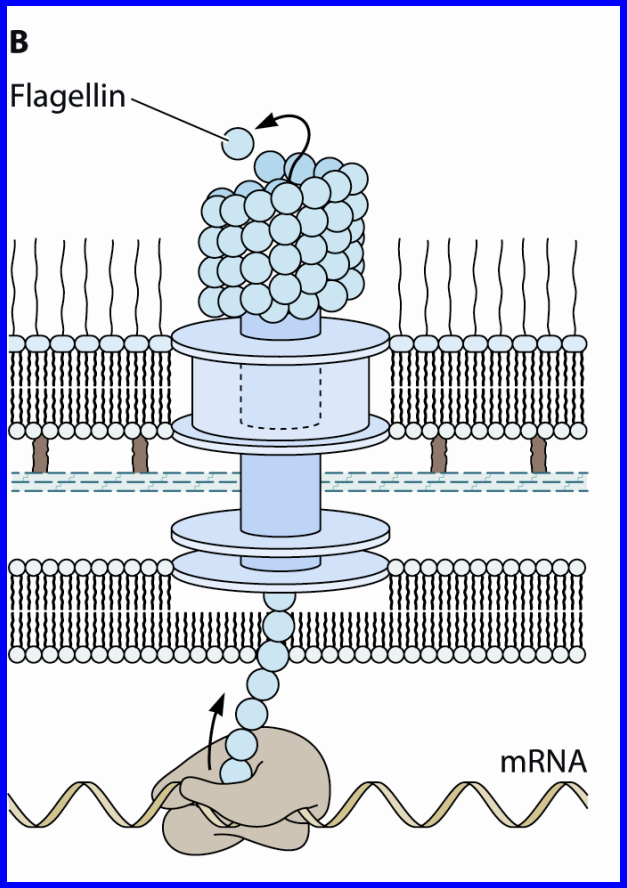
Figure 3.40 6th edition Flagellum of Gram-negative bacteria

d. Assembly of Flagella

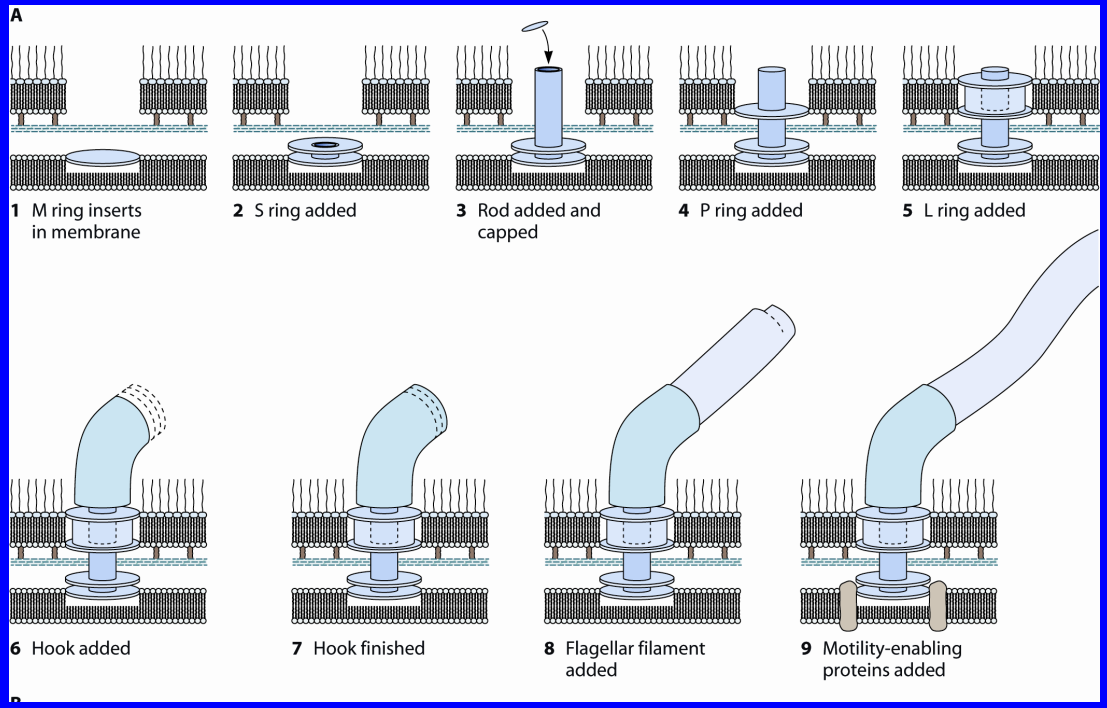
- These two figure shows how the flagellum is assembled. Write down the order of assembly of the major sections

Fig 2.18
Microbe





d. Assembly of Flagella - 2



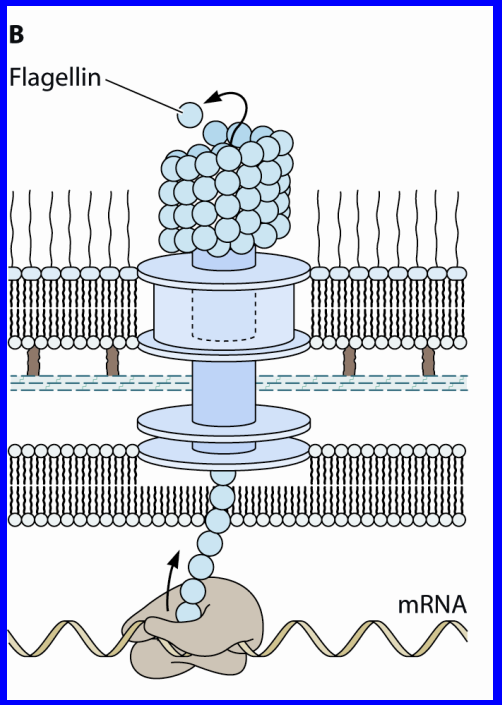
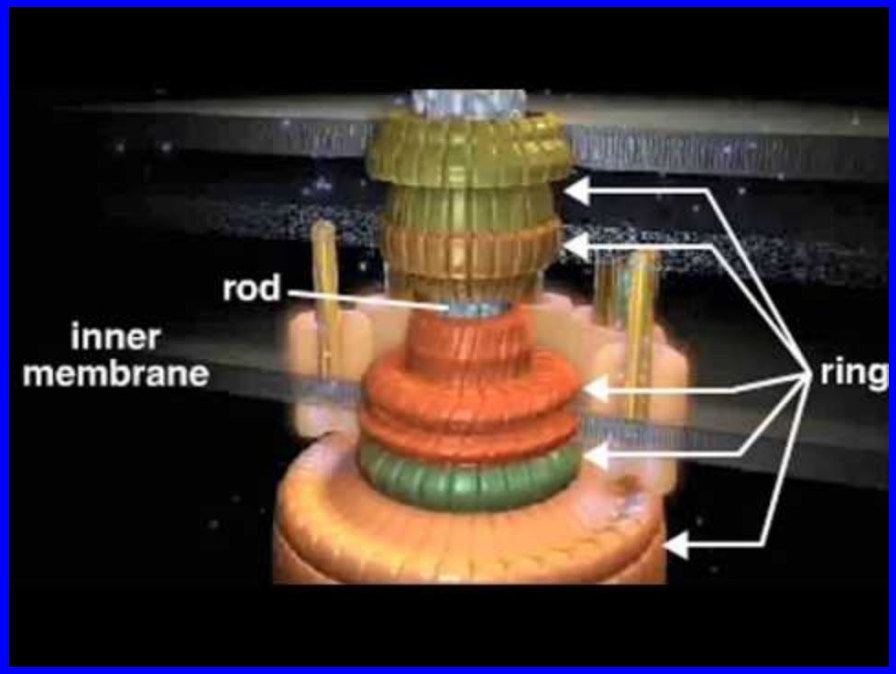


Fig 2.18 Microbe (A) The process begins with the insertion of rings of the basal body into the cell membrane (1 and 2). A rod is added (3), followed by two outer membrane rings (4 ad 5). The hook (6 and7) and the filament (8) are added. The last step is the addition of the motility proteins in the cell membrane (9). (B) Growth of the flagellar filament by extrusion of flagellin subunits through the core of the flagellum.

