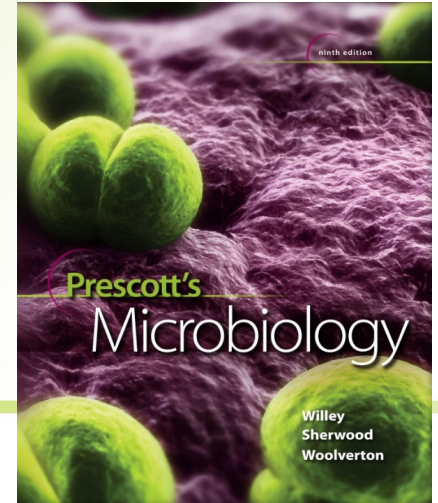


4



Archaeal Cell Structure

Archaea

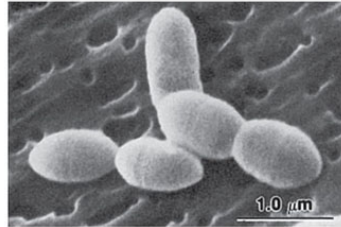
- Many features in common with Eukarya
 - ✓ genes encoding protein: replication, transcription, translation
- Features in common with Bacteria
 - ✓ genes for metabolism
- Other elements are unique to *Archaea*
 - unique rRNA gene structure
 - capable of methanogenesis → the production of methane.
✓

Archaea

- Highly diverse with respect to morphology, physiology, reproduction, and ecology.
- Best known for growth in anaerobic, hypersaline, pH extremes, and high-temperature habitats
- Also found in marine arctic temperature and tropical waters

Archaeal size, shape, arrangement

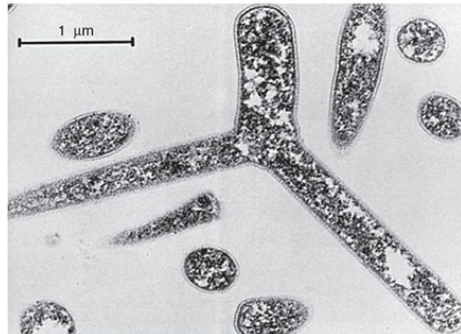
- Much like bacteria, cocci and rods are common shapes
- Other shapes can also exist
 - no spirochetes or mycelial forms yet
 - branched/flat shapes
- Sizes vary (typically **1-2 x 1-5 μm** for rods, 1-5 μm in diameter for cocci)
- Smallest observed is 0.2 μm in diameter
- Largest is a multicellular form that can reach **30 mm in length!** ✓



(a) *Methanobrevibacter smithii*—oval-to-short rod-shaped cells



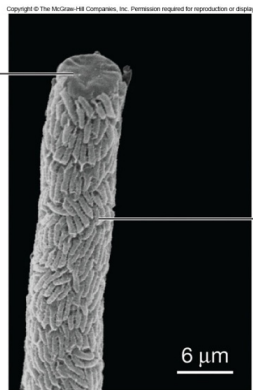
(b) *Methanosarcina mazei*—a coccus that forms clusters



(c) *Thermoproteus tenax*—a branched archaeal cell



(d) *Haloquadratum walsbyi*—a square archaeon



Filamentous archaeon

Bacterial biofilm

a: © Friederich Widdell/Visuals Unlimited; b,c: From J.T. Staley, M.P. Bryant, N. Pfennig and J.G. Holt (Eds), *Bergey's Manual of Systematic Bacteriology*, Vol. 3. © 1989 Williams and Wilkins Co., Baltimore; d: From Walther Stoeckenius: Walsby's Square Bacterium Fine Structures of an Orthogonal Prokaryote

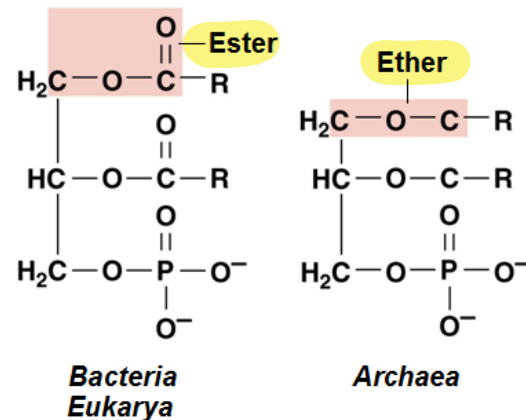
Table 4.1 Comparison of Bacterial and Archaeal Cells

