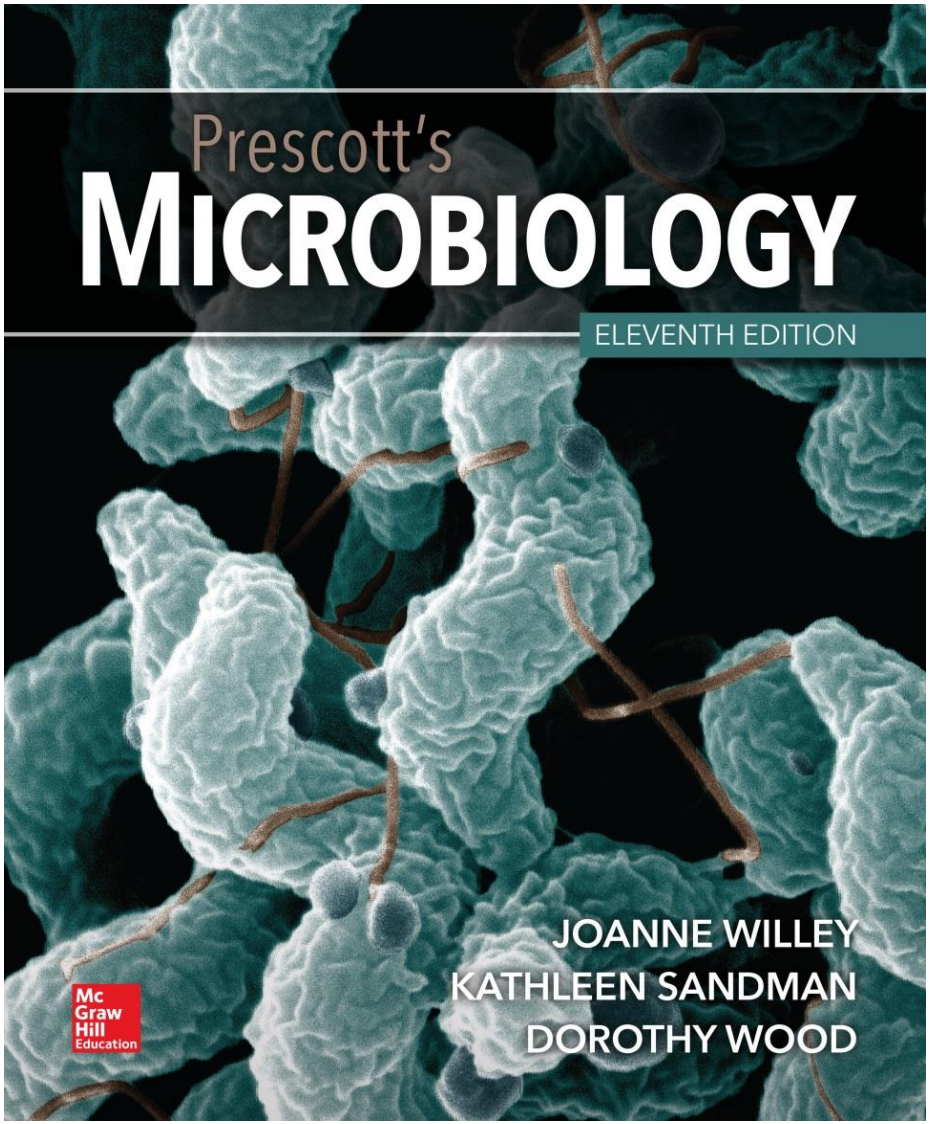


Prescott's MICROBIOLOGY

ELEVENTH EDITION

JOANNE WILLEY
KATHLEEN SANDMAN
DOROTHY WOOD

Chapter 4

Archaeal Cell Structure

Archaea

Features in common with *Bacteria*:

- **Genes for metabolism.**

Other elements are unique to *Archaea.*

- **Unique rRNA gene structure.** (36) Difference between Bacteria and Archaea - YouTube
- **Capable of methanogenesis**.

