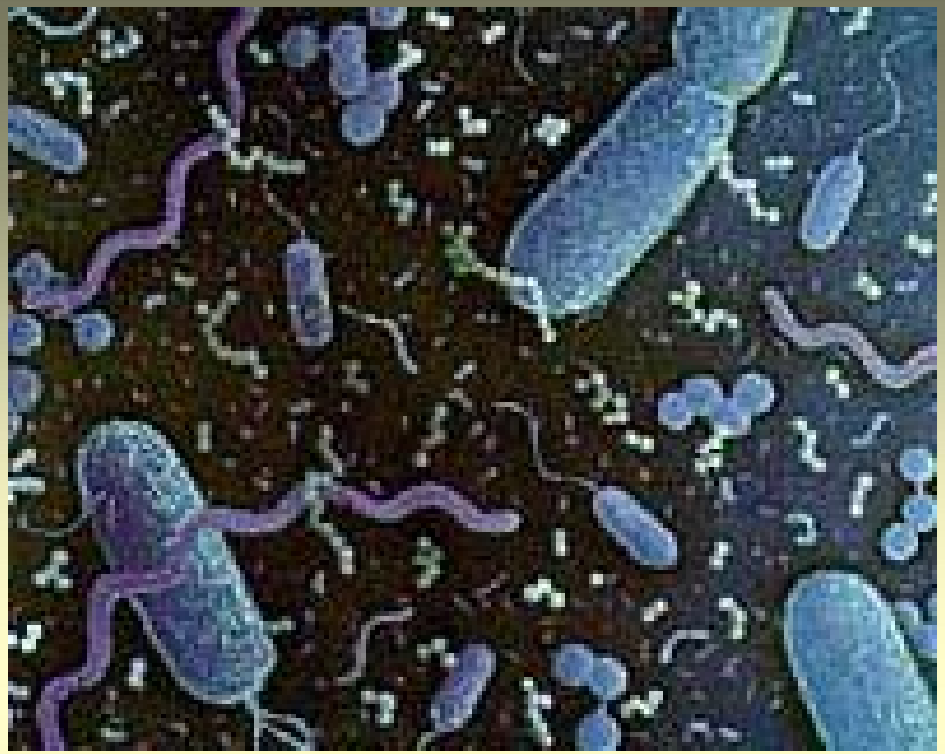
Microbiology: A Systems Approach

First Edition

Cowan & Talaro

Chapter

4



Prokaryotic Profiles: the Bacteria and the Archaea

Chapter 4

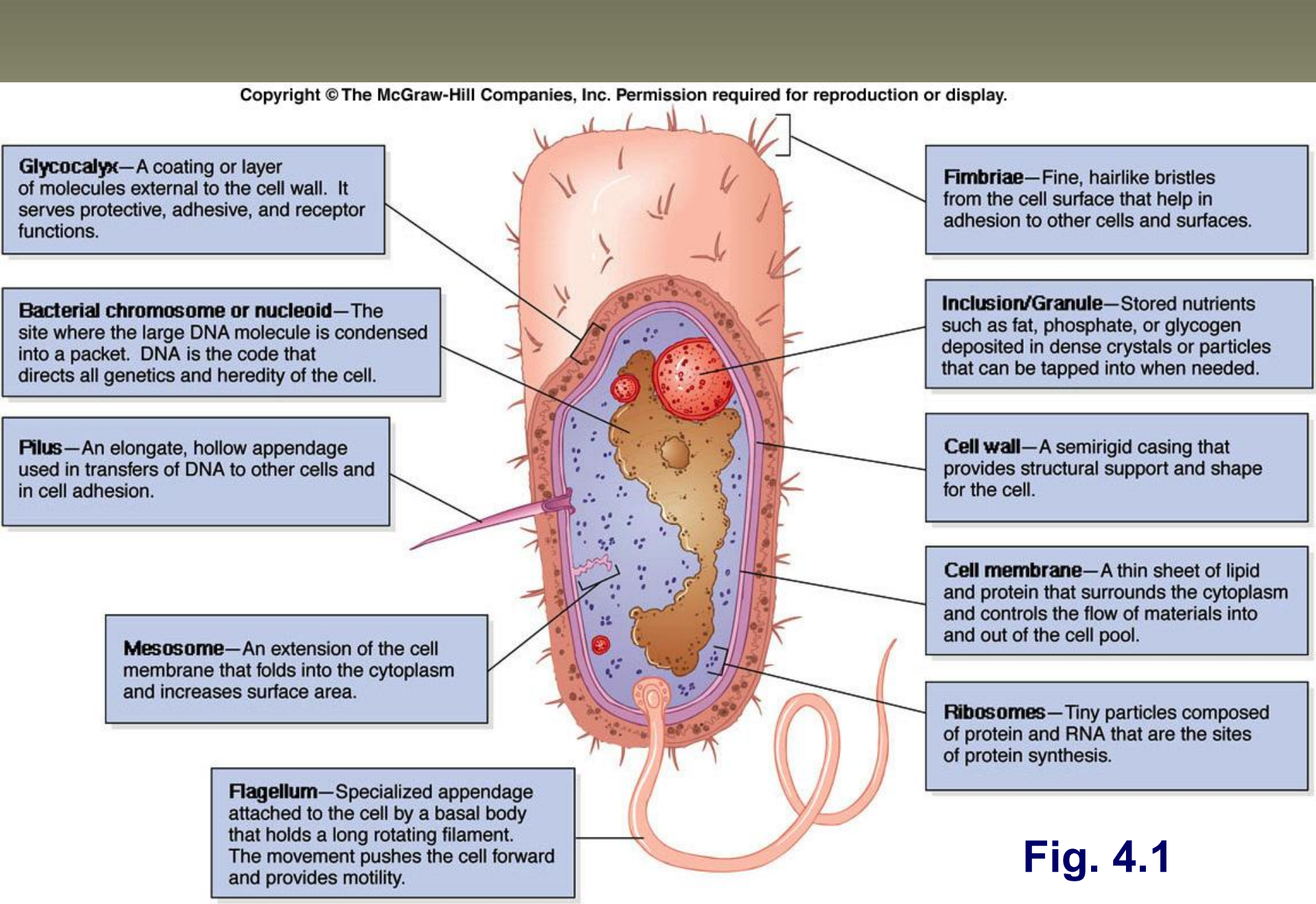


Fig. 4.1

flagella

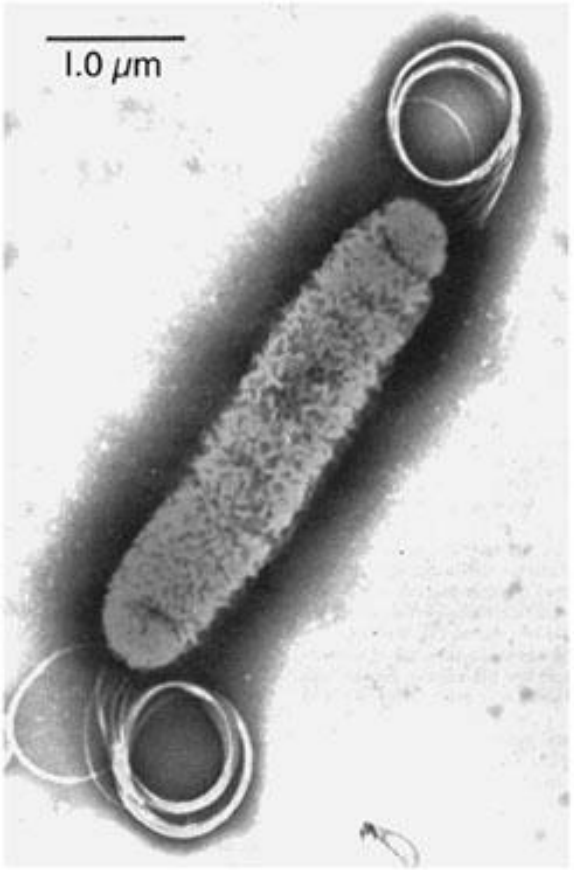
- 3 parts
  - filament – long, thin, helical structure composed of proteins
  - hook- curved sheath
  - basal body – stack of rings firmly anchored in cell wall
- rotates 360^{o}
- 1-2 or many distributed over entire cell
- functions in motility

Flagellar arrangements

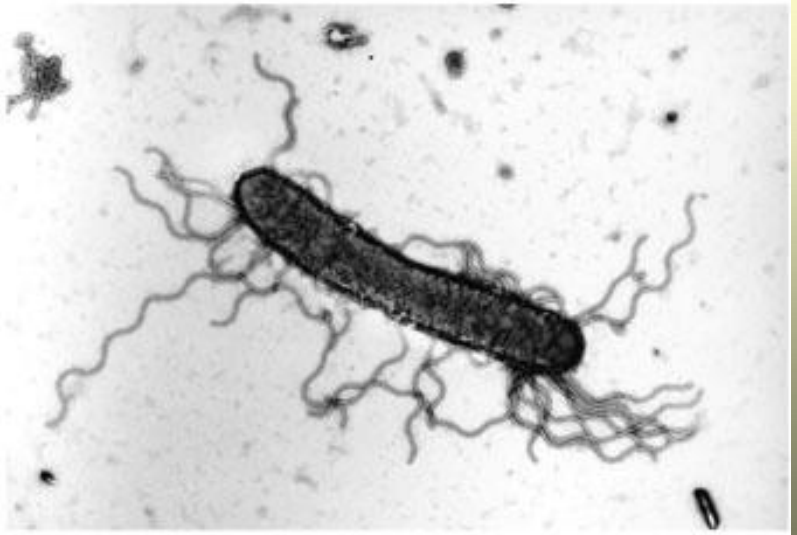
1. monotrichous – single flagellum at one end
2. lophotrichous – small bunches arising from one end of cell
3. amphitrichous – flagella at both ends of cell
4. peritrichous – flagella dispersed over surface of cell, slowest

