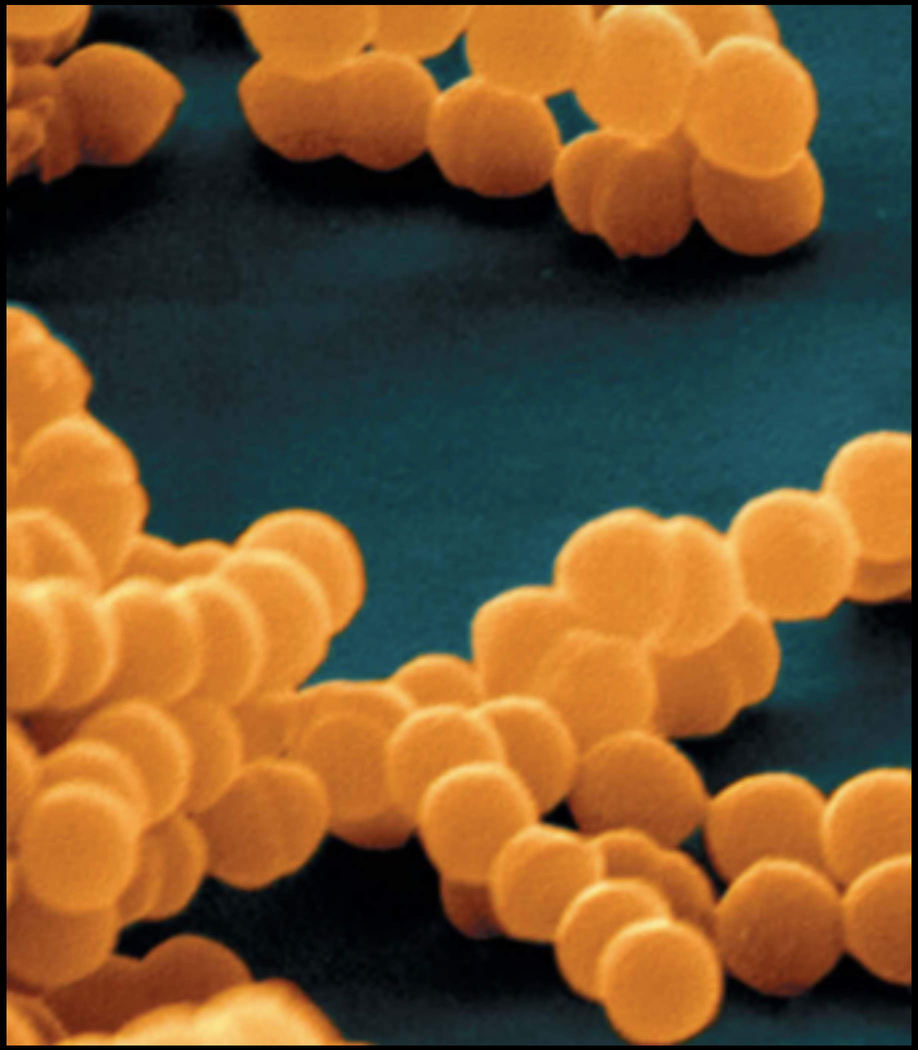
MIKROBIOLOGI

PERTEMUAN KE 4

IRMA MARDIAH M.SI



PROKARIOTA

DOMAIN BAKTERI & ARCHAEA

KONSEP KUNCI

- Domain Bakteri: Bakteri Gram Negatif: proteobakter, nonproteobakter
- Bakteri Gram Positif: G+C rendah, G+C tinggi
- Domain Arkaea
- Keberagaman Mikroba

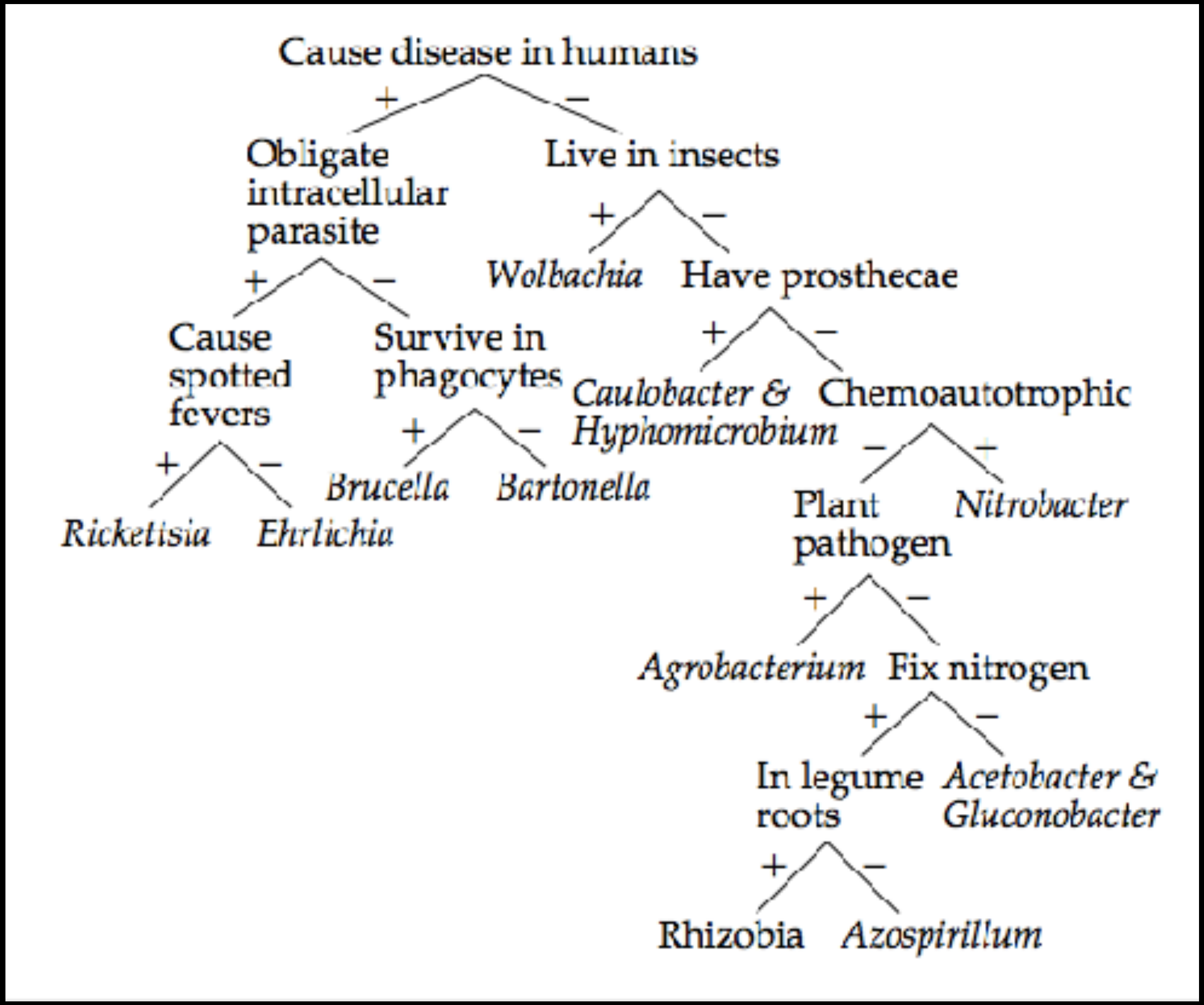
TABLE 11.1 Classification of Selected Prokaryotes*