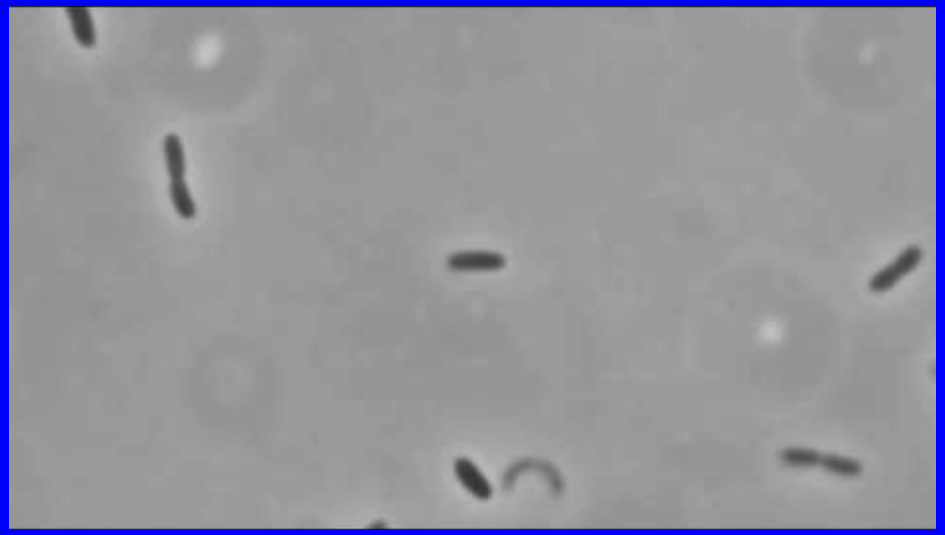
1. Flagella - e

e. Movement of Flagellar proteins
   - How do flagellar proteins move to create motility? Watch these two videos

Flagellar Movement Video 1
Watch from about 0:25 to 1:30



Flagellar Movement Video 2
Watch first 30 sec. Note the flagellum is stuck to the slide and bacteria is trying to move

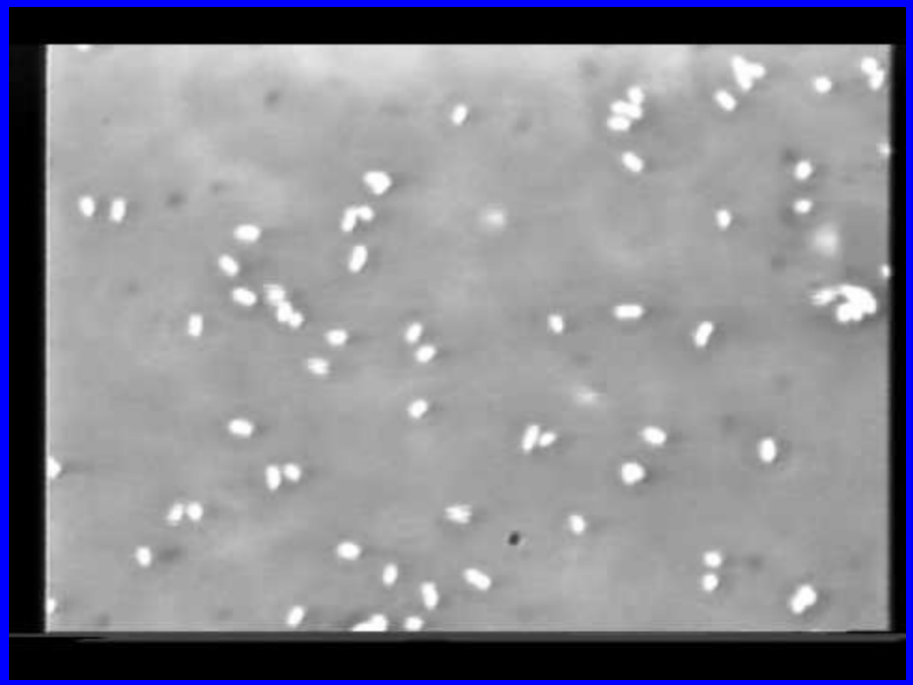


1. Flagella – e2

e. Movement of Flagellar proteins
   - How do flagellar proteins move to create motility?

f. Flagellar Swimming Motility

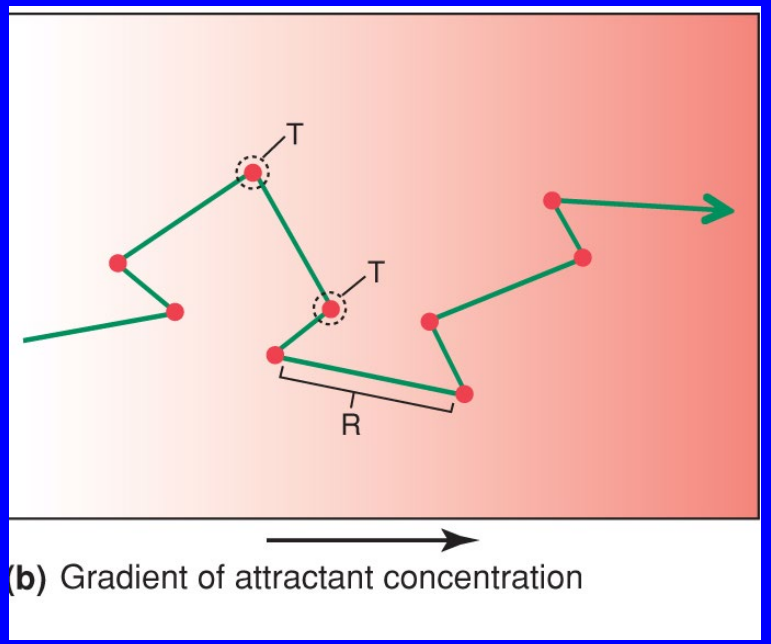
- These two videos show the swimming motility of bacteria mediated by typical flagella
- How would you describe the movement or motility of these bacterial cells?





g. Bacterial Motility

1) Definition: Motility is purposeful movement in a liquid or across a surface
2) Cells can move towards or away from stimuli = taxis
3) Different types of motility have been observed
4) Several assays for Motility and Chemotaxis



2) Taxis

- Movement in response to an external stimuli or effecter (can be towards or away)
- A wide variety of substances and conditions have been shown to affect bacterial motility and taxis
  - Chemicals (some nutrients)
  - Metals (many are toxic)
  - Light
  - Temperature
  - pH
  - Oxygen level

2) Taxis - 2

- Chemotaxis
  - Cells have receptors for attractants and repellents
  - Sends signal that affect whether flagella turn