(a)

(b)



(c)



(d)

axial filaments

- periplasmic, internal flagella, enclosed between cell wall and cell membrane of spirochetes
- motility

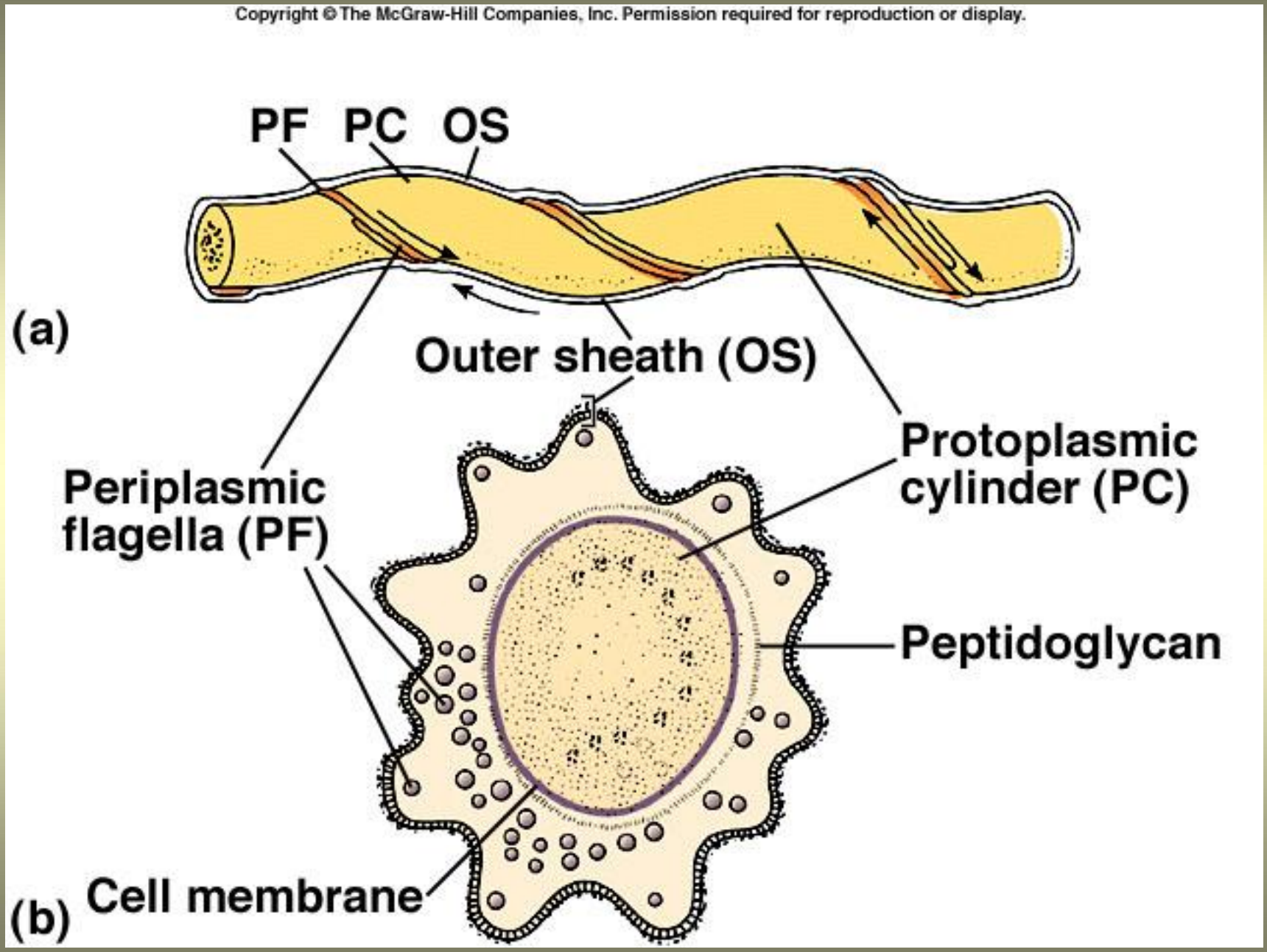
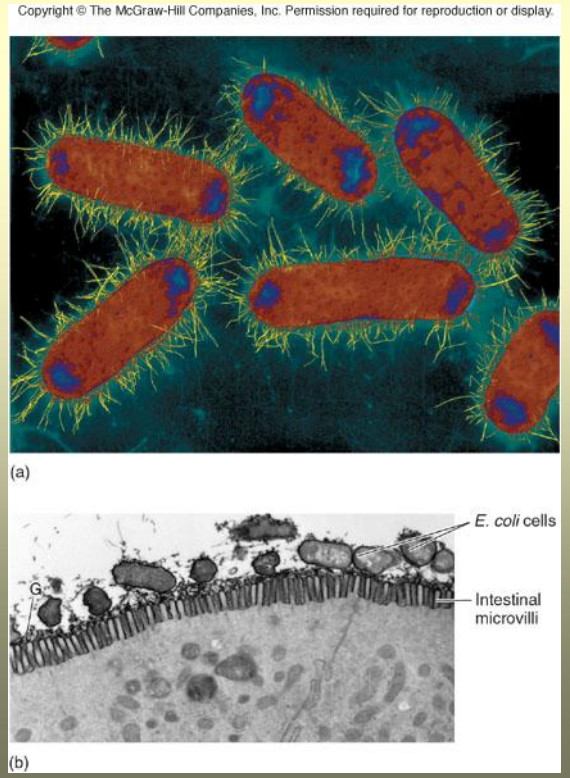


Fig 4.7a b

fimbrae

- fine hairlike bristles from the cell surface
- function in adhesion to other cells and surfaces

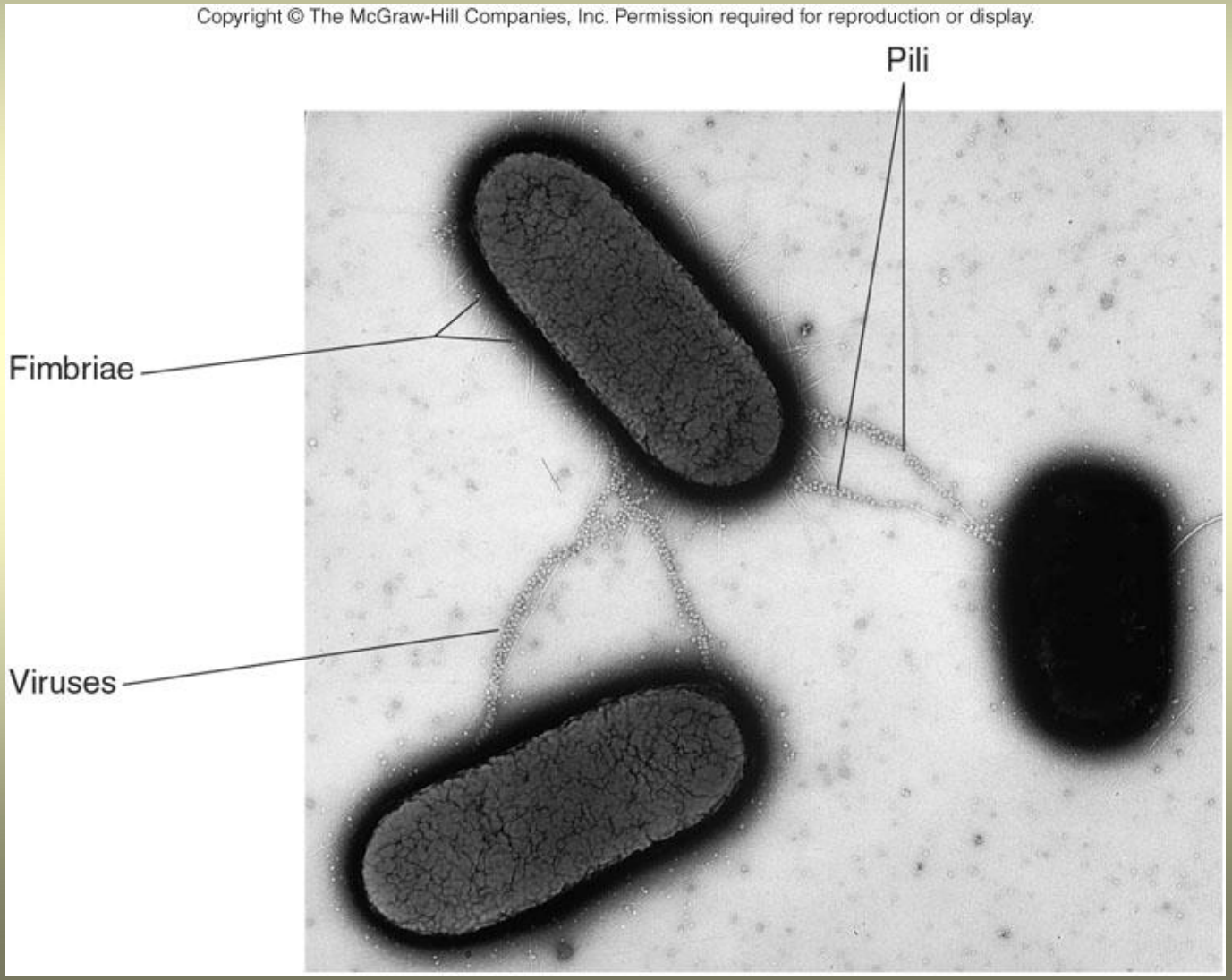


pili

- rigid tubular structure made of pilin protein
- found only in Gram negative cells