Domain	Phyla	Selected Classes	Notes
BACTERIA (Gram-Negative)	Proteobacteria	· Alphaproteobacteria	Includes *Ehrlichia* and *Rickettsia*
		· Betaproteobacteria	Includes *Bordetella* and *Burkholderia*
		· Gammaproteobacteria	Includes *Vibrio*, *Salmonella*, *Helicobacter*, and *Escherichia*
		· Deltaproteobacteria	Includes *Bdellovibrio*
		· Epsilonproteobacteria	*Campylobacter* and *Helicobacter*
	Cyanobacteria	· Cyanobacteria	Oxygenic photosynthetic bacteria
	Chlorobi	· Chlorobia	Photosynthetic; anoxygenic; green sulfur bacteria
	Chloroflexi	· Chloroflexi	Include anoxygenic, photosynthetic, filamentous green nonsulfur bacteria
	Chlamydiae	· Chlamydiae	Grow only in eukaryotic host cells
	Planctomycetes	· Planctomycetacia	Aquatic bacteria; some are stalked
	Bacteroidetes	· Bacteroidetes	Phylum members include opportunistic pathogens
	Fusobacteria	· Fusobacteria	Anaerobic; some cause tissue necrosis and septicemia in humans
	Spirochaetes	· Spirochaetes	Classes include pathogens that cause syphilis and Lyme disease
	Deinococcus-Thermus	· Deinococci	*Deinococcus* and *Thermus*
BACTERIA (Gram-Positive)	Firmicutes	· Bacilli · Clostridia	Low G + C gram-positive rods and cocci
	Tenericutes	· Mycoplasmas	Low G + C wall-less bacteria
	Actinobacteria	· Actinobacteria	High G + C gram-positive bacteria
ARCHAEA	Crenarchaeota	· Thermoprotei	Thermophiles and hyperthermophiles
	Euryarchaeota	· Methanobacteria · Halobacteria	Methanobacteria are important sources of methane
	Nanoarchaeota		Obligate symbionts with other archaea
	Korarchaeota		Hyperthermophiles

*For a complete list of genera discussed in this text, see Appendix E.

Grup Prokariot
Domain bakteria
Gram Negatif

- Proteobakter: Alfaproteobakter
- betaproteobakter
- gammaproteobakter
- deltaproteobakter
- epsiloproteobakter



Alfaproteobakter

- pelagibakter
- azospirillum
- asetobakteraceae: rickettsia
- ehrilichia
- Caulobacter & Hyphomicrobium
- Rhizobium, Bradyrhizobium, Agrobacterium
- Bartonella
- Brucella
- Nitrobacter & Nitrosomonas
- Wolbachia

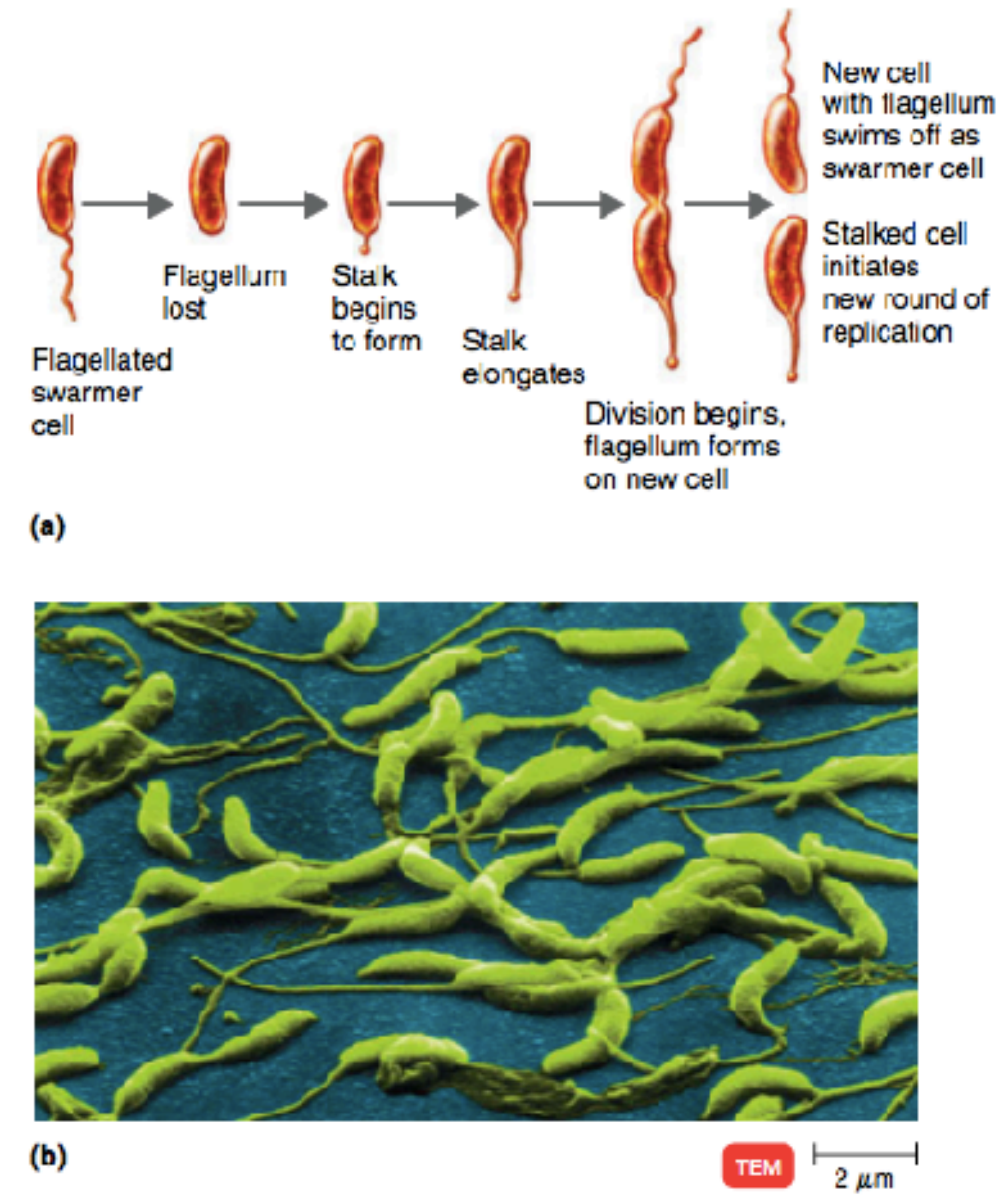
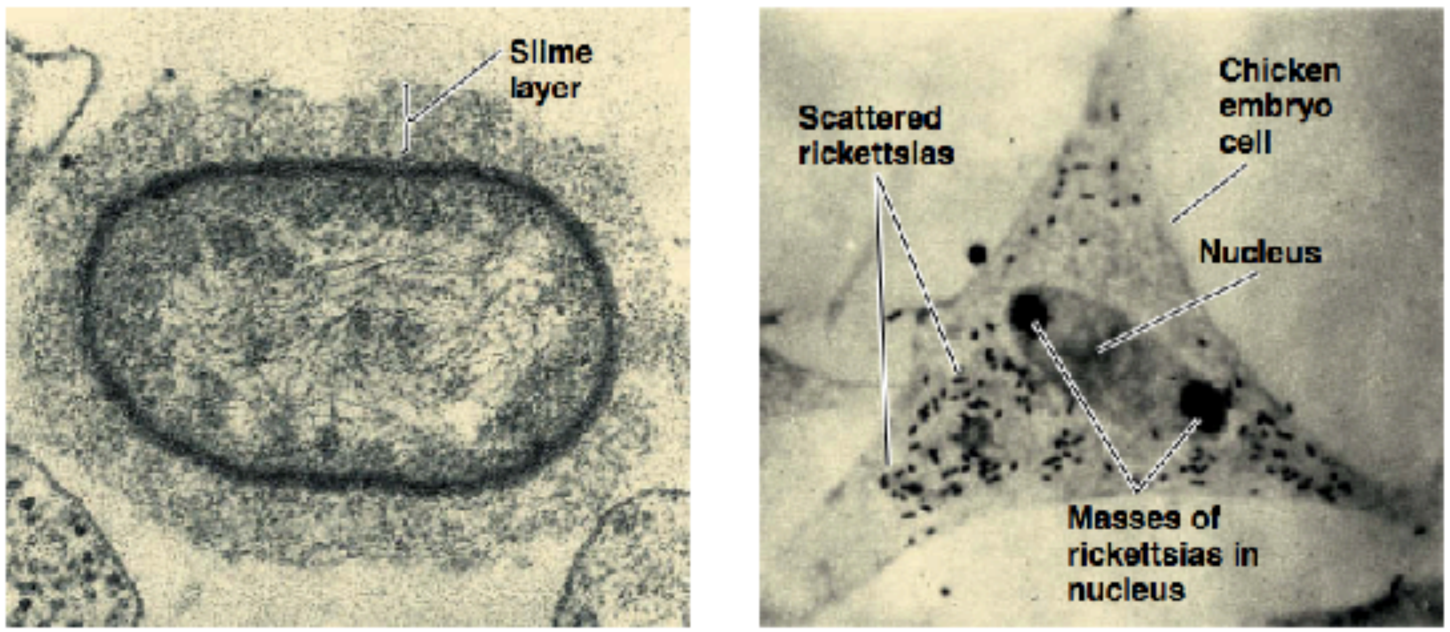