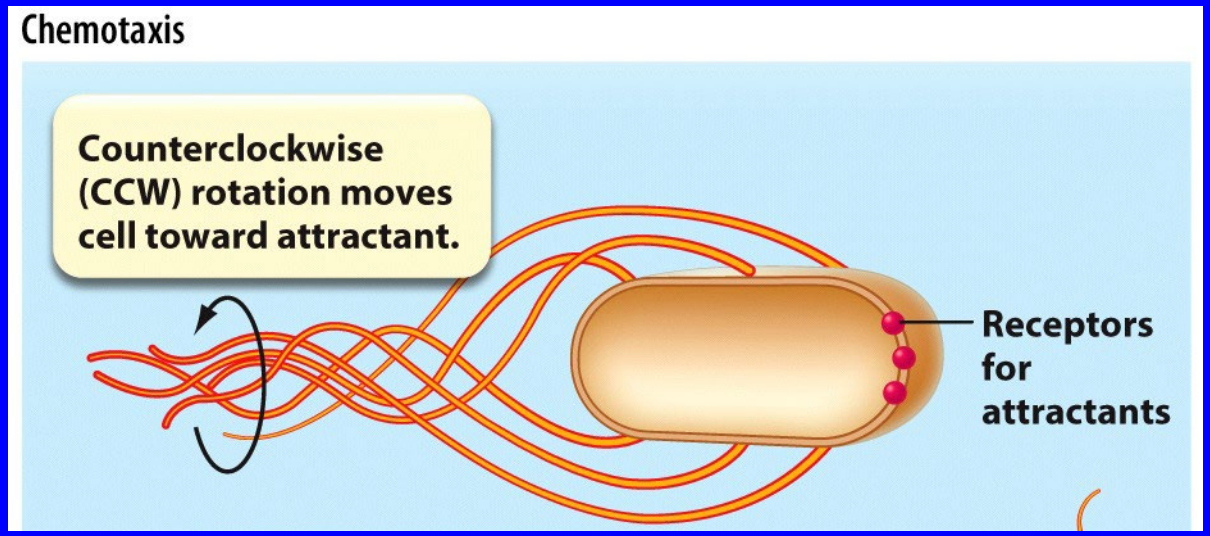
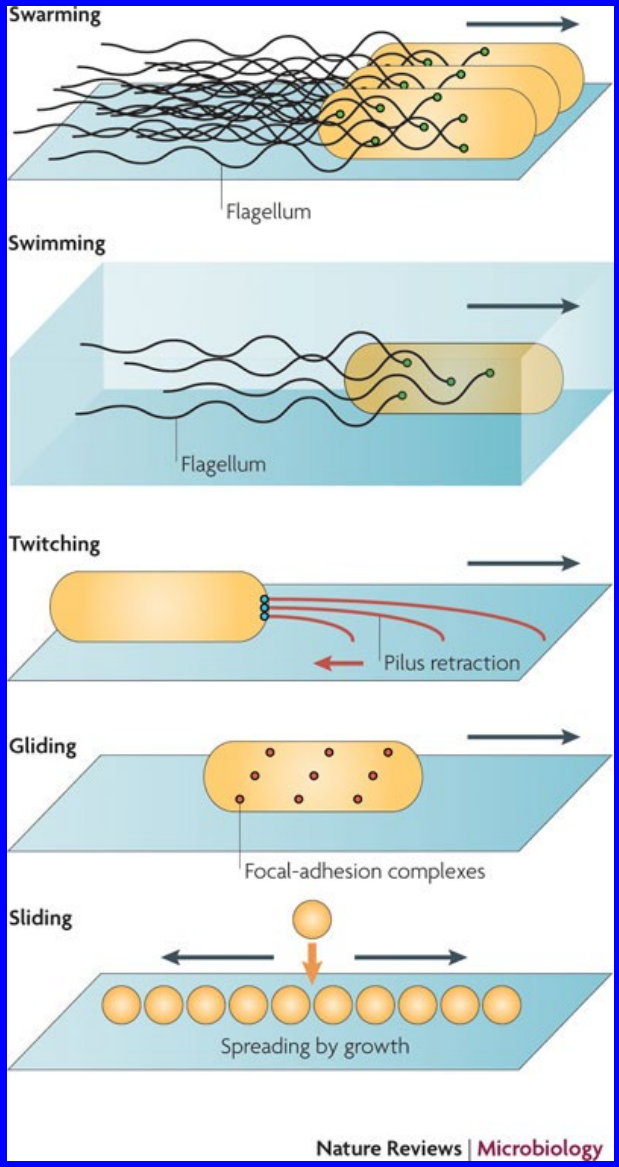


Figure 12.1A
6th edition

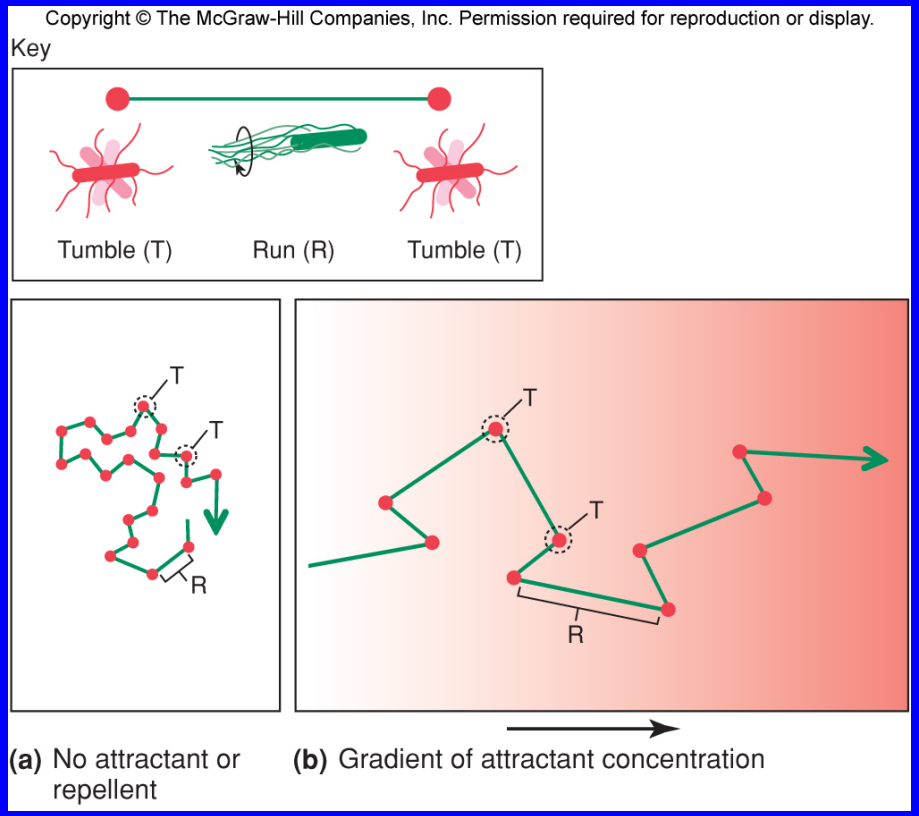
g. Bacterial Motility - 3

3) Types of Bacterial Moti
   a) Flagella Mediated
      1. Typical flagellar - swimming
      2. Periplasmic Flagella
      3. Swarming – on a surface
   b) Non-Flagellar mediated
      1. Twitching – on a surface
      2. Gliding – on a surface
      3. Sliding on a surface



1. Typical Flagellar Swimming Motility

- Directional movement (taxis) mediated by controlling length of runs (on)
- Cells sense change in concentration and then decide if to keep flagella on or to turn off



1. Typical Flagellar Swimming Motility - 2

- For cells with single polar flagella, they can turn either counterclockwise (CCW) or clockwise (CW) for runs
- To stop (tumbles), either stop turning or turn in opposite direction