- Functions
  - joins bacterial cells for DNA transfer (conjugation)
  - adhesion

Conjugation



glycocalyx

- Coating of molecules external to the cell wall, made of sugars and/or proteins
- 2 types
  1. capsule - highly organized, tightly attached
  2. slime layer - loosely organized and attached
- functions
  - attachment
  - inhibits killing by white blood cells
  - receptor

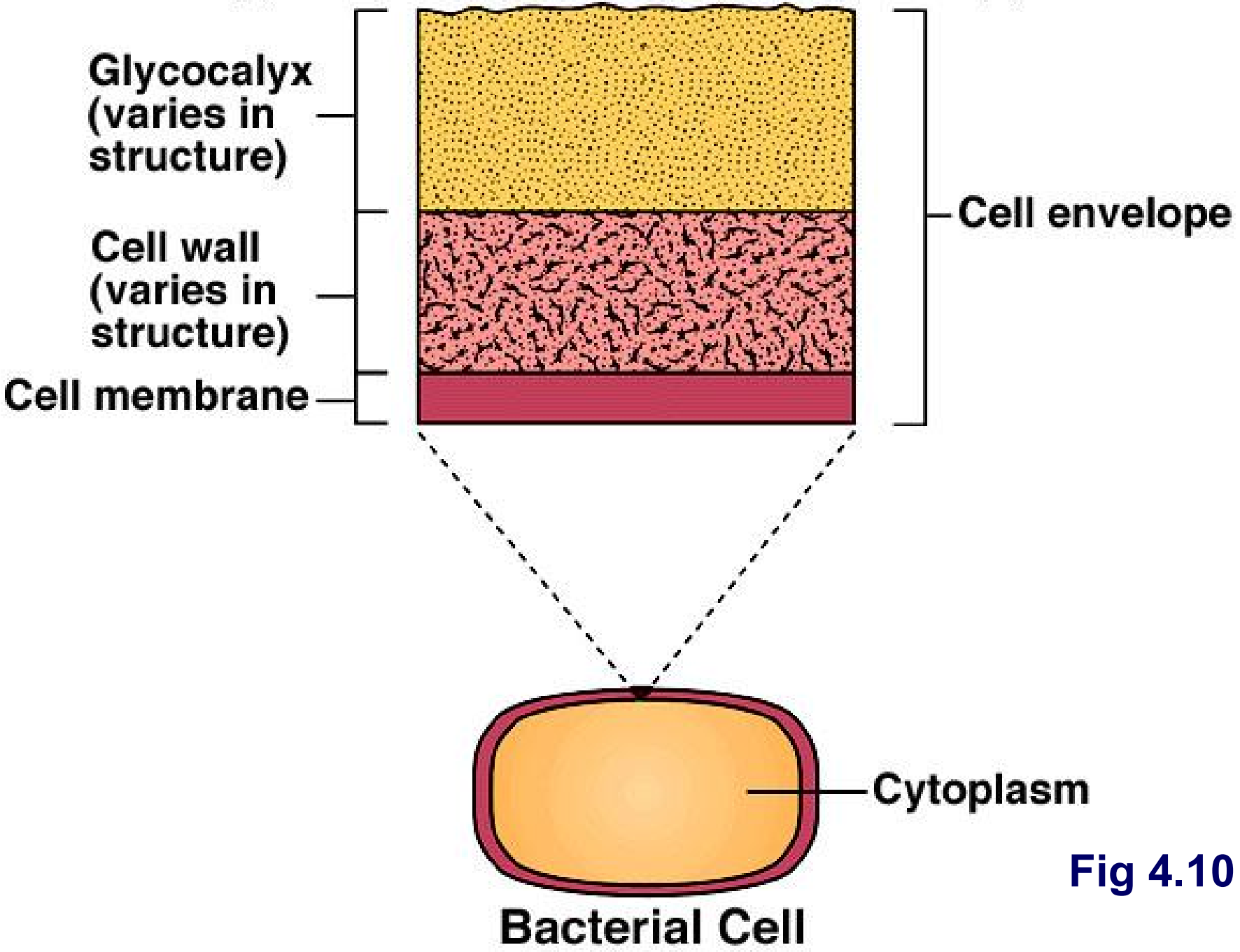
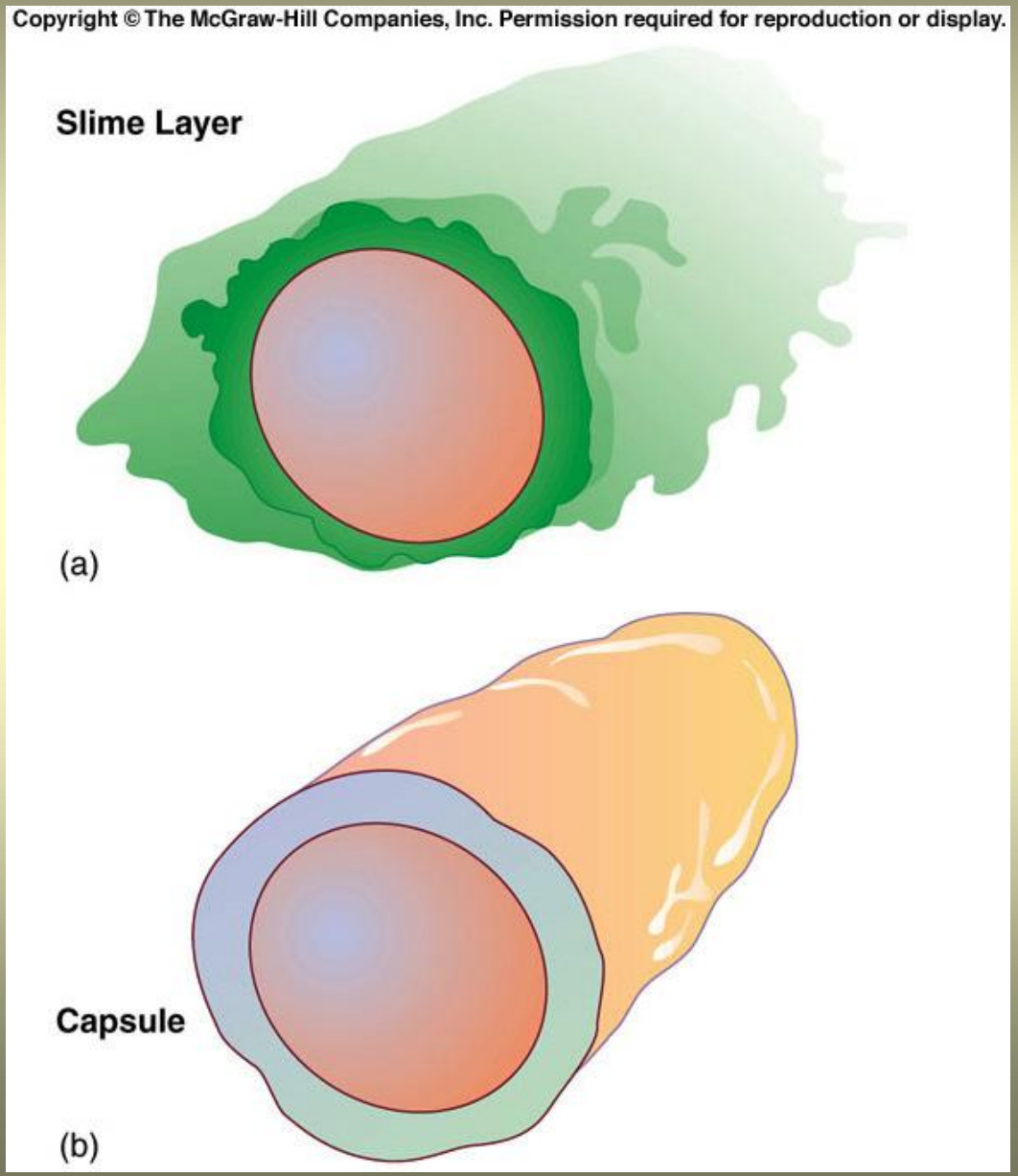
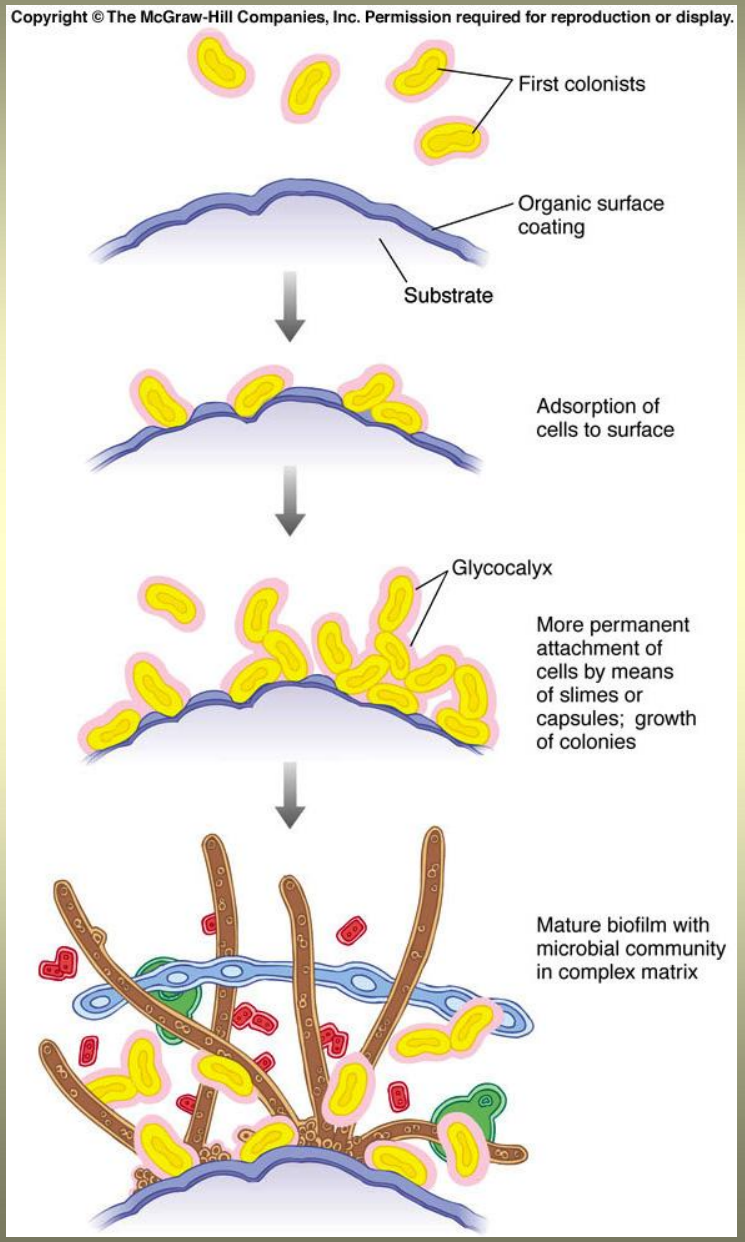