Figure 11.2 ***Caulobacter.***

Q **What is the competitive advantage provided by attaching to a surface?**

Alfaproteobakter



(a) A rickettsial cell that has just been released from a host cell

TEM 0.4 µm

LM 5 µm

Figure 11.1 Rickettsias.

Q How are rickettsias transmitted from one host to another?

(b) Rickettsias grow only within a host cell, such as the chicken embryo cell shown here. Note the scattered rickettsias within the cell and the compact masses of rickettsias in the cell nucleus.

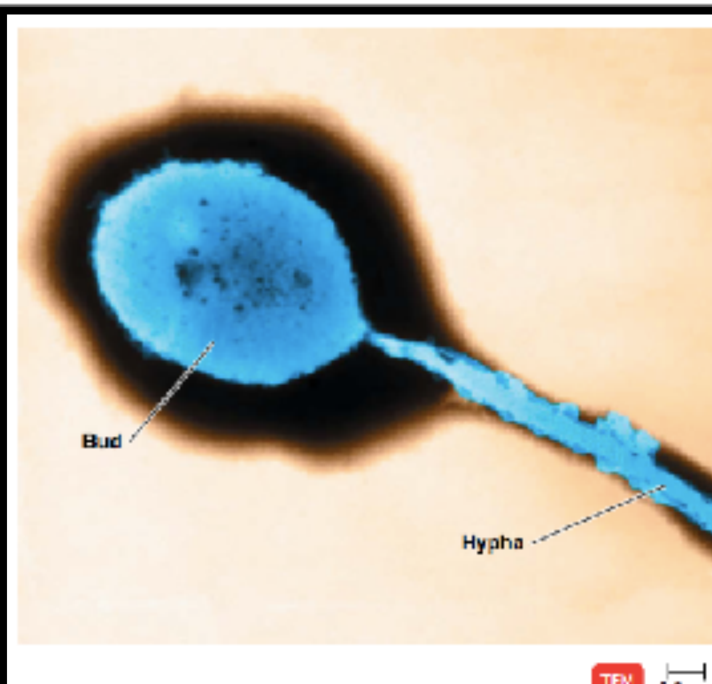


Figure 11.3 ***Hyphomicrobium*, a type of budding bacterium.**

Q Most bacteria do not reproduce by budding; what method do they use?

Betaproteobakter

- Asidithiobacillus
- spirilium
- sphaerotllus
- burkholderia
- Bordetella
- Neisseria
- Zoogloea

Figure 11.4 ***Spirillum volutans.*** These large helical bacteria are found in aquatic environments. Note the polar flagella.

Q Is this bacterium motile? How can you tell?

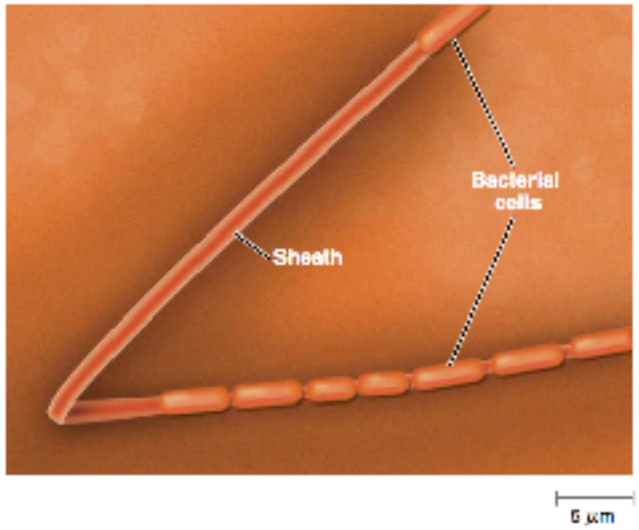


Figure 11.5 ***Sphaerotilus natans.*** These sheathed bacteria are found in dilute sewage and aquatic environments. They form elongated sheaths in which the bacteria live. The bacteria have flagella (not visible here) and can eventually swim free of the sheath.

Q How does the sheath help the cell?

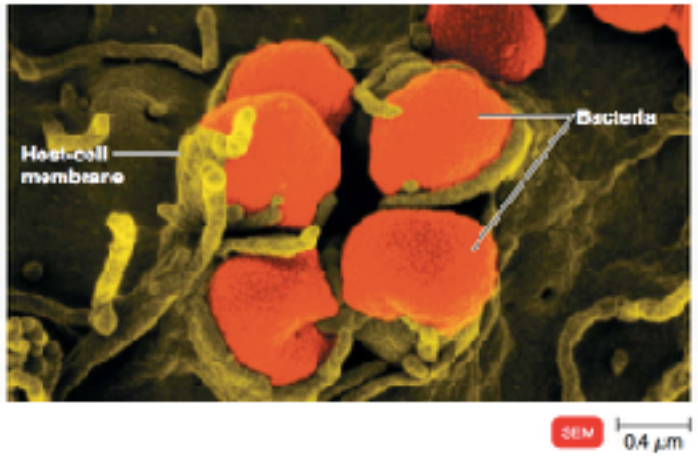


Figure 11.6 **The gram-negative coccus *Neisseria gonorrhoeae.*** This bacterium uses fimbriae and an outer membrane protein called Opa to attach to host cells. After the (red) bacterium attaches, the (green) host cell membrane surrounds it.

Q How do fimbriae contribute to pathogenicity?