Highly diverse with respect to morphology, physiology, reproduction, and ecology.

Best known for growth in anaerobic, hypersaline, pH extremes, and high-temperature habitats.

(36) Methanogenesis - YouTube

Comparison of Bacterial and Archaeal Cells

Property	Bacteria	Archaea
Plasma membrane lipids	Ester-linked phospholipids form a lipid bilayer	Glycerol diethers form lipid bilayers; glycerol tetraethers form lipid monolayers
Cell wall constituents	Peptidoglycan is present in nearly all; some lack cell wall	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	All known are circular, dsDNA
Plasmids present	Yes; circular and linear dsDNA	Yes; circular dsDNA
External structures	Flagella, fimbriae (pili) common	Archaelia, pili common
Capsules or slime layers	Common	Rare

Archaeal Shape, Arrangement, and Size

Much like bacteria, cocci and rods are common shapes.

Other shapes can also exist.

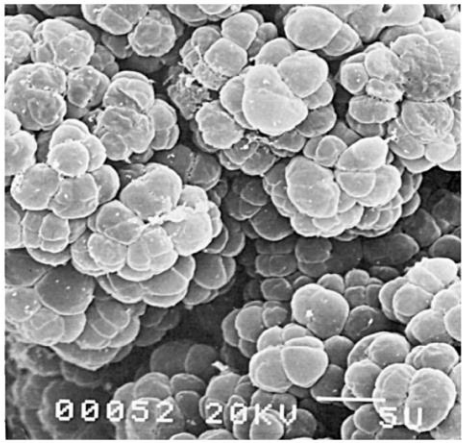
- No spirochetes or mycelial forms yet.
- Branched/flat shapes.

Sizes vary (typically 1 to 2 × 1 to 5 µm for rods, 1 to 3 µm in diameter for cocci).

Smallest observed is 0.2 to 0.4 µm in diameter.

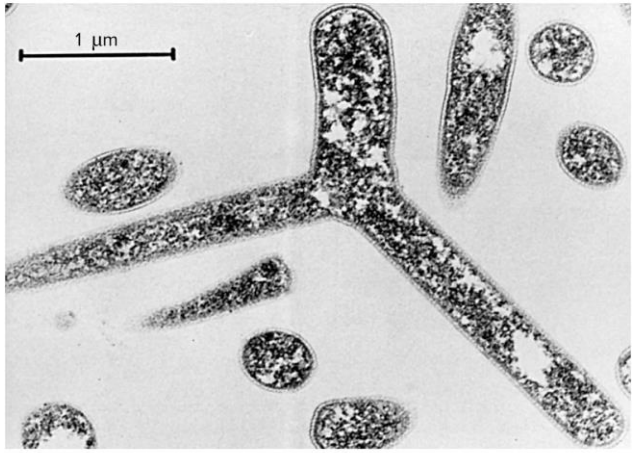
Largest (so far) is a multicellular form that can reach 30 mm in length!

Archaeal Cell Morphology



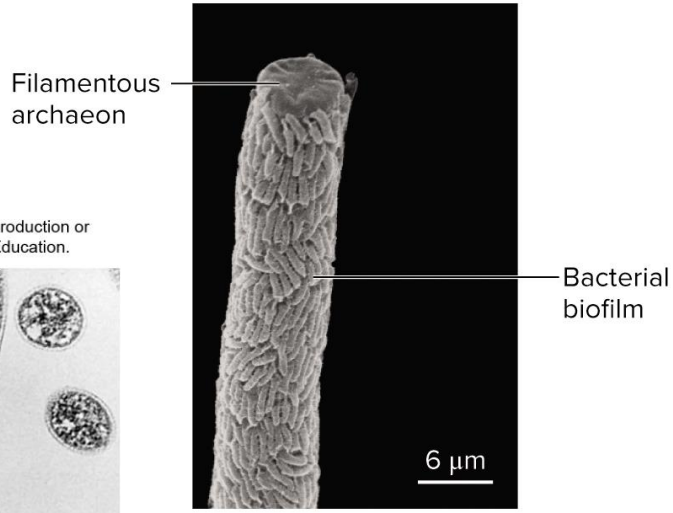
(a) *Methanosarcina mazei*—a coccus that forms clusters