Fig 4.10

2 Types of Glycocalyx



Biofilms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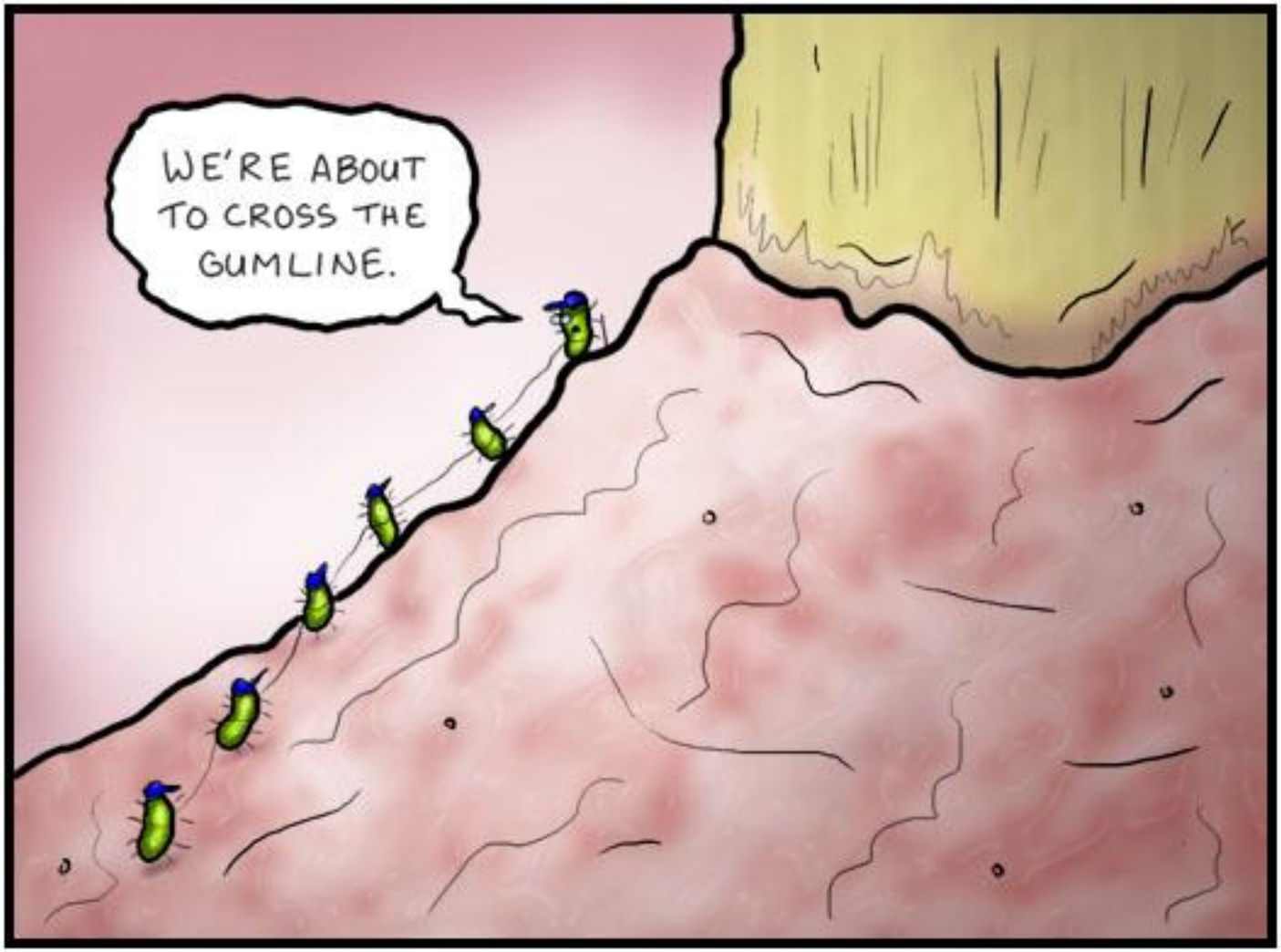
First colonists
Organic surface coating
Substrate
Adsorption of cells to surface
Glycocalyx
More permanent attachment of cells by means of slimes or capsules; growth of colonies
Mature biofilm with microbial community in complex matrix

DOCTOR FUN

7 Feb 2002



Dental caries adventure tours

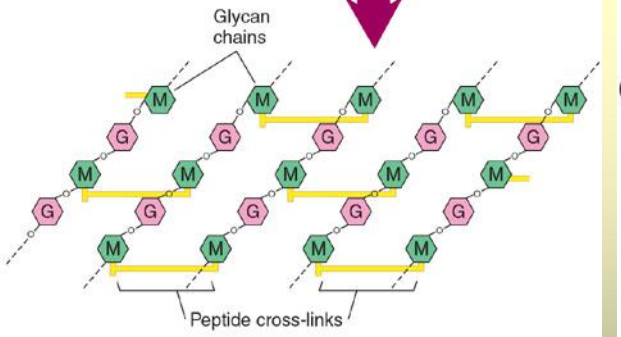
Peptidoglycan

- unique macromolecule composed of a repeating framework of long glycan chains cross-linked by short peptide fragments
- provides strong, flexible support to keep bacteria from bursting or collapsing because of changes in osmotic pressure

Peptidoglycan

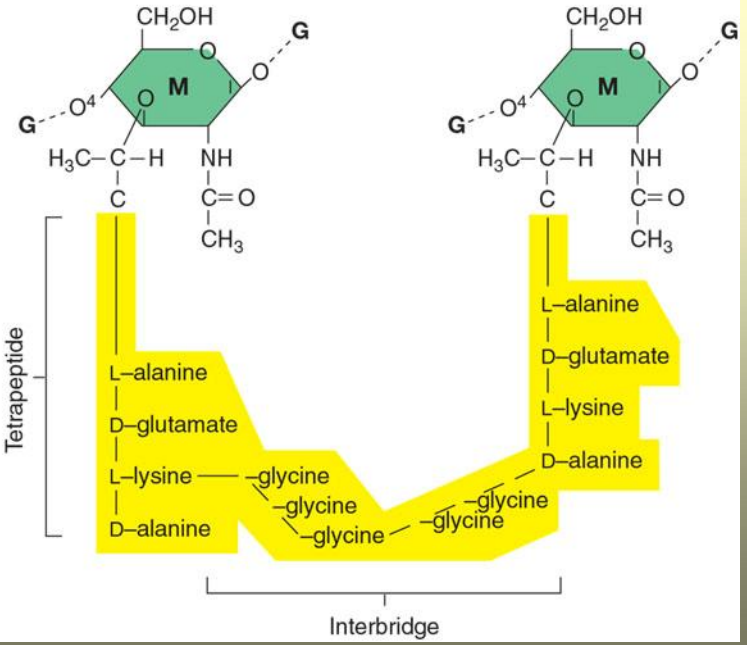
(a) The peptidoglycan of a cell wall can be presented as a crisscross network pattern similar to a chain-link fence, forming a single massive molecule that molds the outer structure of the cell into a tight box.