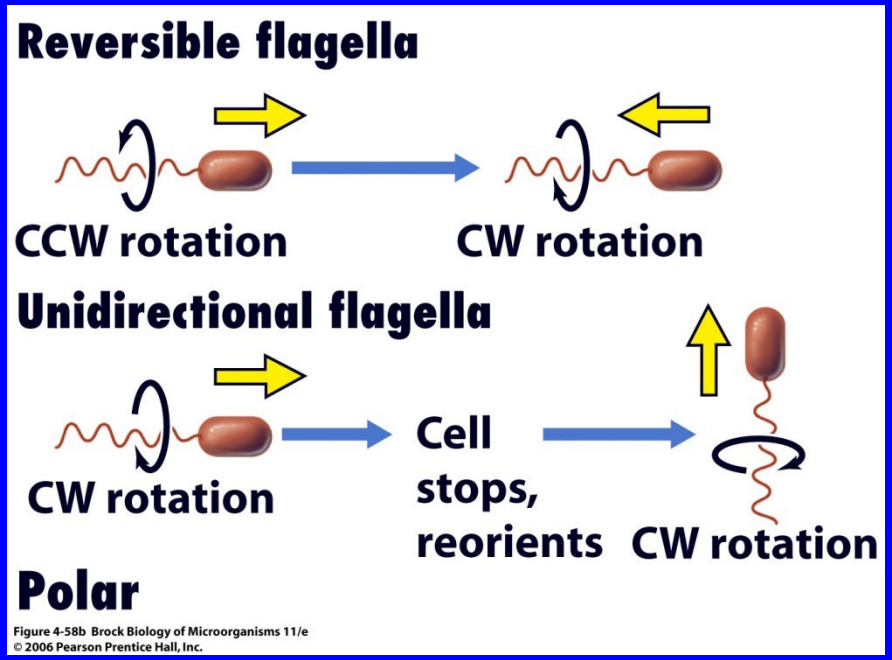


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1. Typical Flagellar Swimming Motility - 3

- In cells with multiple flagella, their turning is coordinated
- Turn counterclockwise for forward movement (movement slower than cells with single flagellum)
- Turn in opposite direction (CW) for stop (tumble)

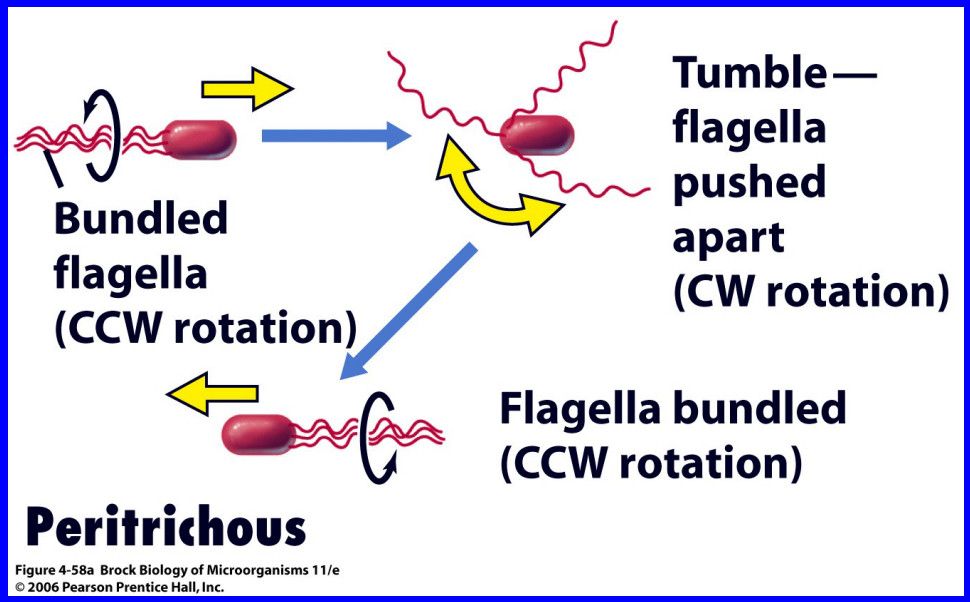
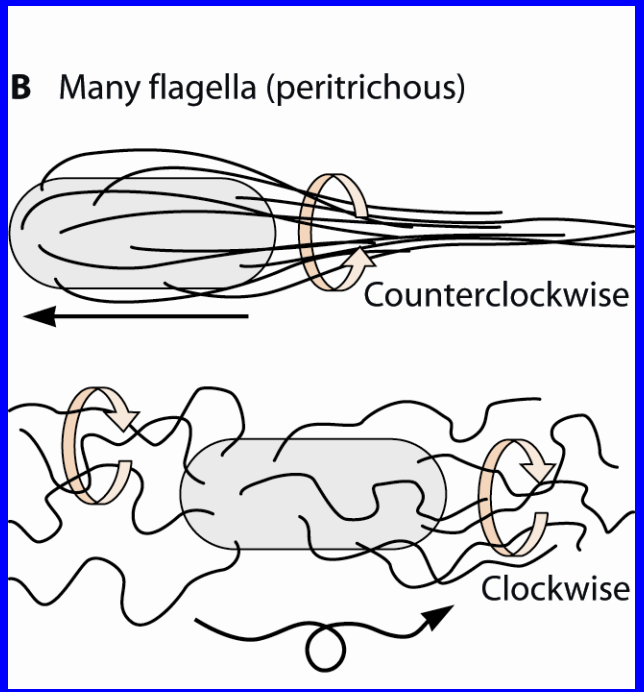


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2. Periplasmic Flagellar Motility - 1

- Observed in spirochete bacteria



2. Periplasmic Flagellar Motility - 2

- Have flagella out from each end
- Direction of rotation of flagella at each end determines direction of motility

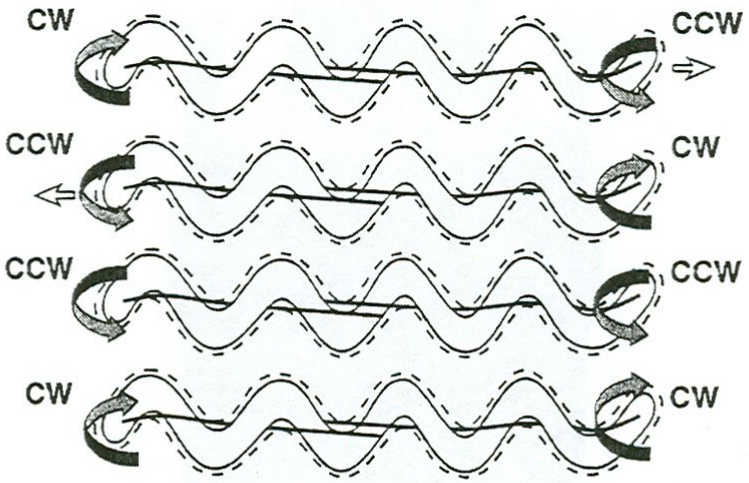
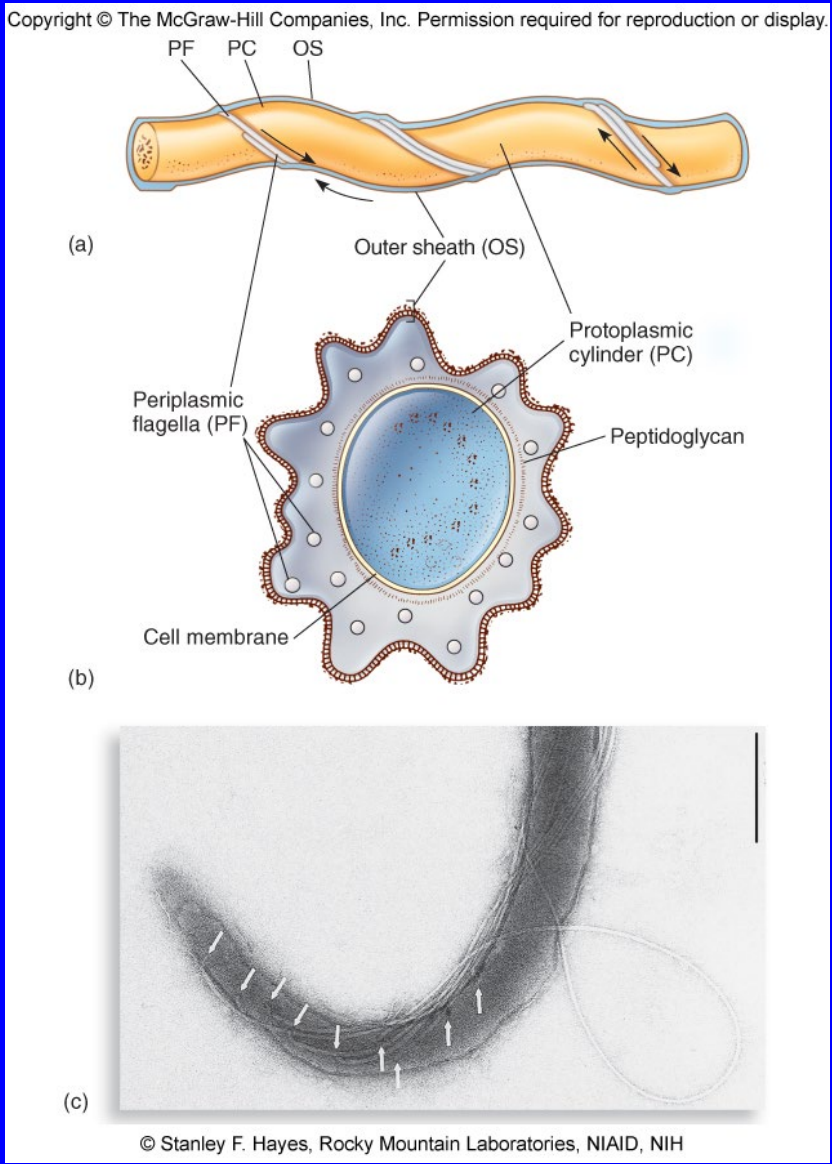