From J.T. Staley, M.P. Bryant, N. Pfenning and J.G. Holt (Eds), Bergey's Manual of Systematic Bacteriology, Vol. 3. ©1989 Williams and Wilkins Co., Baltimore



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

From J.T. Staley, M.P. Bryant, N. Pfenning and J.G. Holt (Eds), Bergey's Manual of Systematic Bacteriology, Vol. 3. ©1989 Williams and Wilkins Co., Baltimore



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Archaeal Cell Envelopes

Differ from bacterial envelopes in the molecular makeup and organization.

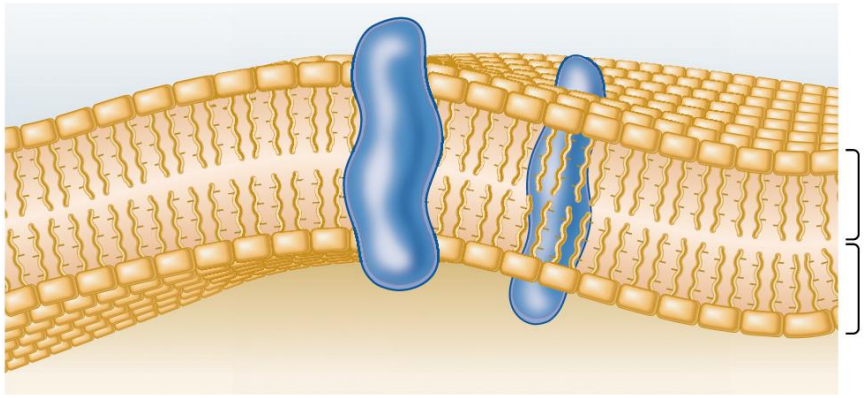
- S-layer may be only component outside plasma membrane.
- Some lack cell wall.
- Capsules and slime layers are rare.

Archaeal Membranes

(36) Archaea - YouTube

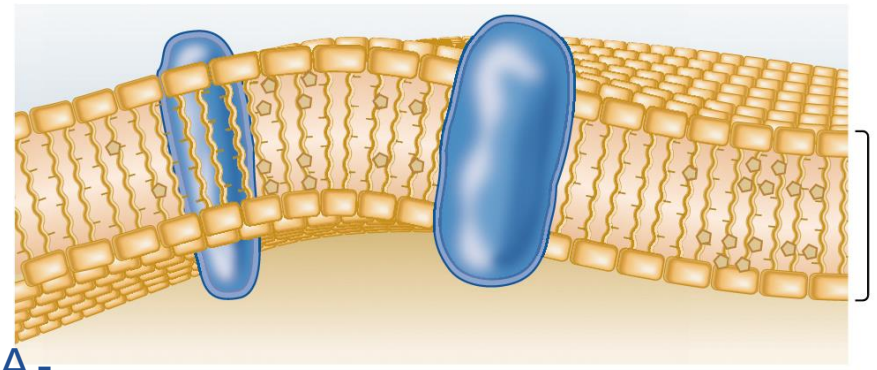
Composed of unique lipids.

- Isoprene units (five carbon, branched).
- Ether linkages rather than ester linkages to glycerol.



(a) Bilayer of C_{20} diethers

Some have a monolayer structure instead of a bilayer structure.