Gammaproteobakter

- Thiotrichales: Beggiatoa, Francisella
- Pseudomonadales: Pseudomonas, Azotobacter & Azomonas, Moraxella, Acinobacter
- Legionellales: Legionella, Coxiella
- Vibrionales
- Enterobacteriales: Escherichia, Salmonella, Shigella, Klebsiella, Serratia, proteus, Yersinia, Erwinia, Enterobacter, Cronobacter
- Pasteurellales: Pasteurella, Haemophillus

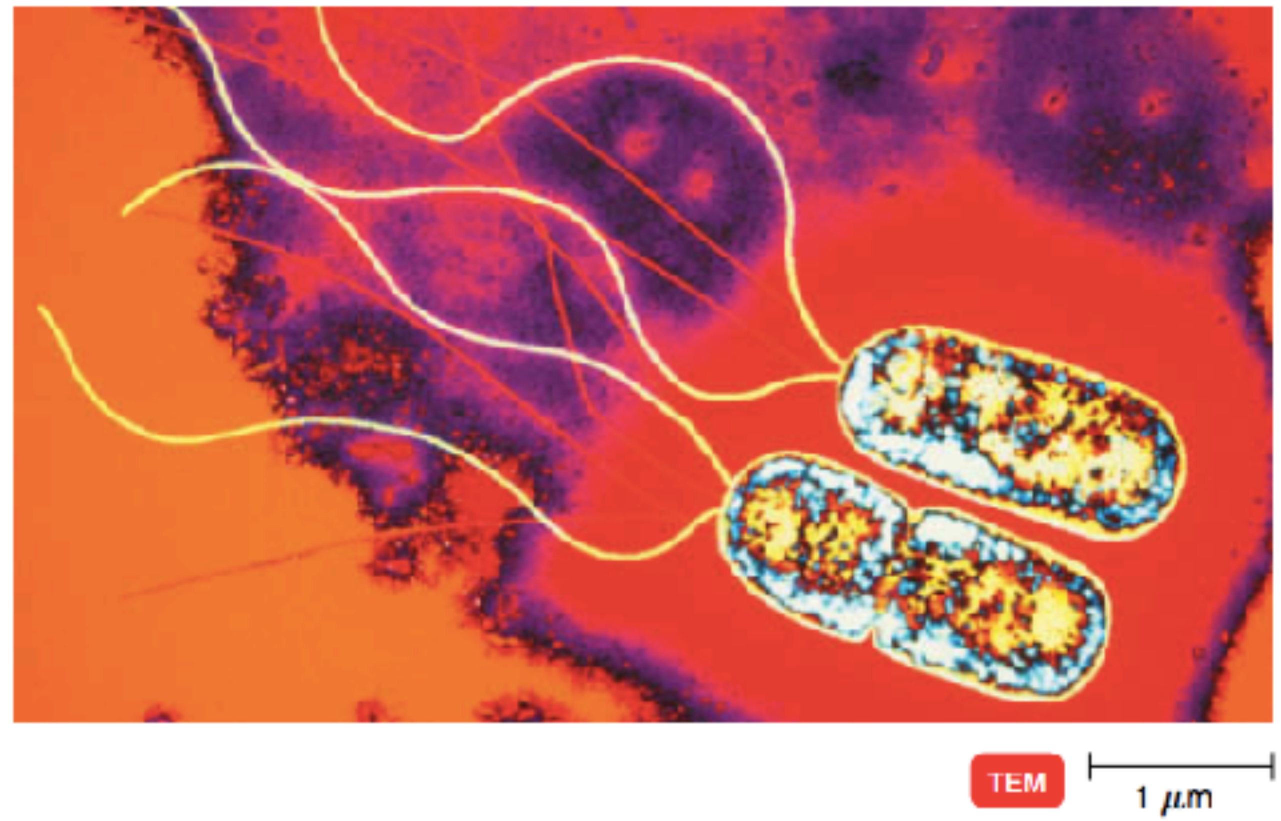
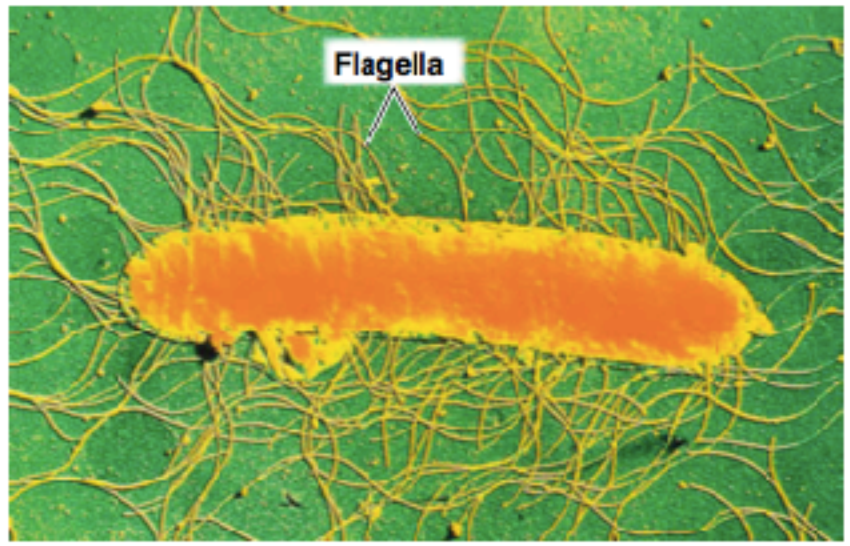


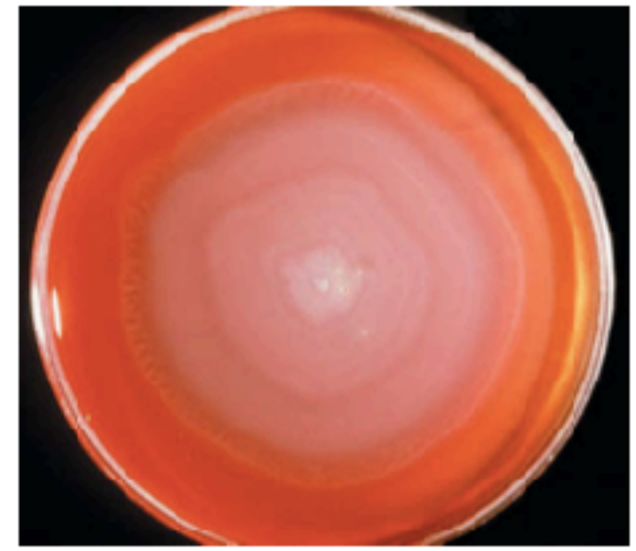
Figure 11.7 ***Pseudomonas.*** This photo of a pair of *Pseudomonas* bacteria shows polar flagella that are a characteristic of the genus. In some species, only a single flagellum is present (see Figure 4.7b, page 77). Note that one cell (on the bottom) is beginning to divide.

Q How does the nutritional diversity of these bacteria make them a problem in hospitals?

Gammaproteobakter



(a) *Proteus mirabilis* with peritrichous flagella TEM 0.4 μm



(b) A swarming colony of *Proteus mirabilis*, showing concentric rings of growth

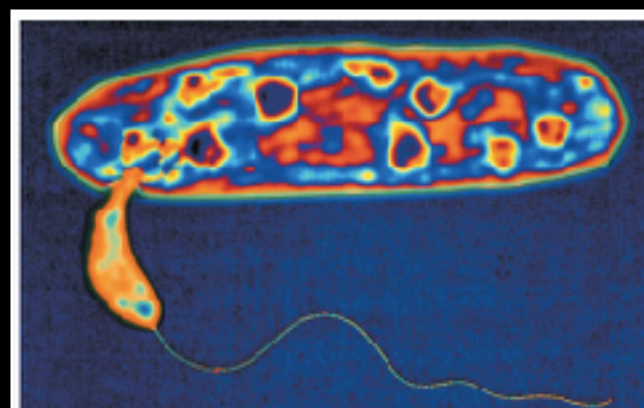
Figure 11.9 ***Proteus mirabilis.*** Chemical communication between bacterial cells causes changes from cells adapted to swimming in fluid (few flagella) to cells that are able to move on surfaces (numerous flagella). The concentric growth **(b)** results from periodic synchronized conversion to the highly flagellated form capable of movement on surfaces.

Q **The photo of the *Proteus* cell is probably a swarmer cell. How would you confirm swarming capability?**

LM 0.7 μm

Figure 11.8 ***Vibrio cholerae.*** Notice the curvature of these rods, which is a characteristic of the genus.

Q **What is the flagellar arrangement of these cells?**



TEM 0.7 μm

Figure 11.10 ***Bdellovibrio bacteriovorus.*** The yellow bacterium is *B. bacteriovorus*. It is attacking a bacterial cell shown in blue.