Figure 5 Swimming cells of *B. burgdorferi* as a function of direction of rotation of the periplasmic flagella. Open arrows indicate direction of swimming. Dotted lines represent the outer membrane sheath. Gray arrows indicate direction of rotation of the periplasmic flagella (*thin lines*). For simplification, only one periplasmic flagellum is shown attached at each end of the cell cylinder. In *B. burgdorferi*, there are between 7 and 11. The top two panels show translational forms, and the bottom two nontranslational forms.

Charon & Goldstein. 2002. Ann. Rev. Genet. 36:47-73

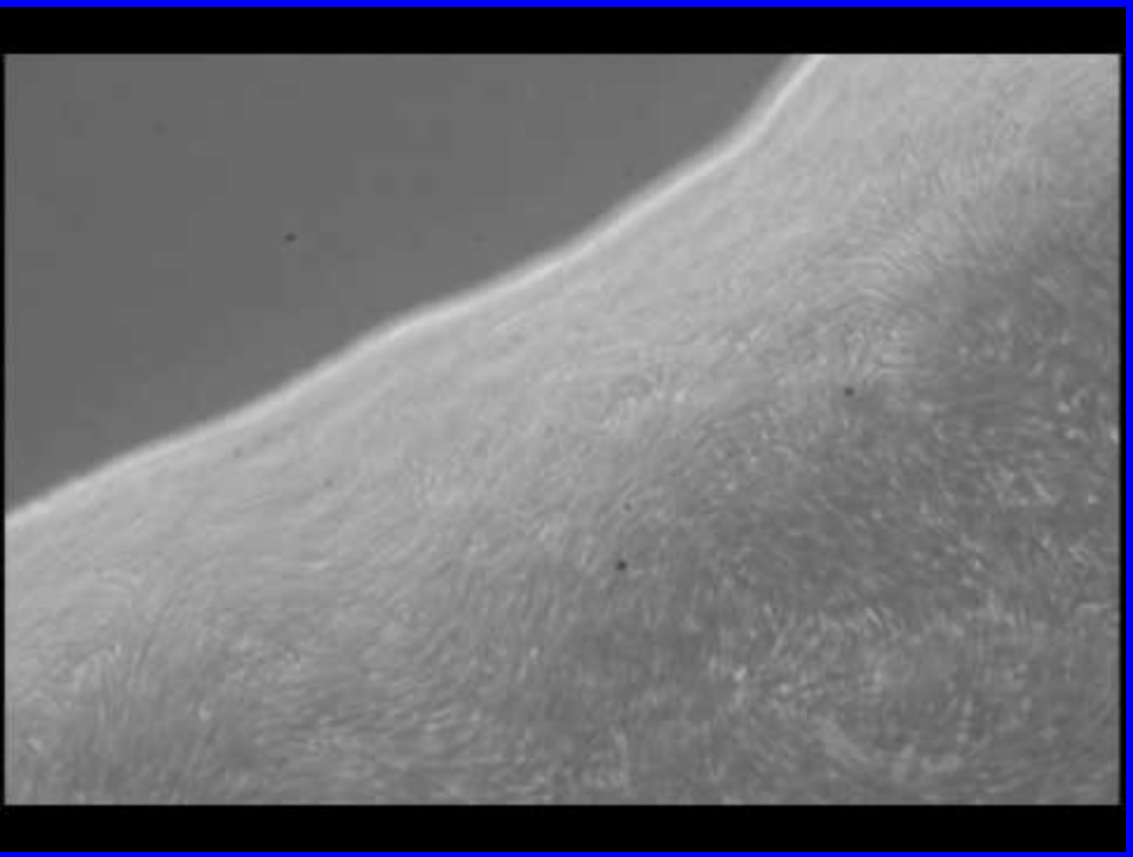
2. Periplasmic Flagellar Motility - 3

- Turning of flagella causes a wiggling or corkscrewing locomotion
  - Good for burrowing into thick mucus



3. Swarming Motility - 1

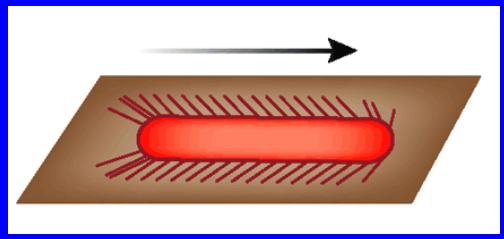
- Two videos showing swarming motility
- Right: *Escherichia coli*
- Left: *Proteus*





3. Swarming Motility - 2

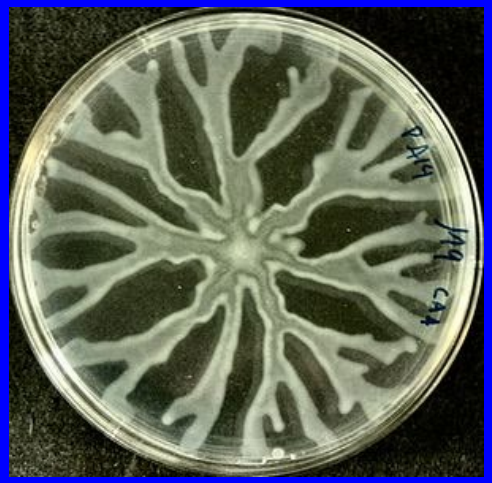
- Movement across a surface or semi-solid media
- Mediated by flagella – position may change to lateral
- Observed in some bacterial species
- A group (raft) of bacteria move together
- Requires a slime layer