Property	Bacteria	Archaea
Plasma membrane lipids	Ester-linked phospholipids and hopanoids form a lipid bilayer; some have sterols	<u>Glycerol diethers form lipid bilayers; glycerol tetraethers form lipid monolayers</u>
Cell wall constituents	Peptidoglycan is present in nearly all; some lack cell walls ✓	Very diverse but peptidoglycan is always absent: some consist of S-layer only, others combine S-layer with polysaccharides or proteins or both; some lack cell walls ✓
Inclusions present	Yes, including gas vacuoles	Yes, including gas vacuoles
Ribosome size	70S	70S
Chromosome structure	Most are circular, double-stranded (ds) DNA; usually a single chromosome	All known are circular, dsDNA
Plasmids present	Yes; circular and linear dsDNA	Yes; circular dsDNA
External structures	Flagella, fimbriae (pili) common	Flagella, pili, and piluslike structures common
Capsules or slime layers	Common	Rare

Archaeal Cell Envelopes

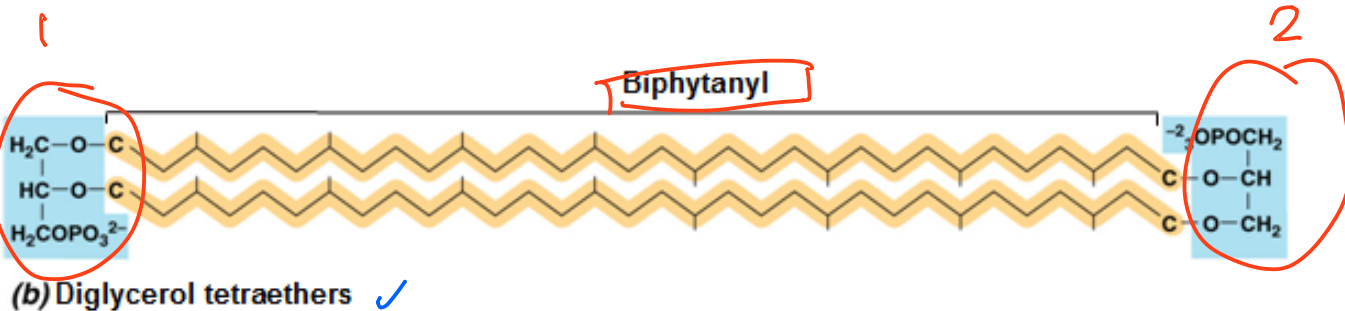
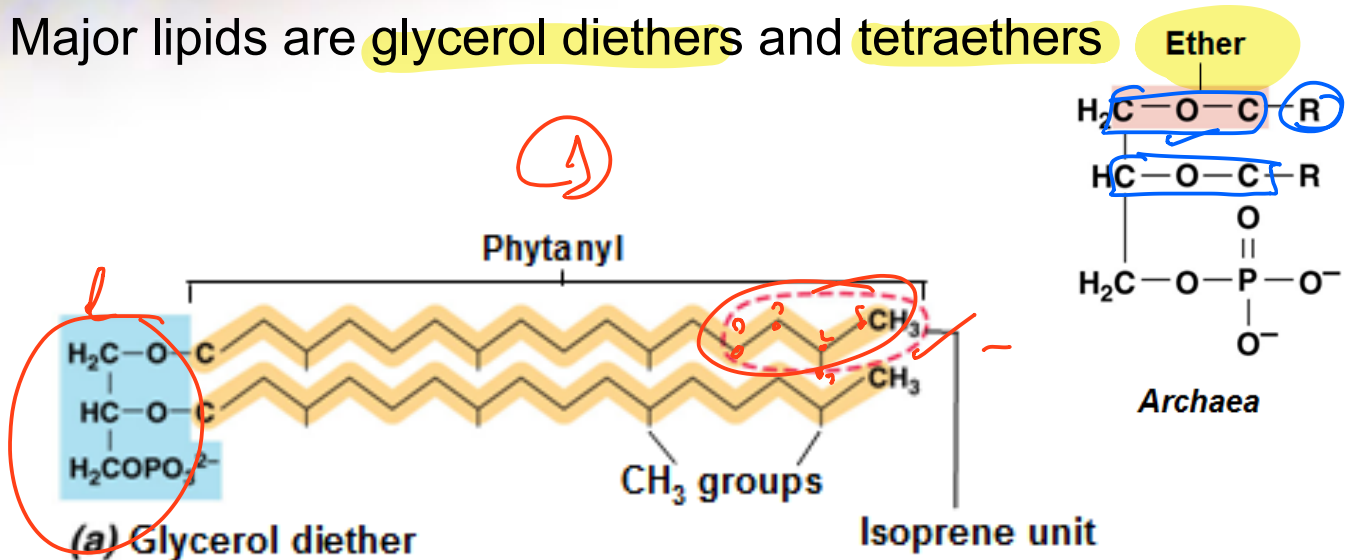
- Differ from bacterial envelopes in the molecular makeup and organization
 - **S layer** may be only component outside plasma membrane
 - some lack cell wall
 - capsules and slime layers are rare