Q **Would this bacterium attack *Staphylococcus aureus*?**

Deltaproteobakter

- Bdellovibrio
- Desulfovibrionales
- Myxococcales
- Vibrionales

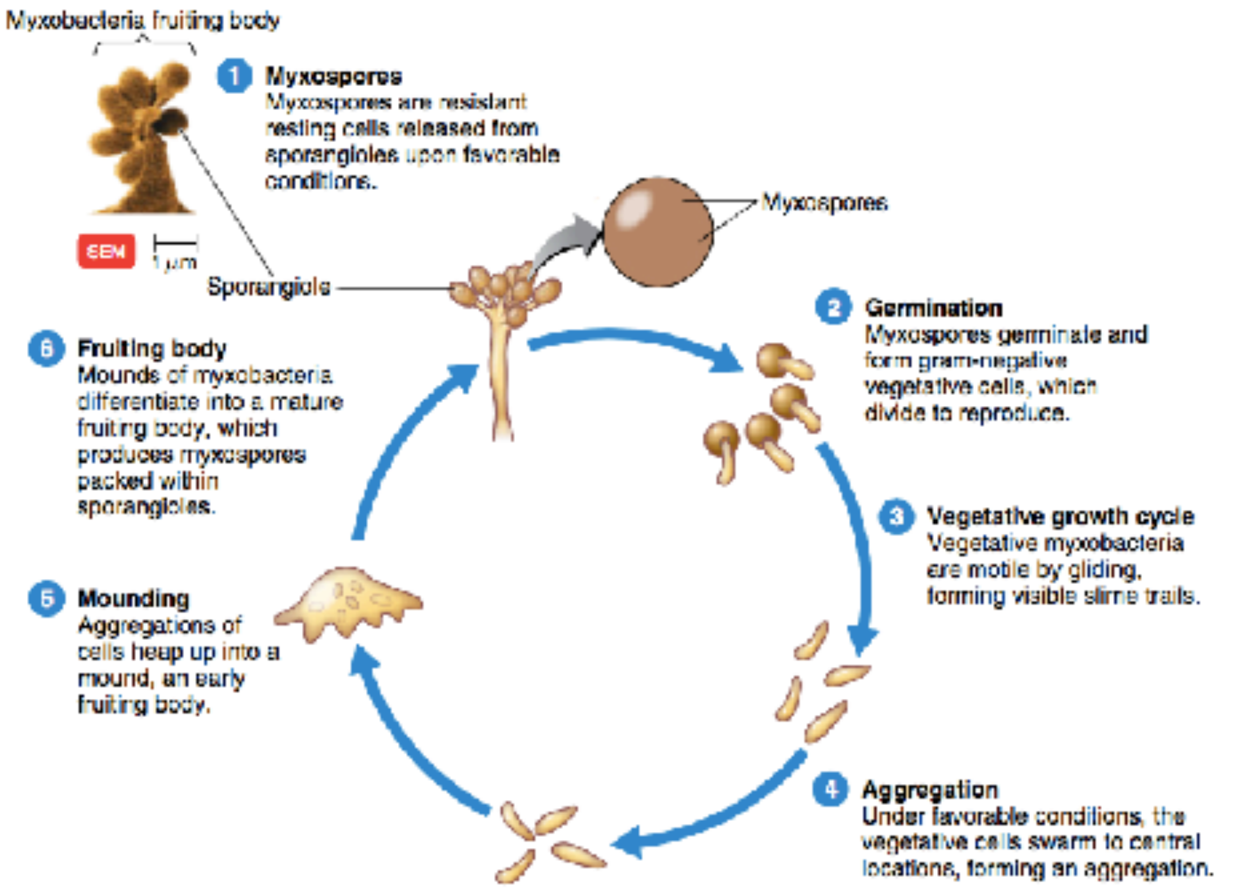


Figure 11.11 Myxococcales.

Q What is the feeding stage of this organism?

Epsilonproteobakter

- Campylobacter
- Helicobacter

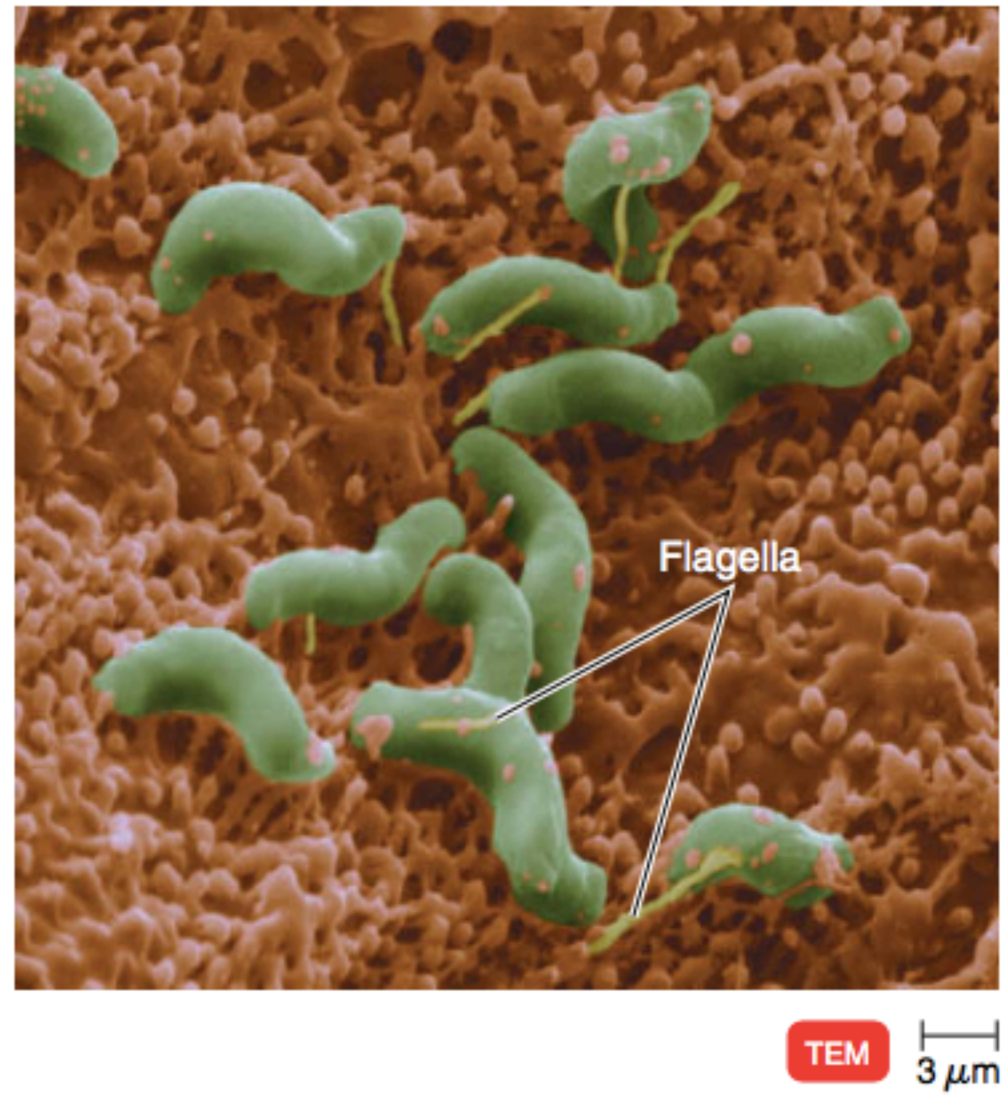


Figure 11.12 ***Helicobacter pylori* on stomach cells.** *H. pylori*, a curved rod, is an example of a helical bacterium that does not make a complete twist.

Q How do helical bacteria differ from spirochetes?