Test: Inoculate plate in center and look for spread of growth



Ring pattern

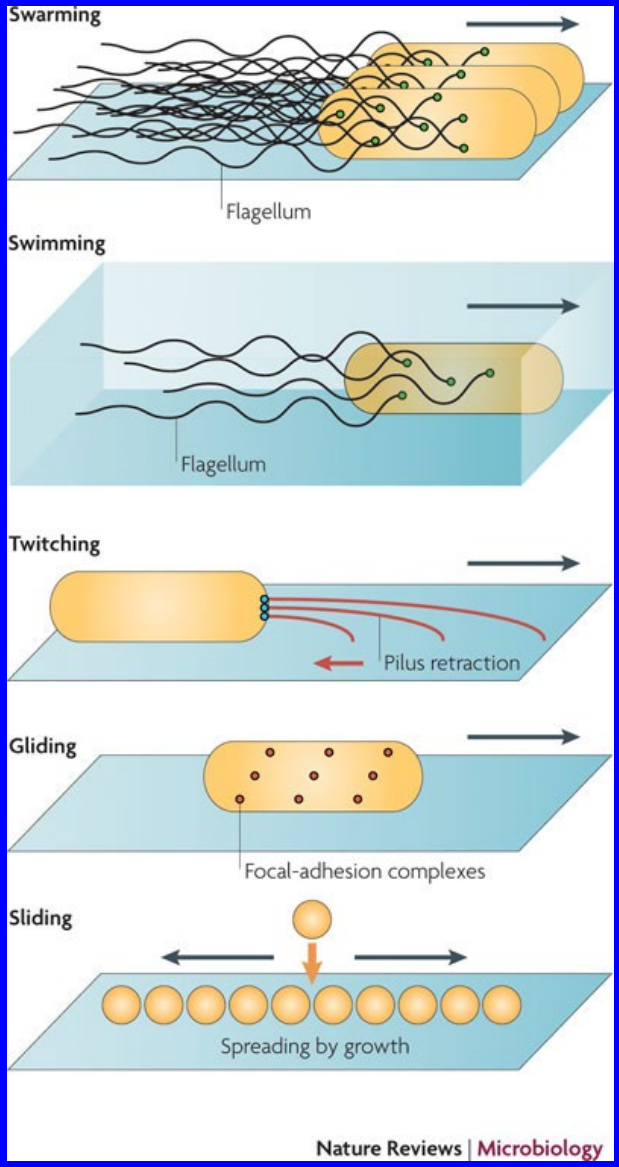


Dendritic pattern

3) Types of Bacterial Motility – b

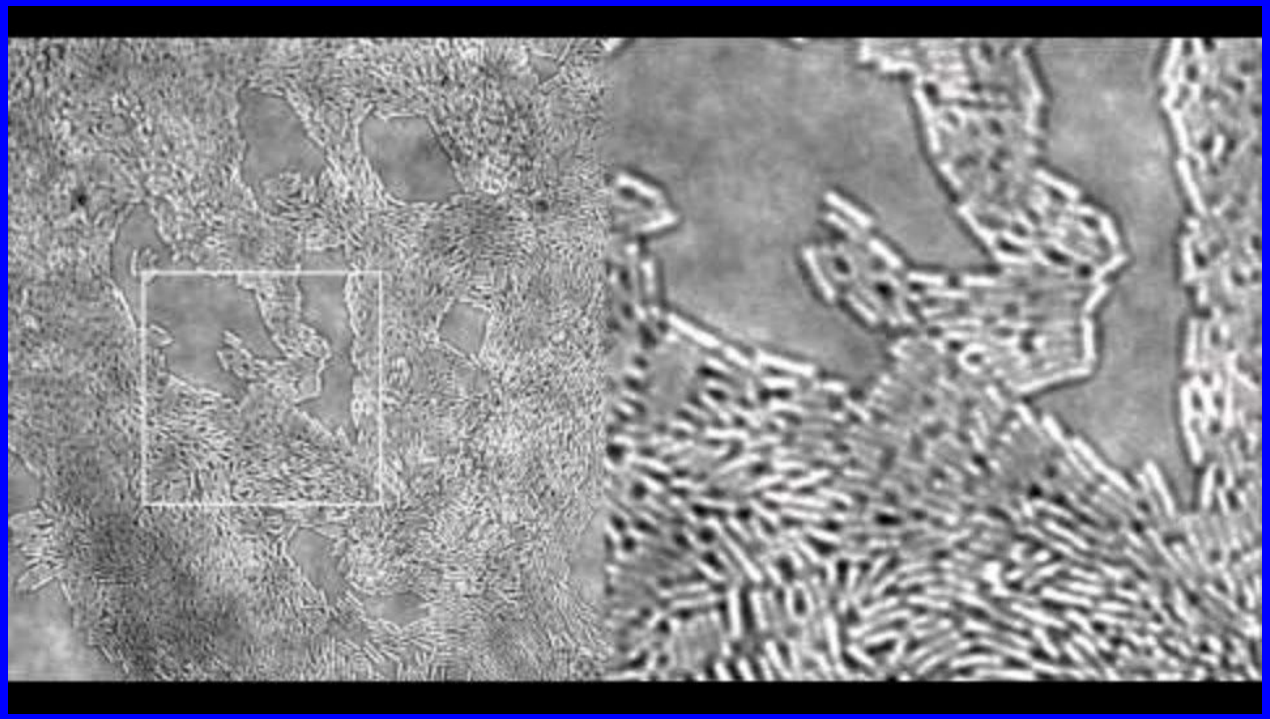
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b) Non-Flagellar mediated
   1. Twitching – on a surface
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   3. Sliding on a surface



b) Non-Flagellar mediated Motility - 1

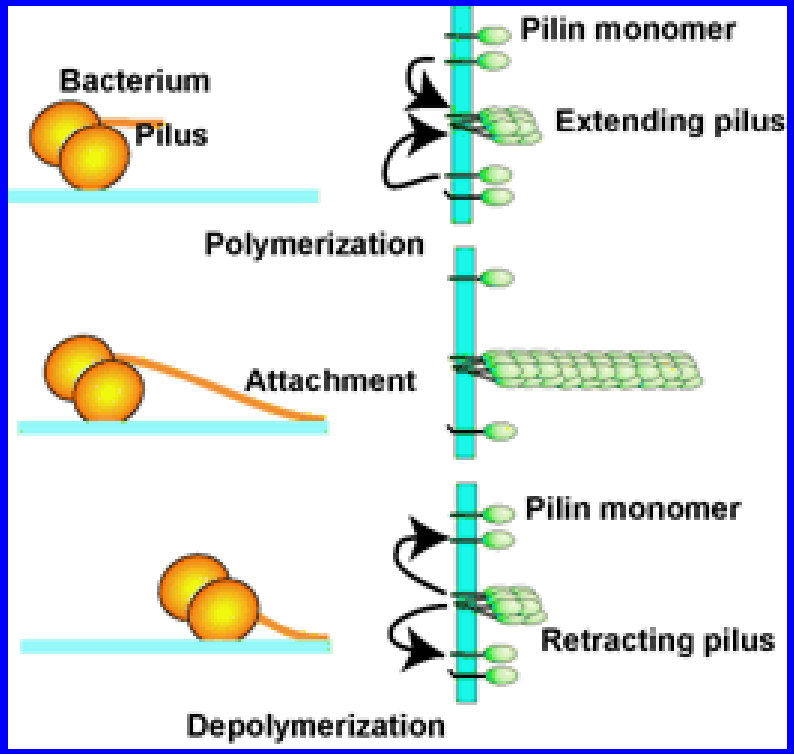
1. Twitching Motility
   - Movement across a surface
   - Mediated by a type of pili (type IV)
   - Observed in several Gram-negative bacteria species