instead of cell wall.



Diether and tetraether

Major lipids are glycerol diethers and tetraethers



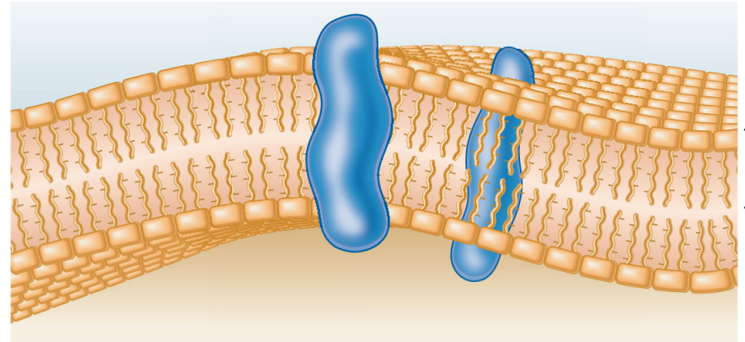
Archaeal Membranes

Composed of unique
lipids ✓

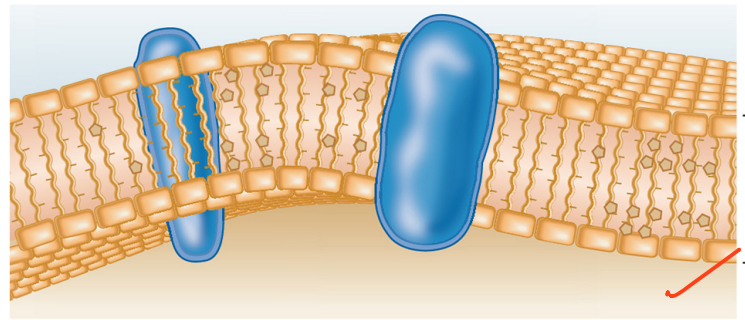
- isoprene units (five carbon, branched) ✓
- ether linkages rather than ester linkages to glycerol

Some have a monolayer structure ~~instead of~~ a bilayer structure

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(a) Bilayer of C₂₀ diethers



(b) Monolayer of C₄₀ tetraethers

Archaeal Membrane Lipids

- Differ from *Bacteria* and *Eukarya* in having branched chain hydrocarbons attached to glycerol by ether linkages
- Polar phospholipids, sulfolipids, glycolipids, and unique lipids are also found in archaeal membranes ✓.

Archaeal Lipids and Membranes

Bacteria/Eukaryotes

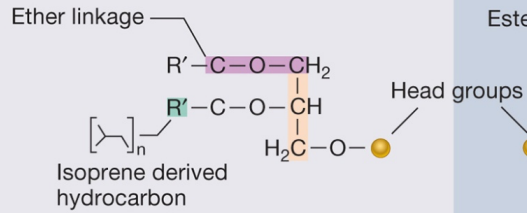
- Fatty acids attached to glycerol by ester linkages

Archaea

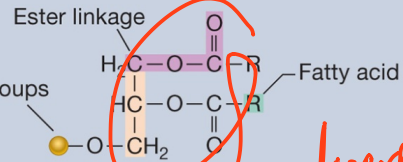
- branched chain hydrocarbons attached to glycerol by ether linkages
- some have diglycerol tetraethers