(b) An idealized view of the molecular pattern of peptidoglycan. It contains alternating glycans (G and M) bound together in long strands. The G stands for *N*-acetyl glucosamine, and the M stands for *N*-acetyl muramic acid. A muramic acid molecule binds to an adjoining muramic acid on a parallel chain by means of a cross-linkage of peptides.



[Cell Wall Video]

(c) A detailed view of the links between the muramic acids. Tetrapeptide chains branching off the muramic acids connect by interbridges also composed of amino acids. The types of amino acids in the interbridge can vary and it may be lacking entirely (gram-negative cells). It is this linkage that provides rigid yet flexible support to the cell and that may be targeted by drugs like penicillin.



4 groups based on cell wall composition

1. Gram positive cells
2. Gram negative cells
3. Bacteria without cell walls
4. Bacteria with chemically unique cell walls

Gram positive

Gram negative

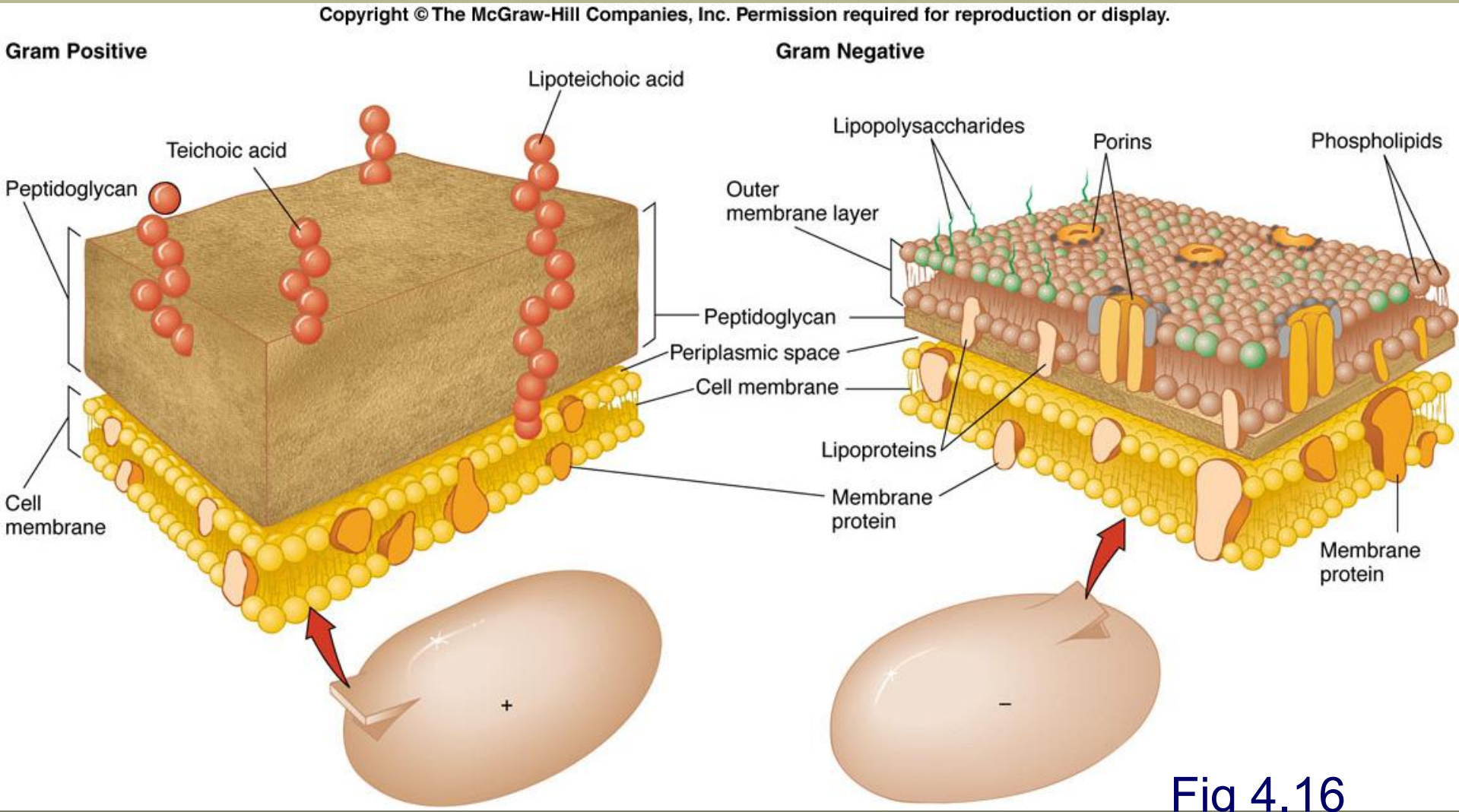
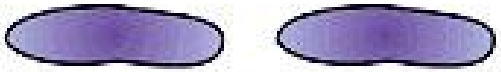
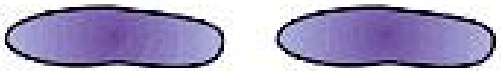
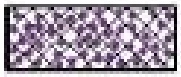
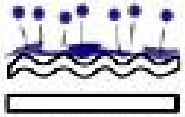


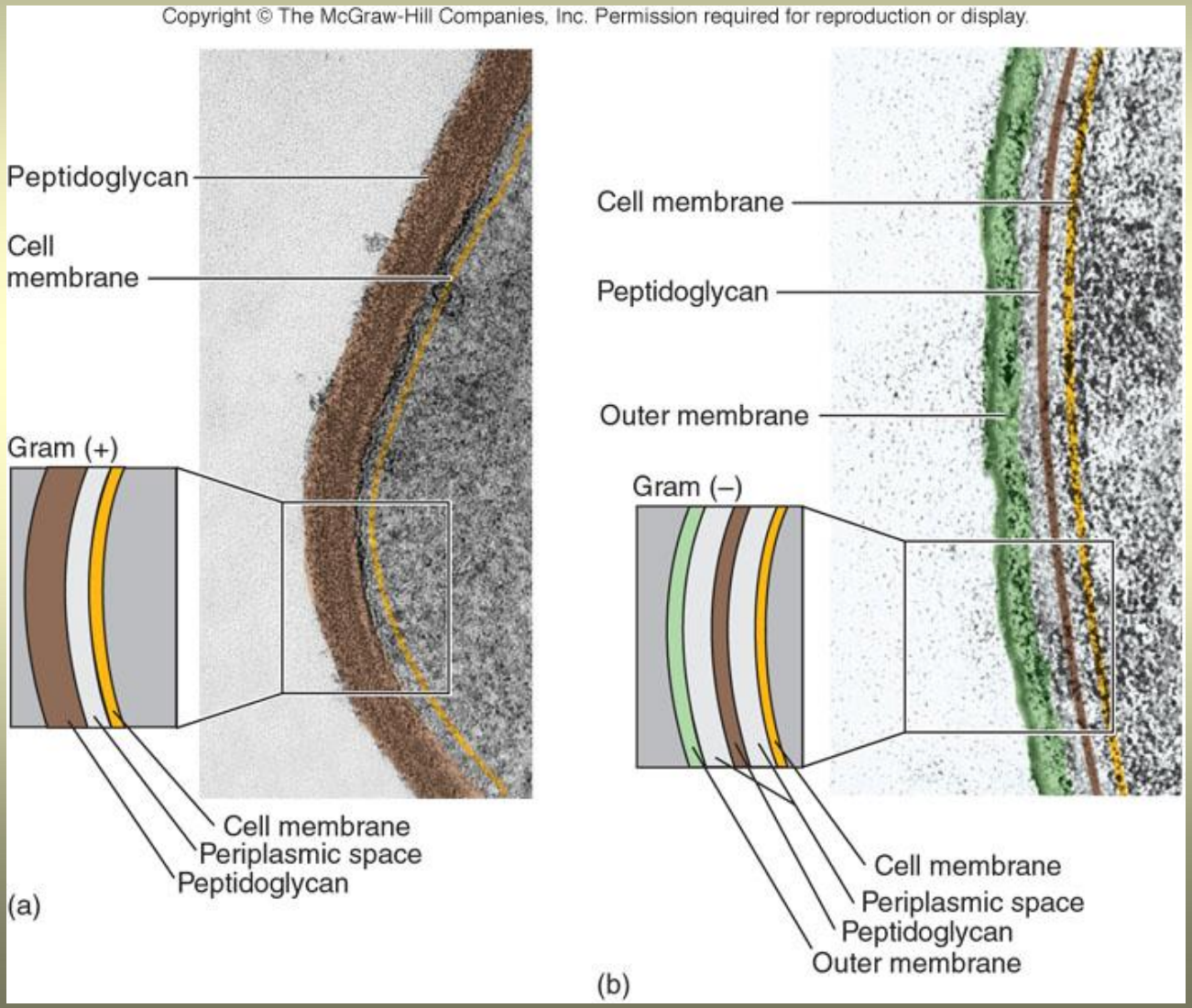
Fig 4.16

Step	Microscopic Appearance of Cell		Chemical Reaction in Cell Wall (very magnified view)	
	Gram (+)	Gram (–)	Gram (+)	Gram (–)
1. Crystal violet				
			Both cell walls affix the dye	
2. Gram's iodine				
			Dye crystals trapped in wall	No effect of iodine
3. Alcohol				
			Crystals remain in cell wall	Cell wall partially dissolved, loses dye
4. Safranin (red dye)				
			Red dye has no effect	Red dye stains the colorless cell