Nonproteobacter

- Cyanobacter (Bakteri fotosintetik oksigen)
- Fila Klorobi & Kloroflеksi (Anoksigenik Fotosintetik Bakteria)
- Clamidiae: Clamidia & clamidofila
- Planktomisetes
- Bakteroidetes: Bakteroides, Sitofagia
- Fusobacteria: Fusbacterium
- Spirochaetes: Treponema, Borella, Leptospira
- Deinococcus-Thermus

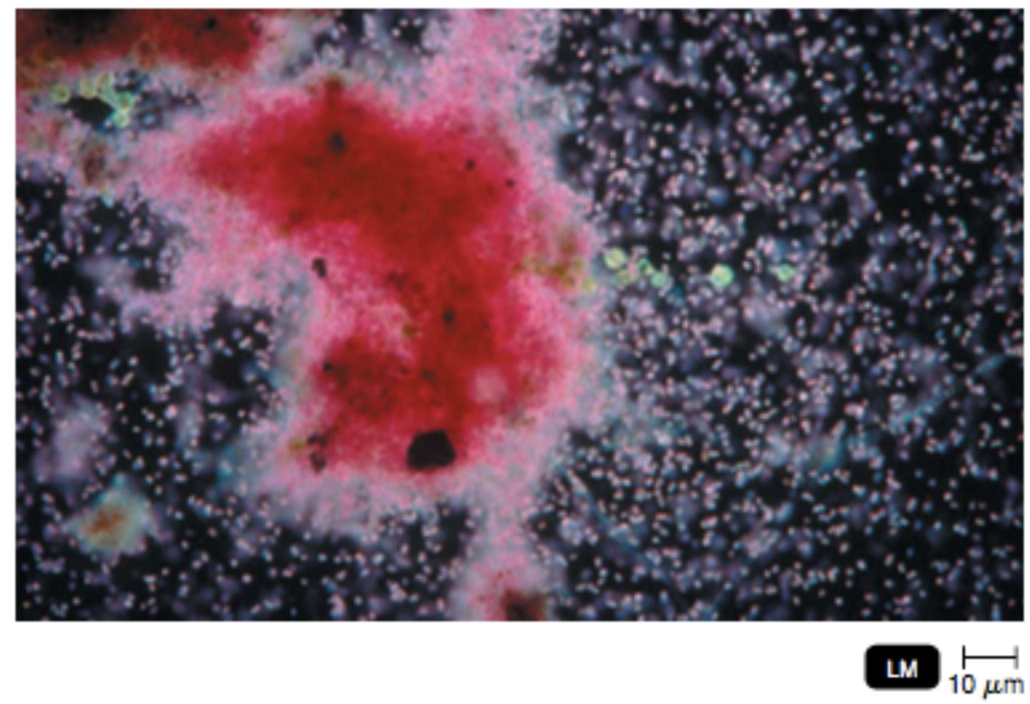
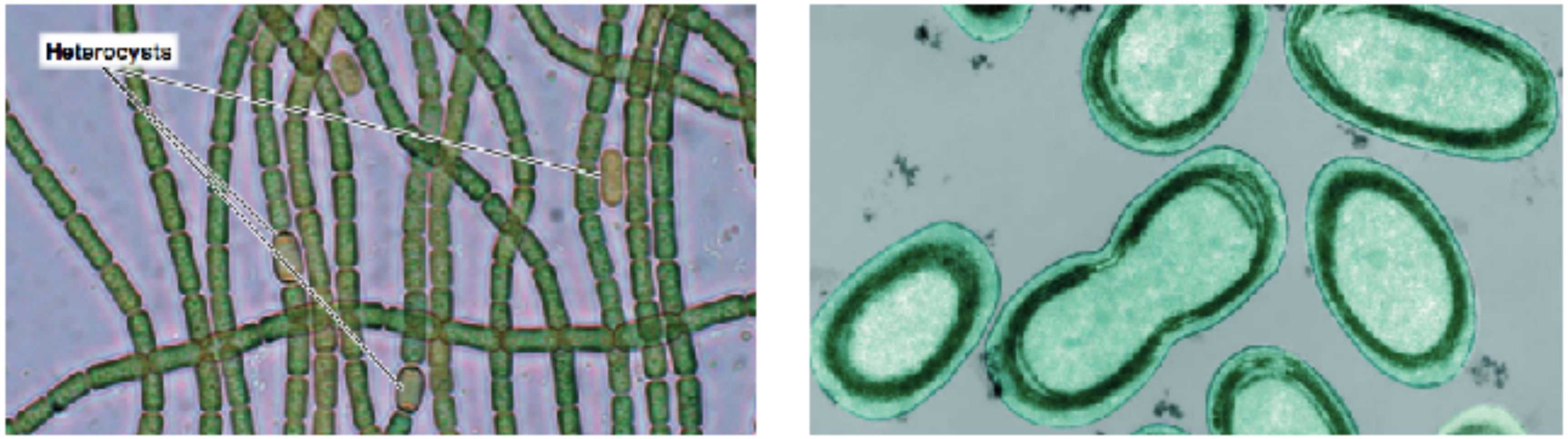


Figure 11.14 Purple sulfur bacteria. The purple color of these *Chromatium* cells is due to carotenoid pigments. These pigments capture light energy and transfer electrons to bacteriochlorophyll.

Q How does the photosynthesis of cyanobacteria differ from that of the purple sulfur bacteria?

Nonproteobacter



(a) Filamentous cyanobacterium showing heterocysts, in which nitrogen-fixing activity is located. LM 10 μm

(b) The unicellular, nonfilamentous cyanobacterium *Prochlorococcus* may be the world's most abundant photosynthetic organism. (*Electron micrograph courtesy of Claire Ting, Williams College*) TEM

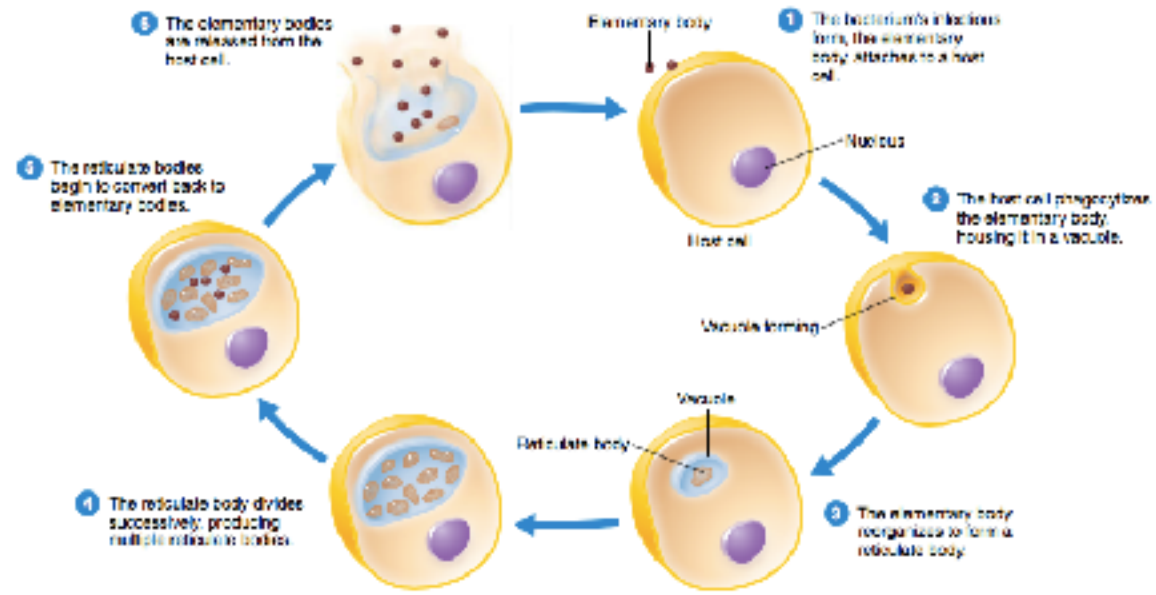
Figure 11.13 Cyanobacteria.