Glycerol diether ✓

Archaeal membranes

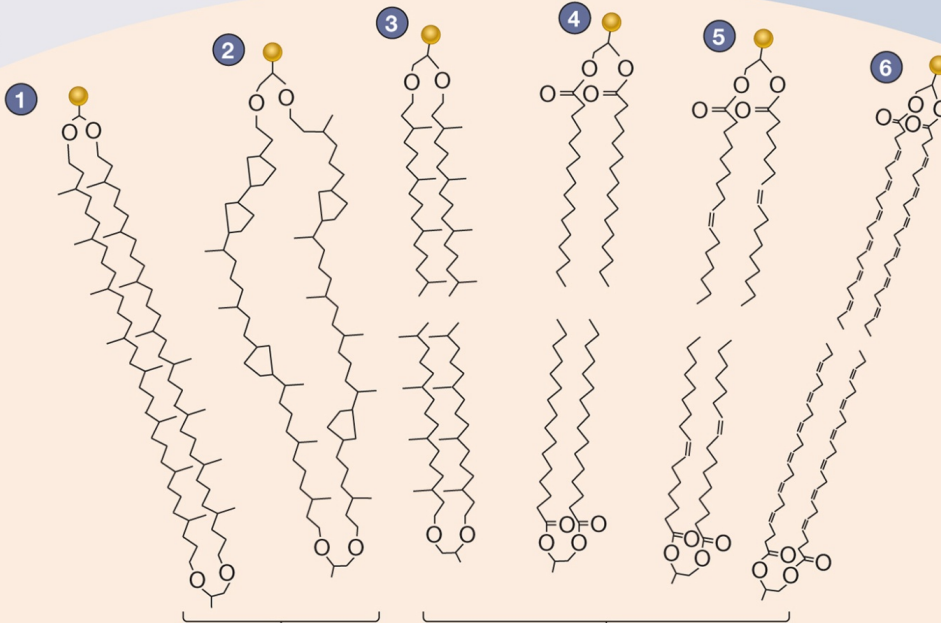


Bacterial membranes



glycerol

(a)



(b)

Monolayers

Bilayers

Archaeal Cell Surfaces

- **Cell envelopes**

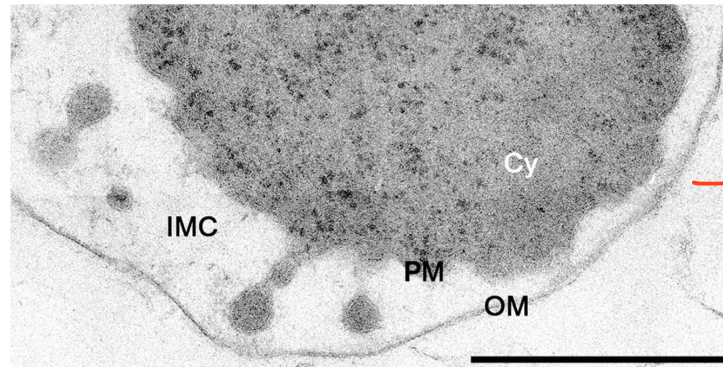
- varied S layers attached to plasma membrane

looks like peptidoglycan
But not peptidoglycan
glycan

- pseudomurein (peptidoglycan-like polymer)

- complex polysaccharides, proteins, or glycoproteins found in some other species

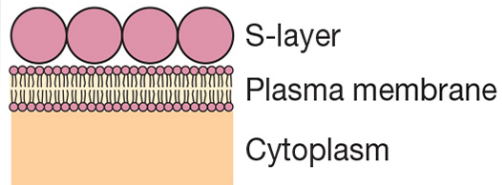
- only *Ignicoccus* has outer membrane



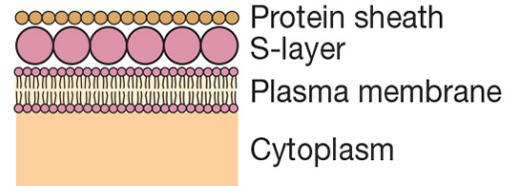
→ *Ignicoccus*

Archaeal Cell Walls Differ from Bacterial Cell Walls

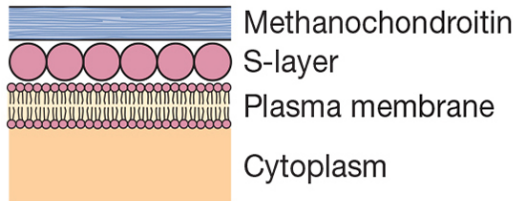
- Lack peptidoglycan
- Most common cell wall is S layer
- May have protein sheath external to S layer
- S layer may be outside membrane and separated by pseudomurein
- ✓ Pseudomurein may be outermost layer – similar to Gram-positive microorganisms