Gram positive cell wall

- Consists of
  - a thick, homogenous sheath of peptidoglycan 20-80 nm thick
  - tightly bound acidic polysaccharides, including teichoic acid and lipoteichoic acid
  - cell membrane
- Retain crystal violet and stain purple

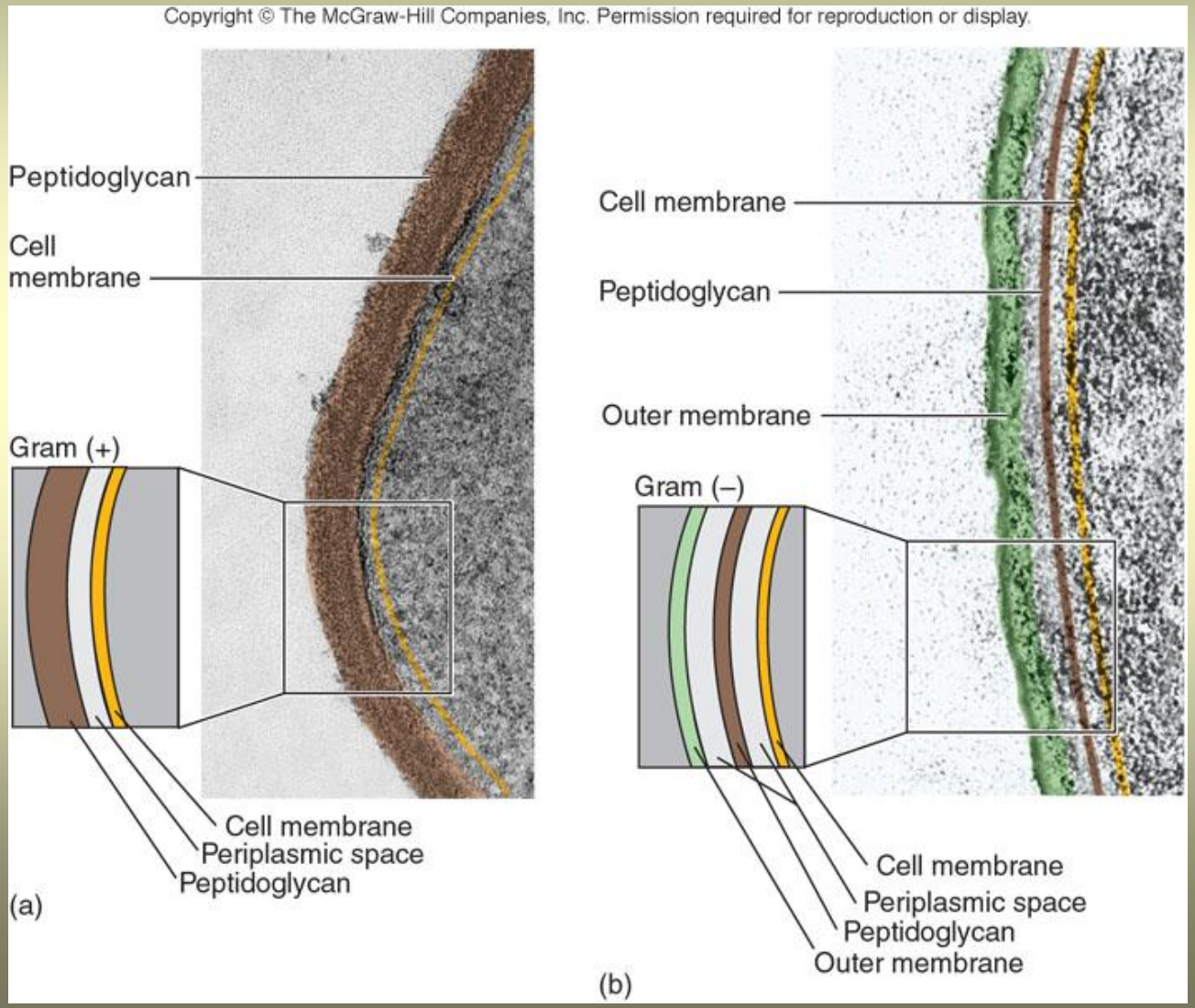
Gram positive wall



Gram negative cell wall

- Consists of
  - an outer membrane containing lipopolysaccharide (LPS)
  - thin shell of peptidoglycan
  - periplasmic space
  - inner membrane
- Lose crystal violet and stain red from safranin counterstain

Gram negative cell wall



Cytoplasm

- dense gelatinous solution of sugars, amino acids, & salts
- 70-80% water
- serves as solvent for materials used in all cell functions

Cytoplasmic Membrane Video

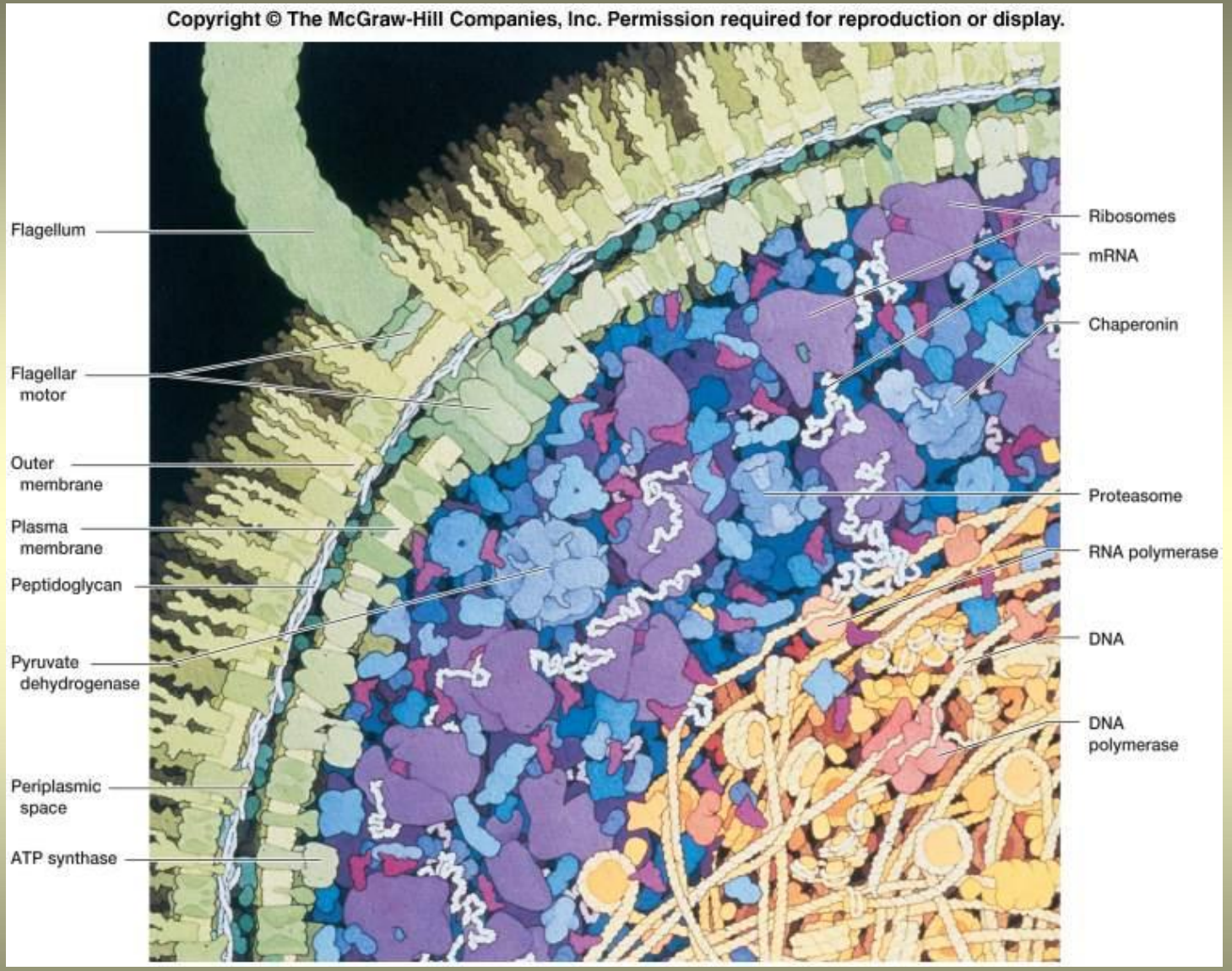


Figure 3.10

Chromosome

- single, circular, double-stranded DNA molecule that contains all the genetic information required by a cell
- DNA is tightly coiled around a protein, aggregated in a dense area called the **nucleoid**