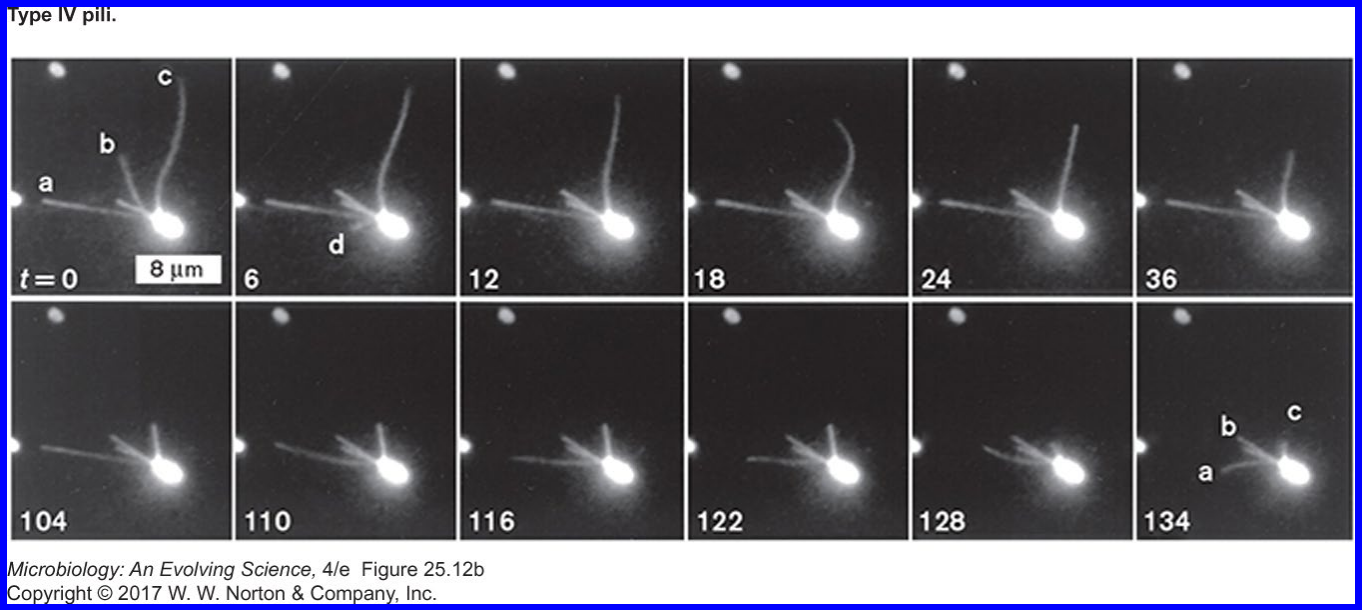


This video is at 20X speed

1. Twitching Motility

- Type IV pili thought to extend, attach and then shorten to pull cell forward





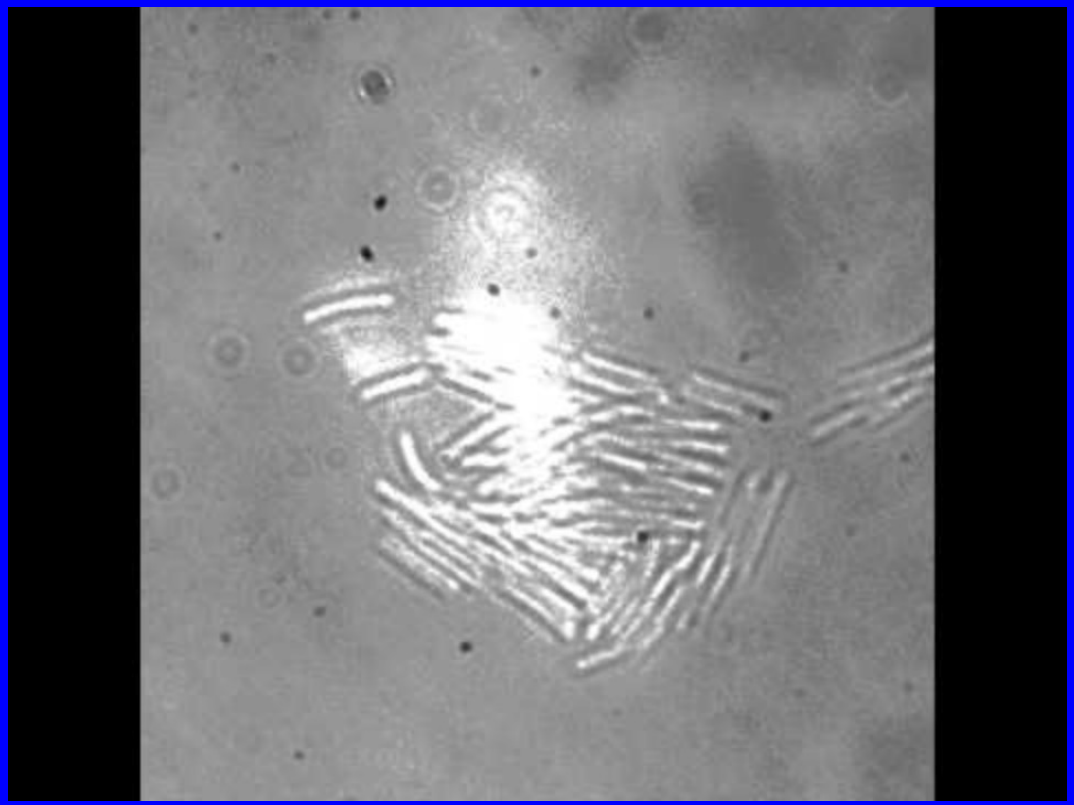
Microbiology: An Evolving Science, 4/e Figure 25.12b
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Figure 25.12b
6th edition

b) Non-Flagellar mediated Motility - 2

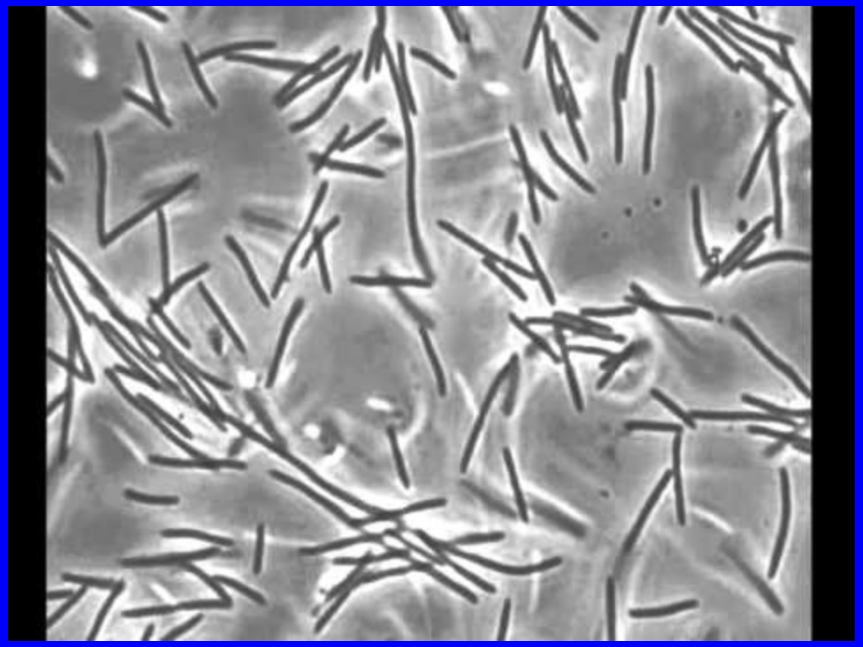
2. Gliding Motility
   - Motility across a solid surface
   - Observed in over 12 genera of bacteria
   - Mechanism not understood in all genera

Video: Gliding Motility of *Myxococcus*



2. Gliding Motility

- Bacteroidetes
  Flavobacterium
  - Thought to have motility proteins in membrane that act like feet
  - No slime involved