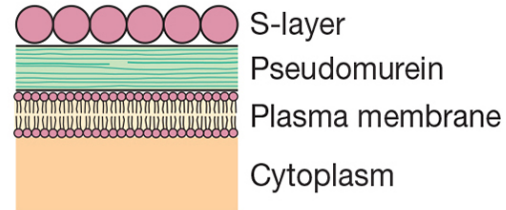
(a)



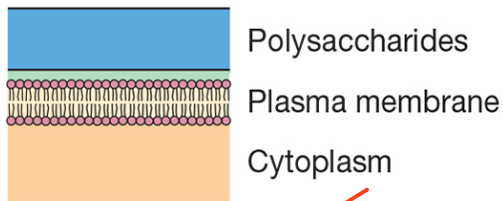
(b)



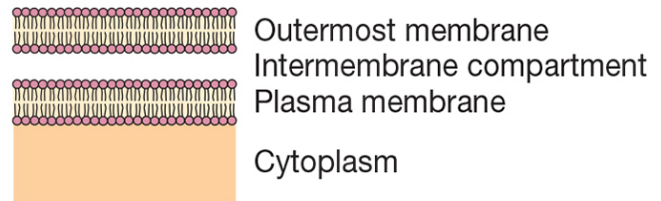
(c)



(d)

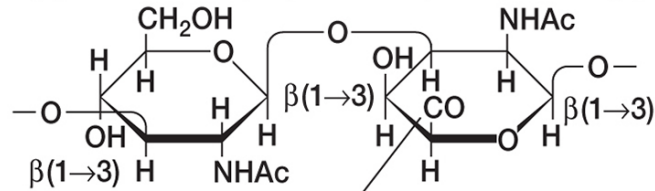


(e)



(f)

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Glu — (NH₂)

Ala

Lys — Glu

(Glu)

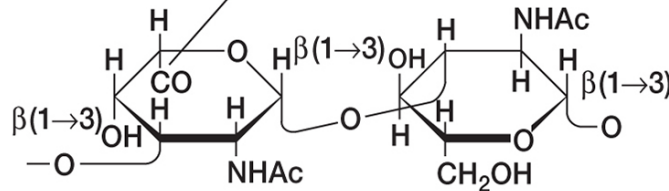
Lys

(Ala)

Ala

Glu — (NH₂)

X Pseudomonas



N-acetylglucosamine

N-acetylglucosamine

NAS

Archaeal vs. bacterial cytoplasm

- ✓ Very similar – **lack of membrane-enclosed organelles**
- May contain inclusion bodies (e.g. **gas vesicles for buoyancy control**)
→ floating on aquatic environments
- All the usual components
 - **ribosomes** ✓
 - **nucleoid region** ✓
 - **inclusion bodies** ✓
- Some structures may be different, however...

Ribosomes

- Complex structures, sites of protein synthesis
 - consisting of protein/RNA
- Entire ribosome
 - bacterial/archaeal ribosome = 70S
 - eukaryotic (80S) S = Svedburg unit
- Bacterial and archaeal ribosomal RNA
 - 16S small subunit
 - 23S and 5S in large subunit
 - archaea have additional 5.8S (also seen in eukaryotic large subunit)
- Proteins vary
 - archaea more similar to eukarya than to bacteria

The Nucleoid

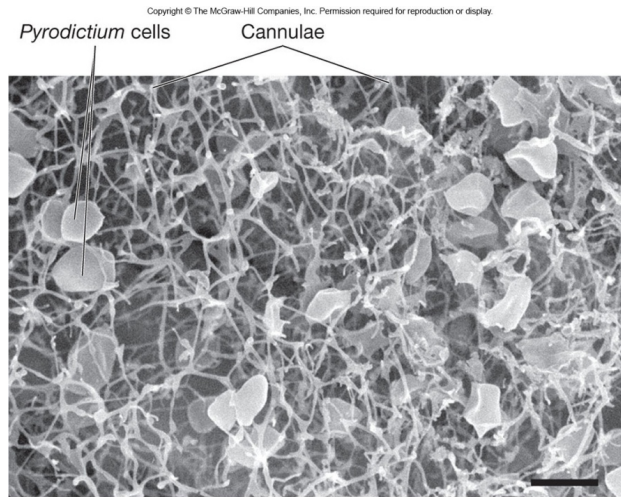
- Irregularly shaped region in bacteria and archaea
- ✓ Usually not membrane bound (few exceptions)
- ✓ Location of chromosome and associated proteins
- **Usually 1** (some evidence for polyploidy in some archaeons)
- Supercoiling and nucleoid proteins (**histones, Alba, condensins**) aid in folding