Q What does *anoxygenic* mean?

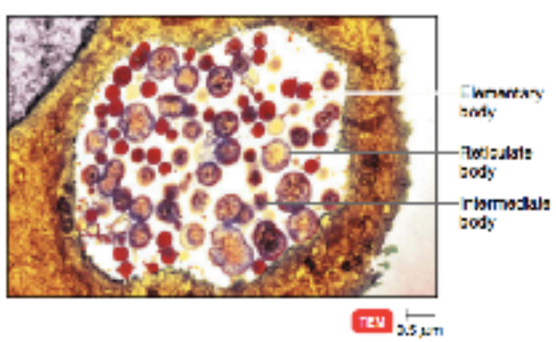
TABLE 11.2 Selected Characteristics of Photosynthesizing Bacteria

Common Name	Example	Phylum	Comments	Electron Donor for CO_2 Reduction	Oxygenic or Anoxygenic
Cyanobacteria	*Anabaena*	Cyanobacteria	Plantlike photosynthesis; some use bacterial photosynthesis under anaerobic conditions	Usually H_2O	Usually oxygenic
Green nonsulfur bacteria	*Chloroflexus*	Chloroflexi	Grow chemoheterotrophically in aerobic environments	Organic compounds	Anoxygenic
Green sulfur bacteria	*Chlorobium*	Chlorobi	Deposit sulfur granules inside cells	Usually H_2S	Anoxygenic
Purple nonsulfur bacteria	*Rhodospirillum*	Proteobacteria	Can grow chemoheterotrophically as well	Organic compounds	Anoxygenic
Purple sulfur bacteria	*Chromatium*	Proteobacteria	Deposit sulfur granules inside cells	Usually H_2S	Anoxygenic

Nonproteobacter



(a) Life cycle of the chlamydias, which takes about 48 hours to complete



(b) Micrograph of *Chlamydophila pecorum* in the cytoplasm of a host cell. The **elementary bodies** are the infectious stage; they are dense, dark, and relatively small. **Reticulate bodies**, the form in which chlamydias reproduce within the host cell, are larger with a speckled appearance. Intermediate bodies, a stage between the two, have a dark center.

Figure 11.15 Chlamydias.

Q Which stage of the life cycle is infectious to humans?

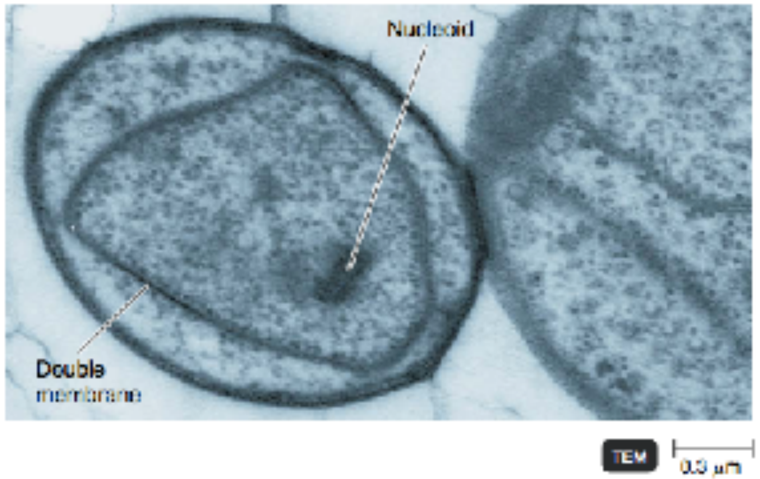


Figure 11.16 *Gemmata obscuriglobus*. This planctomycete exhibits a double membrane surrounding its nucleoid, which resembles a eukaryotic nucleus.

Q Can you see a resemblance between the double membrane around the nucleoid in this photo and the membrane around the nuclear envelope shown in Figure 4.24?

Figure 11.17 *Fusobacterium*. This is a common anaerobic rod found in the human intestine. Notice the characteristic pointed ends.

Q In what other place in the human body do you often find *Fusobacterium*?

Bacteria Gram-Positif
(G+C rendah)

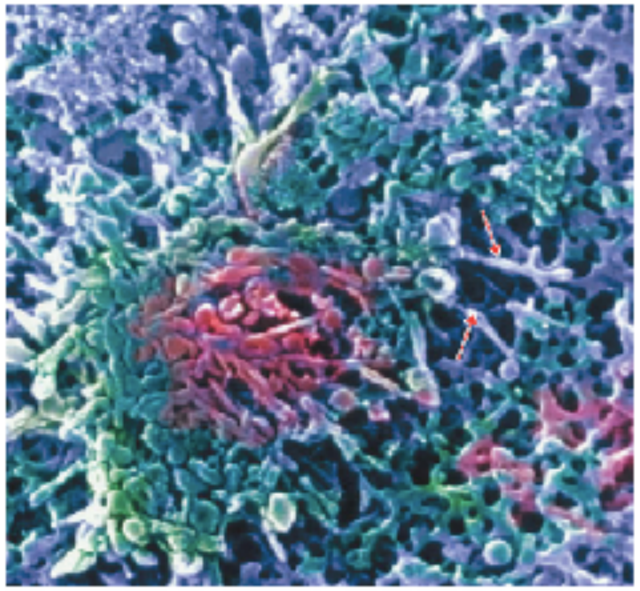
- Firmicutes
    - Klostridiales: klostridium, epulopisikum
    - Bacillales: Bacillus, Staphylococcus
    - Lactobacillales: Lactobacillus, Streptococcus, beta-hemolytic streptococci, non-beta-hemolytic streptococci, enterococcus, listeria
- Tenericutes

Figure 11.19 ***Clostridium difficile.*** The endospores of clostridia usually distend the cell wall, as seen in some of these cells.

Q **What physiological characteristic of *Clostridium* makes it a problem in contamination of deep wounds?**

Bacteria Gram-Positif

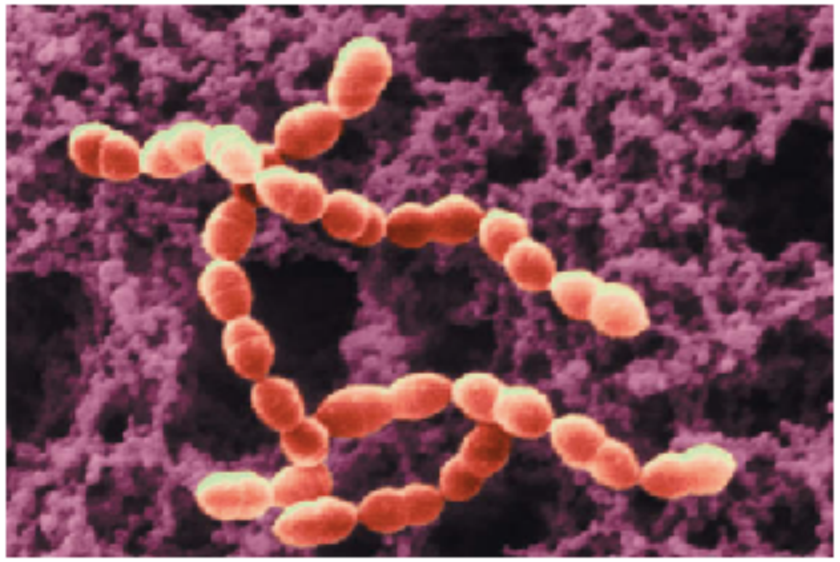
(G+C rendah)



SEM 0.75 μm

Figure 11.24 ***Mycoplasma pneumoniae.*** This micrograph shows the filamentous growth of *M. pneumoniae*. This bacterium does not have a cell wall; the cell membrane is the outermost layer. The cells are so small that they cannot be examined by light microscopy. Individual cells (arrows) have extensions at each end that probably aid in gliding motility and in attachment to the host cells. They depend on the host for survival and do not survive as free-living organisms.