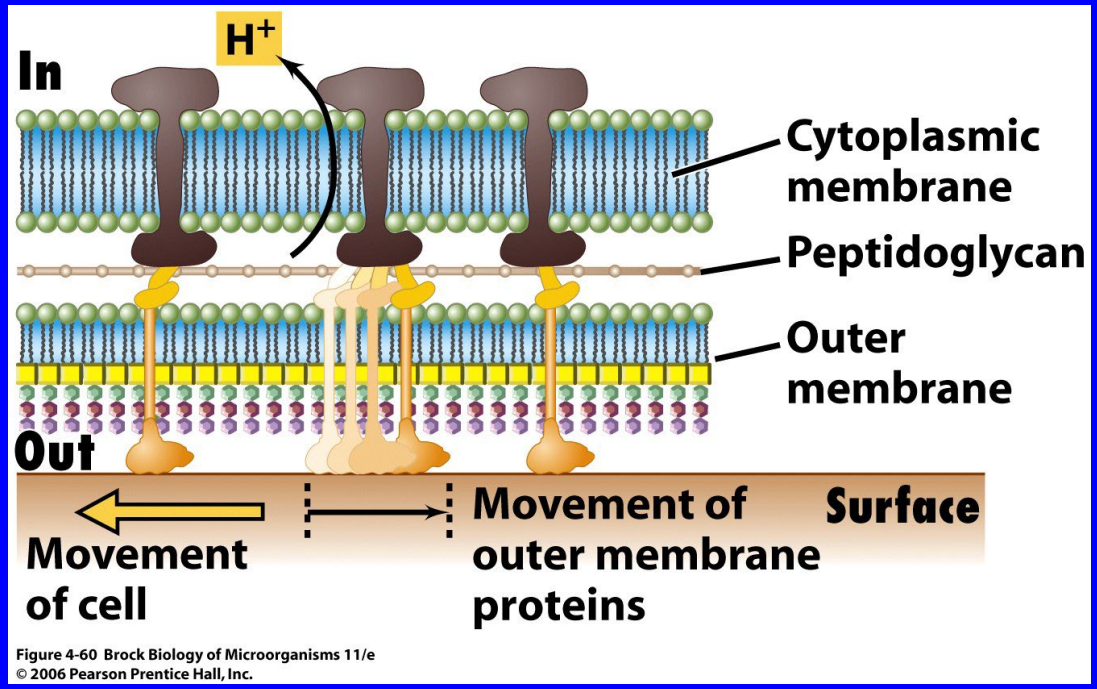
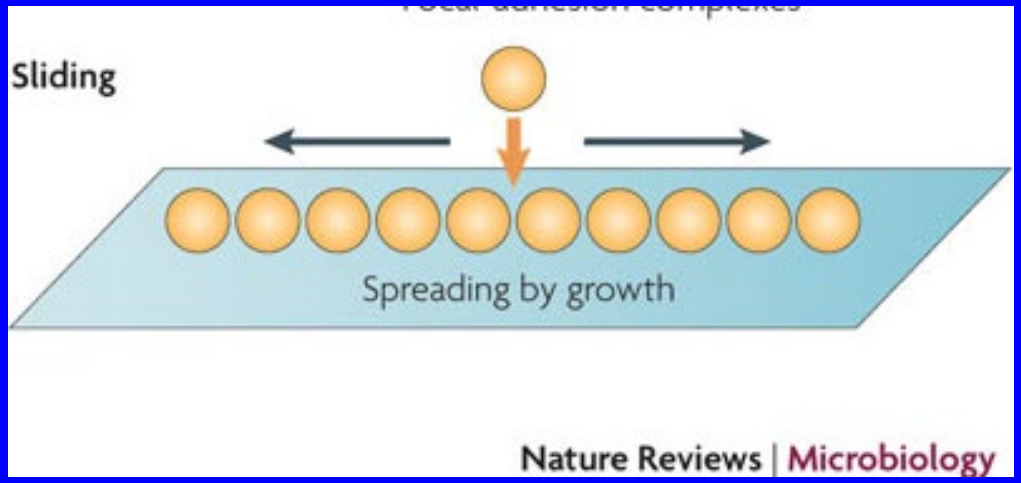


Figure 4-60 Brock Biology of Microorganisms 11/e
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b) Non-Flagellar mediated Motility - 3

3. Sliding -
   - Passive spreading movement across a surface
   - Powered by the pushing force of dividing cells
   - Requires synthesis of additional surface factors
     - Surfactants or
     - Exopolysaccharide or protein slime layer



4). Motility and Chemotaxis Assays - 1

a) Microscopic observation

- Bright field or dark-field light microscopy
  - Can observe movement in live wet mounts
  - Need to make sure is movement is purposeful and not just vibrational movement
  - Lack of observation of movement is not definitive
- Can also detect flagella with
  - Flagellar stain
  - Electron microscopy

4) Motility and Chemotaxis Assays - 2

b) Motility agar

- Semi-soft agar (0.75% instead of 1.5%)
- Stab inoculating loop into tube with media
- Not sure if it will detect all forms of motility

Left: Growth only at stab – non-motile

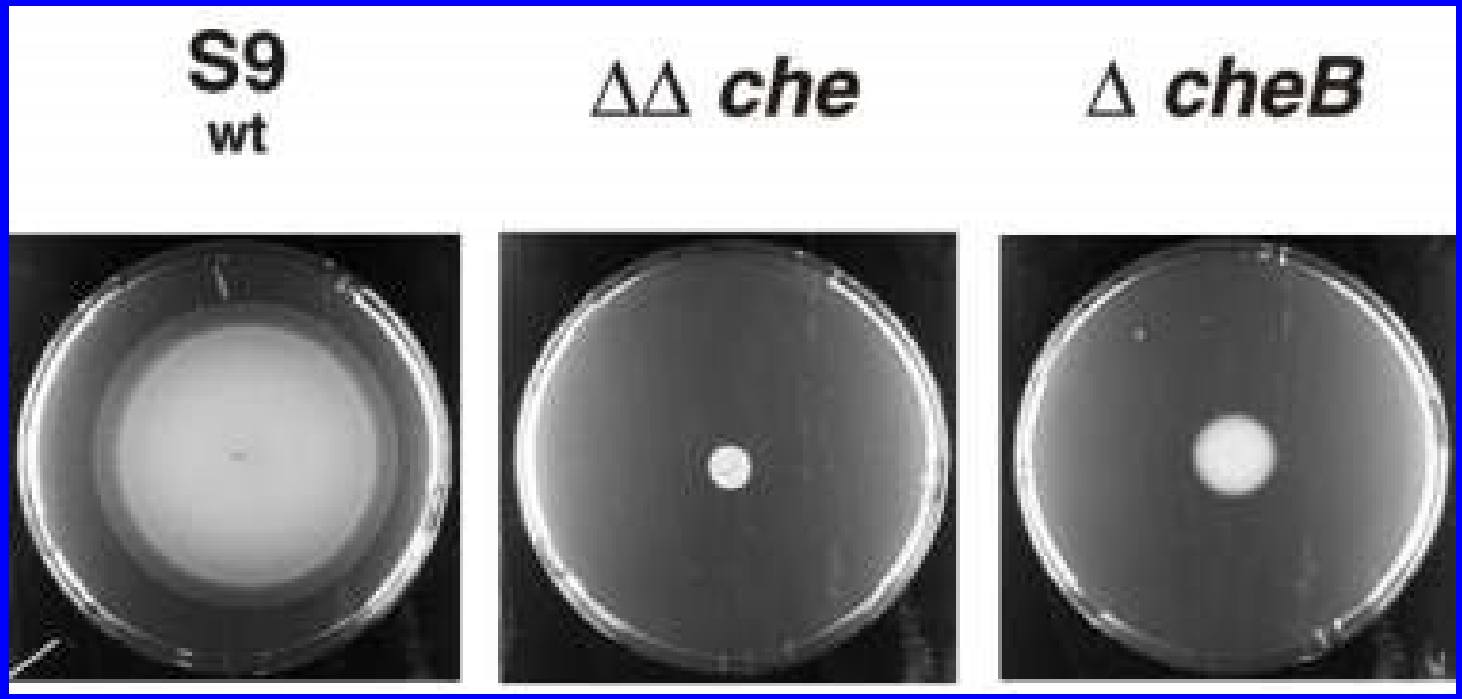
Right: Turbidity throughout – bacteria motile



4) Motility and Chemotaxis Assays - 3

c). Semi-solid swarm plates

- Put bacterial cells in center of soft agar plate (bacteria can swim through semi-solid agar)
- Look for spread of bacteria - circle



4) Motility and Chemotaxis Assays

d) Agar plates with soft agar and potential attractant

- Put bacterial cells in well in one end
- Place test substance in the other end