(b) Monolayer of C_{40} tetraethers

(231) MEMBRANE LIPIDS IN ARCHAEA - YouTube

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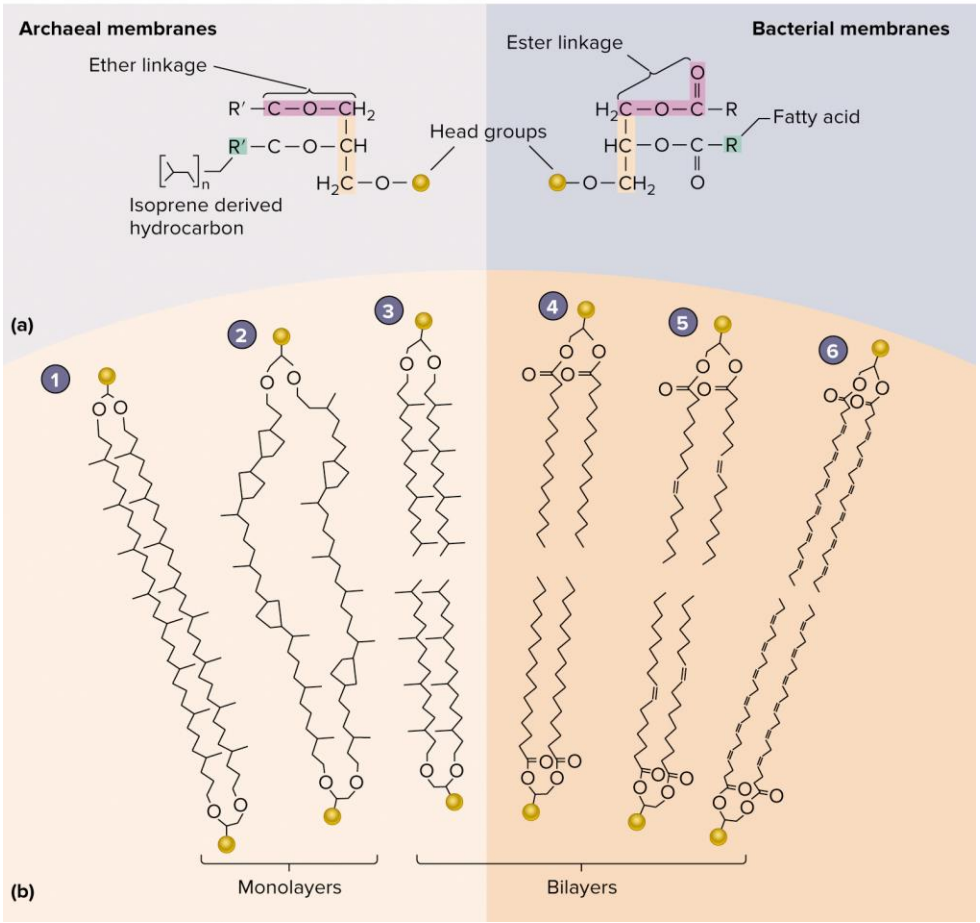
Archaeal Membrane Lipids

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.

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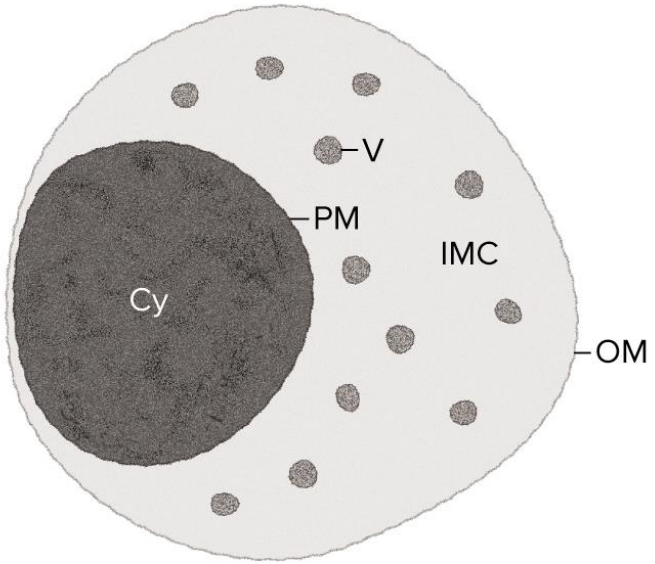
Archaeal Cell Surfaces

Cell envelopes.