Archaeal external structures:

- **Pili**
 - not well understood as of yet
 - **some composed of pilin protein and homologous to bacterial type IV pili proteins** ^{4.}
 - pili formed have a central lumen **similar to bacterial flagella, but not bacterial pili**
 - may be **involved in archaeal adhesion mechanisms**

Archaeal external structures:

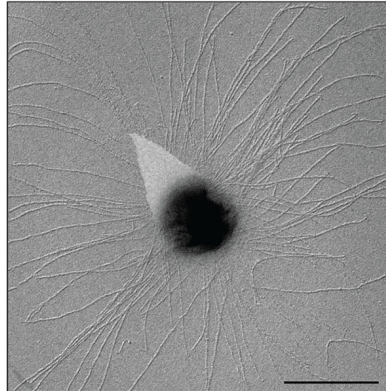
- Cannulae
 - hollow, tubelike structures on the surface of thermophilic archaee in the genus *Pyrodictium*
 - function is unknown
 - may be involved in formation of networks of multiple daughter cells



Archaeal external structures:

- **Hami**
 - not well understood
 - ‘grappling hook’ appearance
 - involvement in **cell adhesion** mechanisms?

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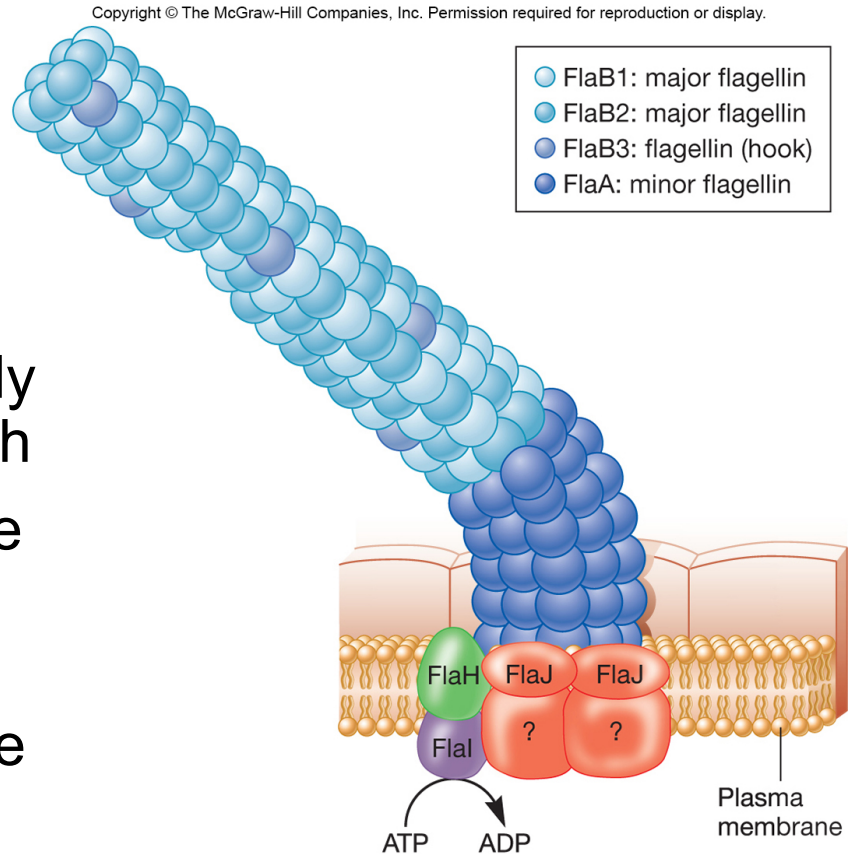
(a) Hami radiating from cell



(b) “Grappling hooks” at distal ends of hami

Differences of Archaeal Flagella

- Flagella thinner
- More than one type of flagellin protein
- Flagellum are not hollow
- Hook and basal body difficult to distinguish
- More related to Type IV secretions systems
- Growth occurs at the base, not the end



4.5 Comparison of *Bacteria* and *Archaea*

1. Compare and contrast bacterial and archaeal cells in terms of the structures observed and their chemical makeup.

Table 4.1 **Comparison of Bacterial and Archaeal Cells**

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