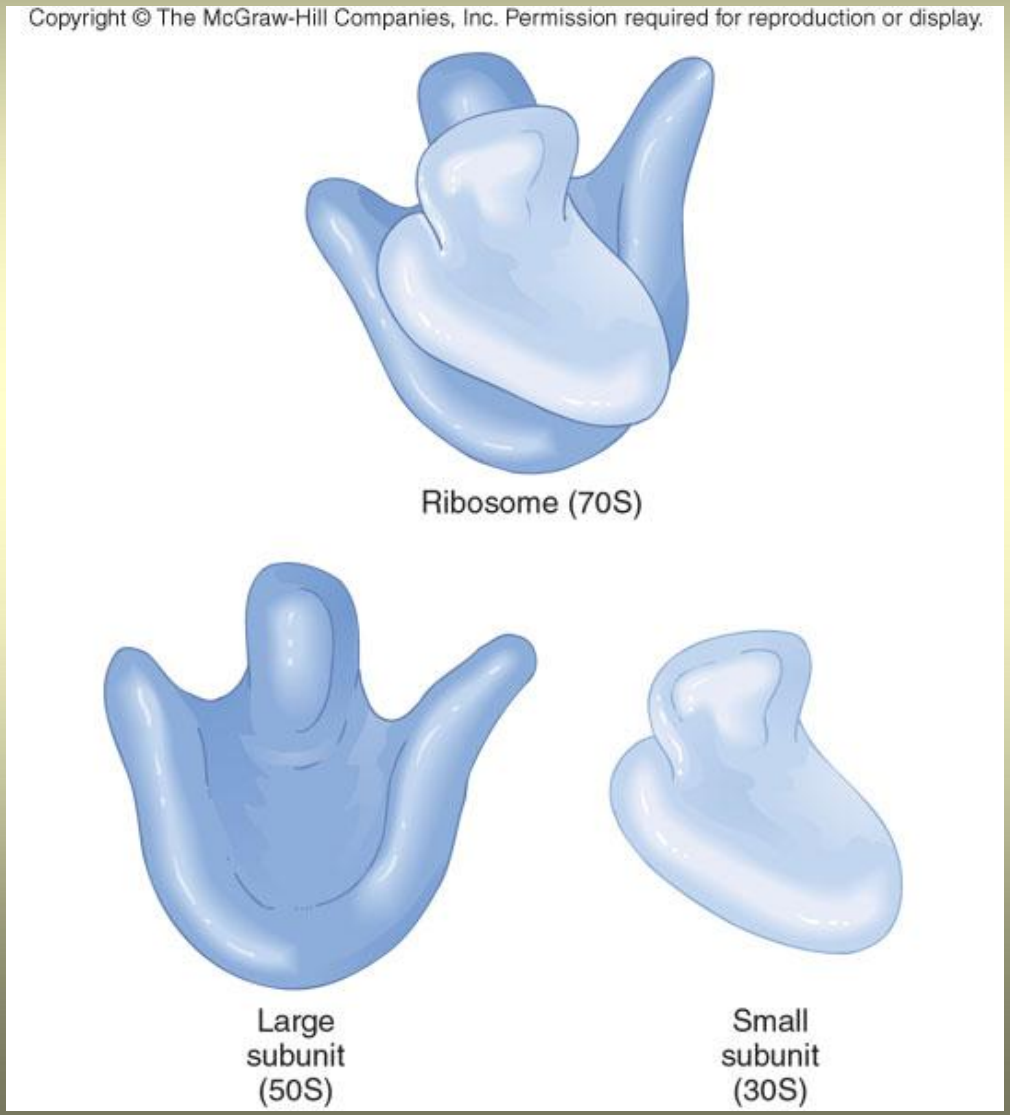
plasmids

- small circular, double-stranded DNA
- free or integrated into the chromosome
- duplicated and passed on to offspring
- not essential to bacterial growth & metabolism
- may encode antibiotic resistance, tolerance to toxic metals, enzymes & toxins
- used in genetic engineering- readily manipulated & transferred from cell to cell

ribosomes

- made of 60% ribosomal RNA & 40% protein
- consist of 2 subunits: large & small
- procaryotic differ from eucaryotic ribosomes in size & number of proteins
- site of protein synthesis
- All cells have ribosomes.

ribosomes



Inclusions, granules

- intracellular storage bodies
- vary in size, number & content
- bacterial cell can use them when environmental sources are depleted
- Examples: glycogen, poly-β-hydroxybutyrate, gas vesicles for floating, sulfur and polyphosphate granules