- Varied S layers attached to plasma membrane.
- Pseudomurein (peptidoglycan-like polymer).
- Complex polysaccharides, proteins, or glycoproteins found in some other species.
- Only *Ignicoccus* has outer membrane.



Archaeal Cells and Nutrient Uptake

Archaeal cells use many of the same mechanisms for nutrient uptake exhibited in bacteria.

- **Facilitated diffusion.**
- **Active transport (primary and secondary).**

The phosphoenolpyruvate:sugar phosphotransferase system (PTS) group translocation mechanism has been found in some archaea.

Archaeal Cell Walls 1

Lack peptidoglycan.

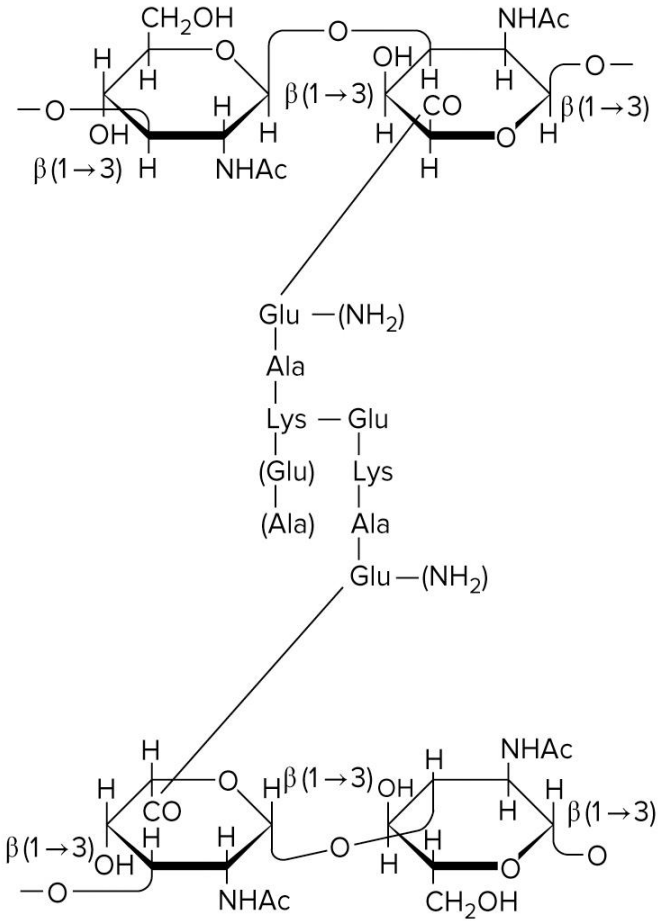
Most common cell wall is S-layer.

May have protein sheath external to S-layer.

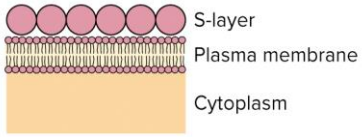
S-layer may be outside membrane and separated by pseudomurein.

Pseudomurein may be outermost layer—similar to Gram-positive microorganisms.