Inclusions

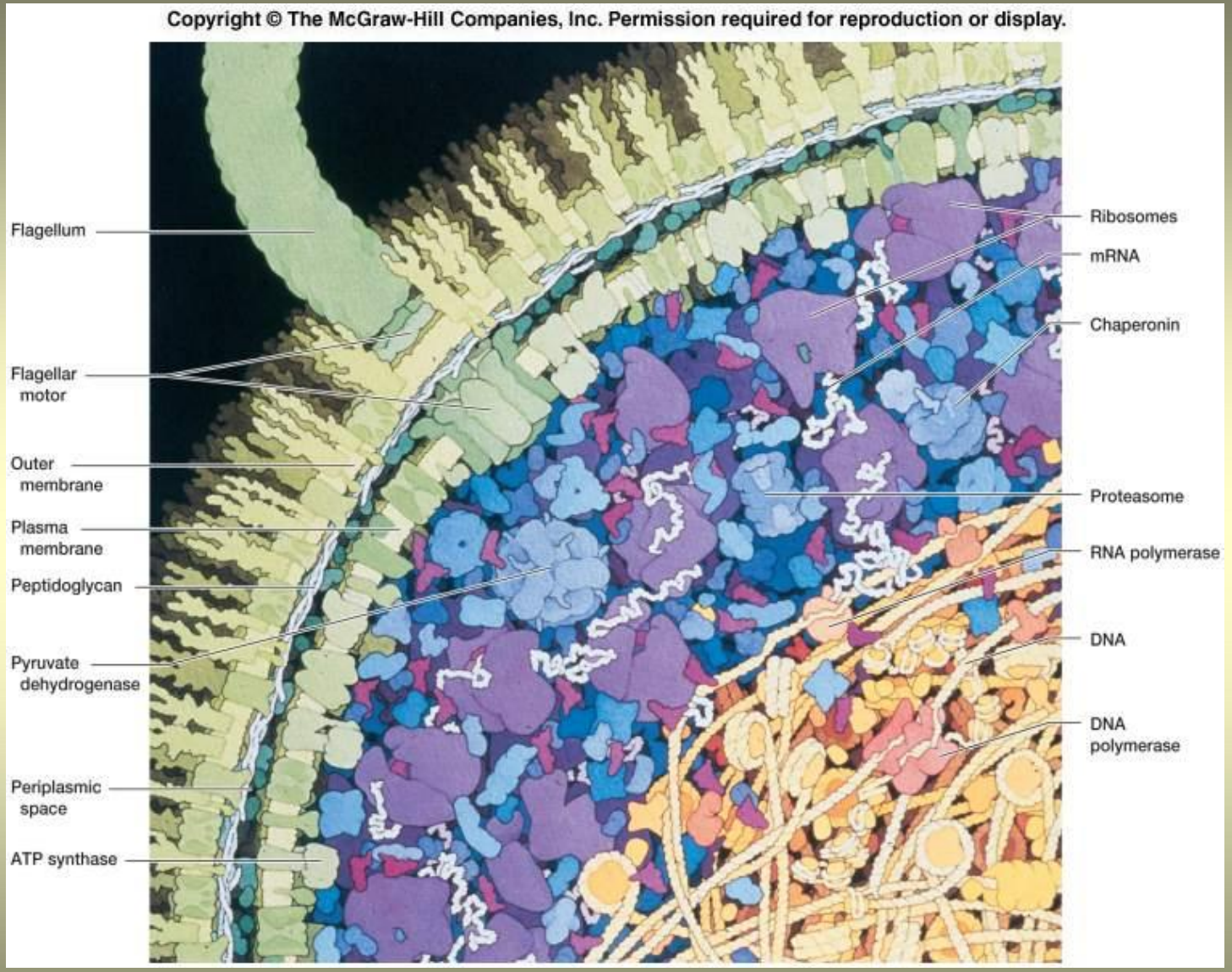


Figure 3.10

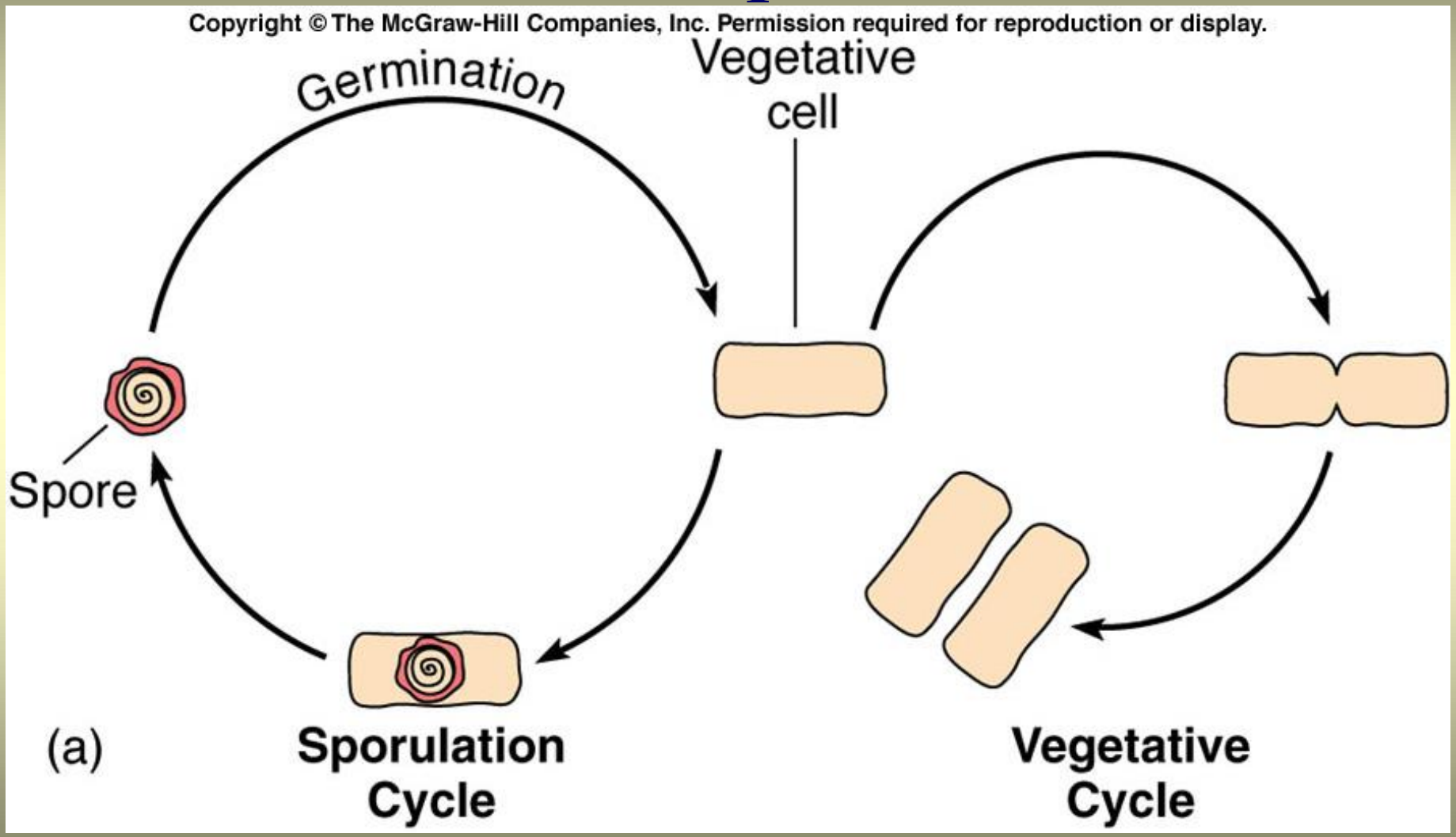
endospores

- Resting, dormant cells
- produced by some G+ genera: *Clostridium*, *Bacillus & Sporosarcina*
- Have a 2-phase life cycle – vegetative cell & an endospore
- **sporulation** -formation of endospores
- **germination**- return to vegetative growth
- hardiest of all life forms
- withstand extremes in heat, drying, freezing, radiation & chemicals not a means of reproduction

endospores

- resistance linked to high levels of calcium & dipicolinic acid
- dehydrated, metabolically inactive
- thick coat
- longevity verges on immortality 25, 250 million years.
- pressurized steam at 120ºC for 20-30 minutes will destroy.

endospores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Germination
Vegetative cell
Spore
(a)
Sporulation Cycle
Vegetative Cycle

Endospore Formation

Endospore
Video Clip

3 shapes of bacteria

- cocci - spherical
- bacilli - rod
- spiral - helical, comma, twisted rod, spirochete

Coccus

Rod, or bacillus

Curved forms: Spirillum/Spirochete

Diplococci
(cocci in pairs)

Neisseriae
(coffee-bean shape
in pairs)

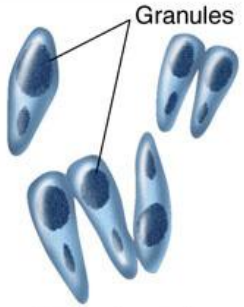
Coccobacilli

Vibrios
(curved rods)

Tetrads
(cocci in packets of 4)

Sarcinae
(cocci in packets of
8,16, 32 cells)

Mycobacteria



Corynebacteria
(palisades arrangement)

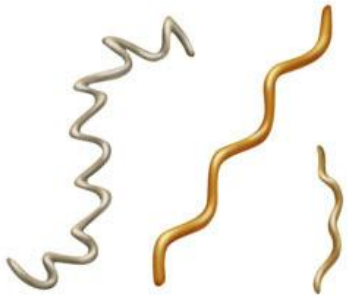
Spirilla

Streptococci
(cocci in chains)

Micrococci and staphylo-
cocci (large cocci in
irregular clusters)

Spore-forming rods

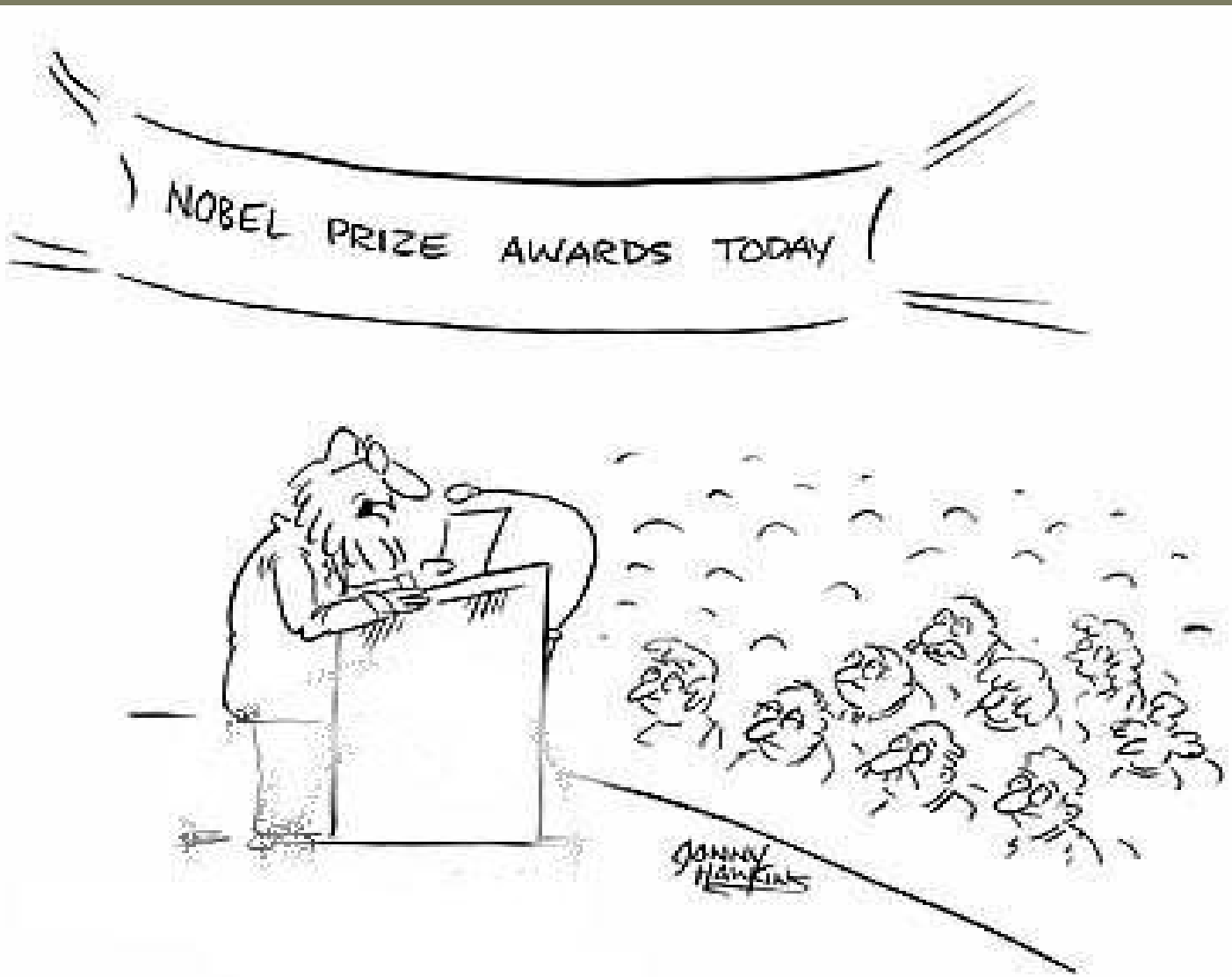
Streptomycetes
(moldlike, filamentous
bacteria)



Spirochetes

Archaea: the other procaryotes

- constitute third Domain Archaea
- seem more closely related to Domain Eukarya than to bacteria
- contain unique genetic sequences in their rRNA
- have unique membrane lipids & cell wall construction
- live in the most extreme habitats in nature, extremophiles
- adapted to heat salt acid pH, pressure & atmosphere
- includes: methane producers, hyperthermophiles, extreme halophiles, and sulfur reducers



"First of all, I'd like to thank the bacteria..."