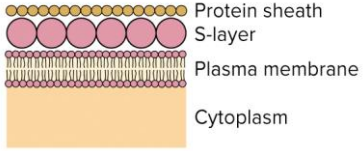
Archaeal Cell Walls 2



N-acetyltalosaminuronic acid *N*-acetylglucosamine



(a)



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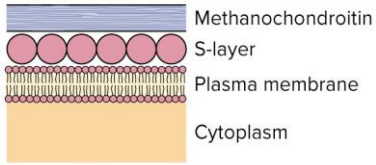

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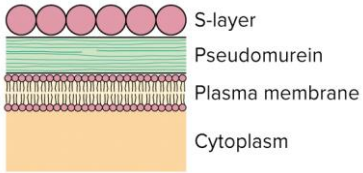

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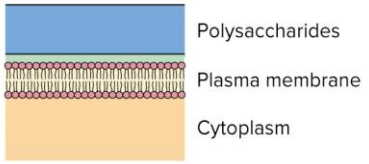

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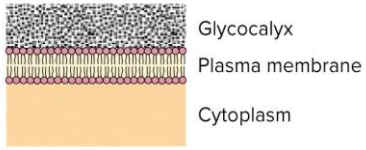

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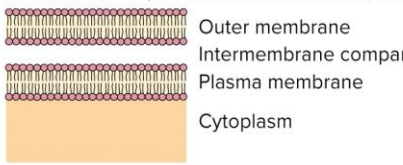

(g)

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Archaeal versus Bacterial Cytoplasm

Very similar—lack of membrane-enclosed organelles.

May contain inclusion bodies (for example gas vesicles for buoyancy control).

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.
- At least one archaeon **have additional 5.8S rRNA** (also seen in eukaryotic large subunit).

Proteins in ribosomes vary.

- Archaea more similar to eukarya than to bacteria, but there are some that are unique to archaea.

The Nucleoid

Irregularly shaped region in bacteria and archaea.

Usually not membrane bound (few exceptions).

Location of **single circular chromosome and associated proteins.**

Some evidence for polyploidy in some archaeons.

Supercoiling and nucleoid-associated proteins (NAPs, **including histones in some cases)** aid in folding and chromosome condensation.

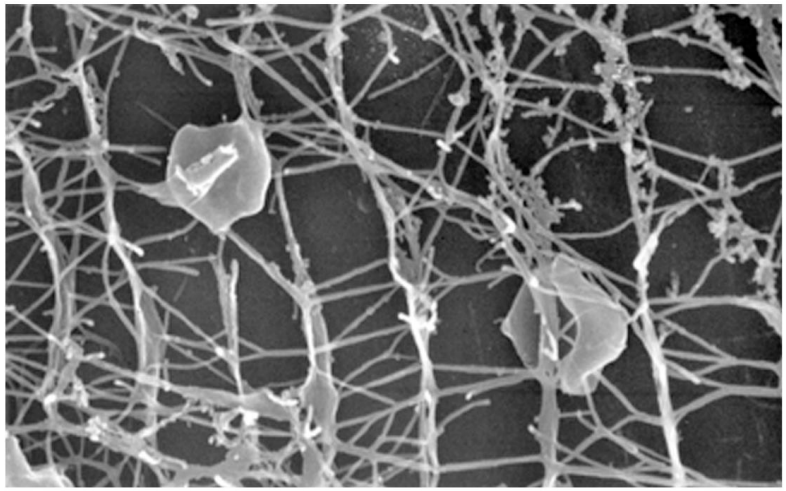
Archaeal External Structures 1

Pili.

- Not well understood as of yet.
- Some composed of pilin protein and homologous to bacterial type IV pili proteins.
- **May be involved in archaeal adhesion mechanisms.**

Cannulae.

- Hollow, tubelike structures on surface of thermophilic archae in genus *Pyrodictium.*
- **Function unknown**.
- May be involved in **formation of networks of multiple daughter cells.**



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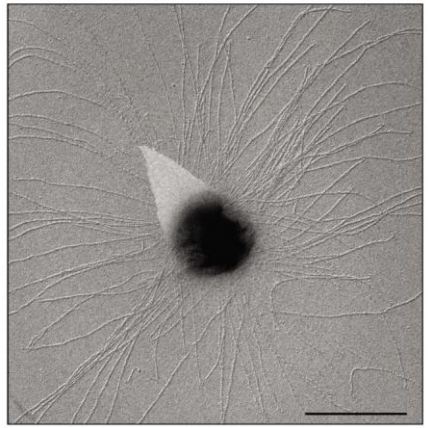
Archaeal External Structures 2

Hami.

- Not well understood.
- ‘Grappling hook’ appearance.
- Involvement in cell adhesion mechanisms?



(a) Hami radiating from cell

©Dr. Christine Moissl-Eichinger

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

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Differences of Archaeal Flagella

Flagella thinner.

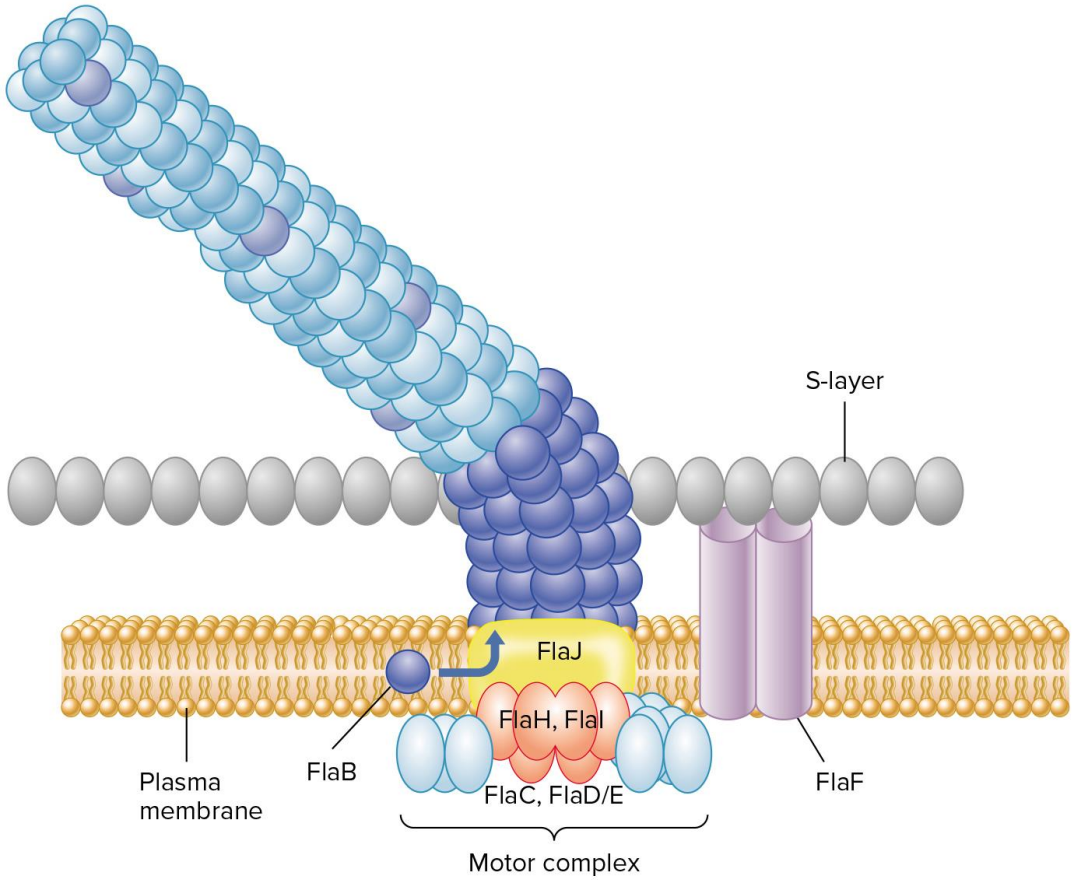
More than one type of flagellin protein.

Filament is not hollow.

Hook and basal body difficult to distinguish.

More related to type IV bacterial pili.

Growth occurs at the base, not the end.



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