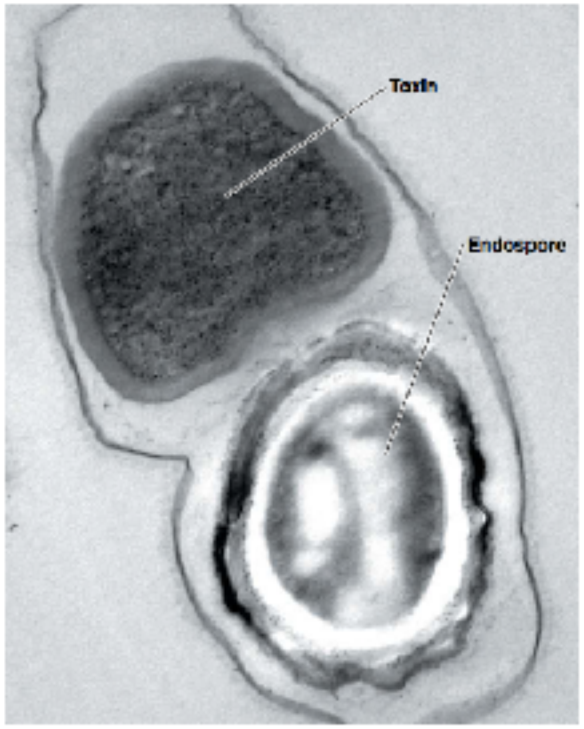
Q How can the cell structure of mycoplasmas account for their pleomorphism?



SEM 1 μm

Figure 11.23 ***Streptococcus.*** Notice the chains of cells characteristic of most streptococci. Many of the spherical cells are dividing and are somewhat oval in appearance—especially when viewed with a light microscope, which has lower magnification than this electron micrograph.

Q How does the arrangement of *Streptococcus* differ from *Staphylococcus*?



Bacillus thuringiensis. The protein shown next to the endospore, called a parasporal body, is toxic to an insect that ingests it.

TEM 0.2 μm

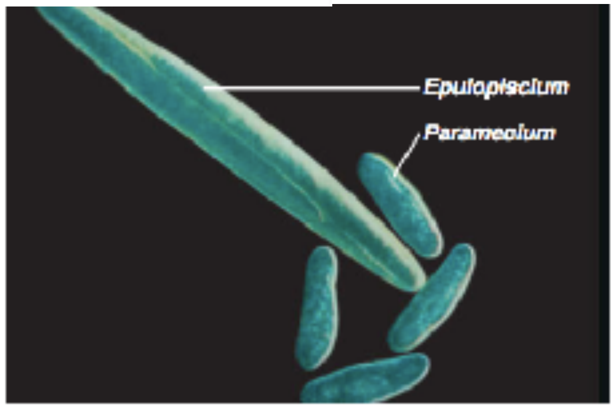
Figure 11.21 ***Bacillus.***

Q What structure is made by both *Clostridium* and *Bacillus*?

SEM 1 μm

Figure 11.22 ***Staphylococcus aureus.*** Notice the grapelike clusters of these gram-positive cocci.

Q What is an environmental advantage of a pigment?

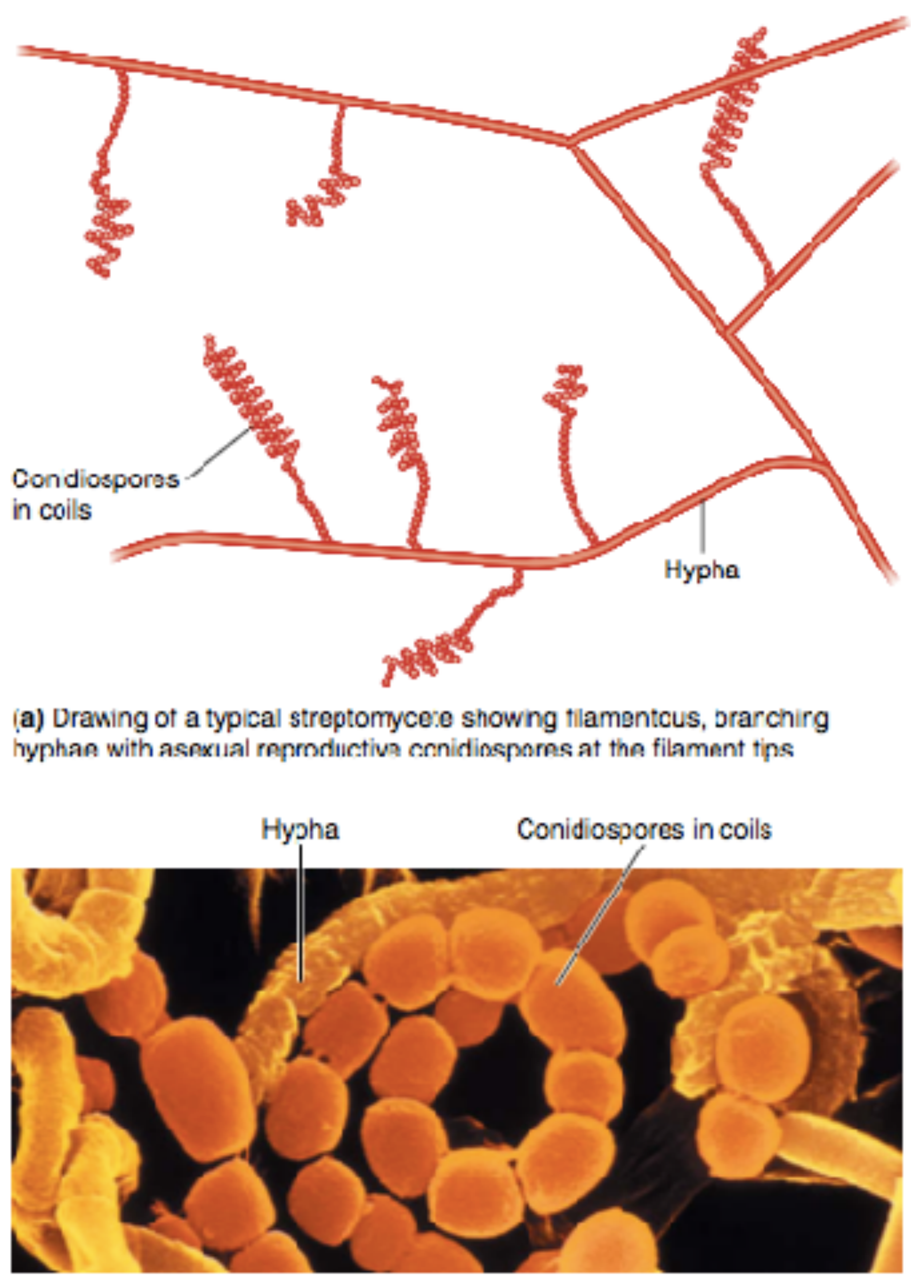


LM 100 μm

Figure 11.20 **A giant prokaryote, *Epulopiscium fishelsoni.*** *Paramecium* is a protozoan, a group whose members are normally larger than bacterial cells.

Bacteria Gram-Positif
(G+C tinggi)

- Mycobacterium
- Corynebacterium
- propionlbacterium
- gardnerella
- frankia
- streptomyces
- actinomyces
- nocardia



(a) Drawing of a typical streptomycete showing filamentous, branching hyphae with asexual reproductive conidiospores at the filament tips

(b) Coils of conidiospores supported by hyphae of the streptomycete

Figure 11.25 ***Streptomyces.***

Why is *Streptomyces* not classified with fungi?

Figure 11.26 ***Actinomyces.*** Notice the branched filamentous hyphae.

Why are these bacteria not classified as fungi?

Domain Archaea

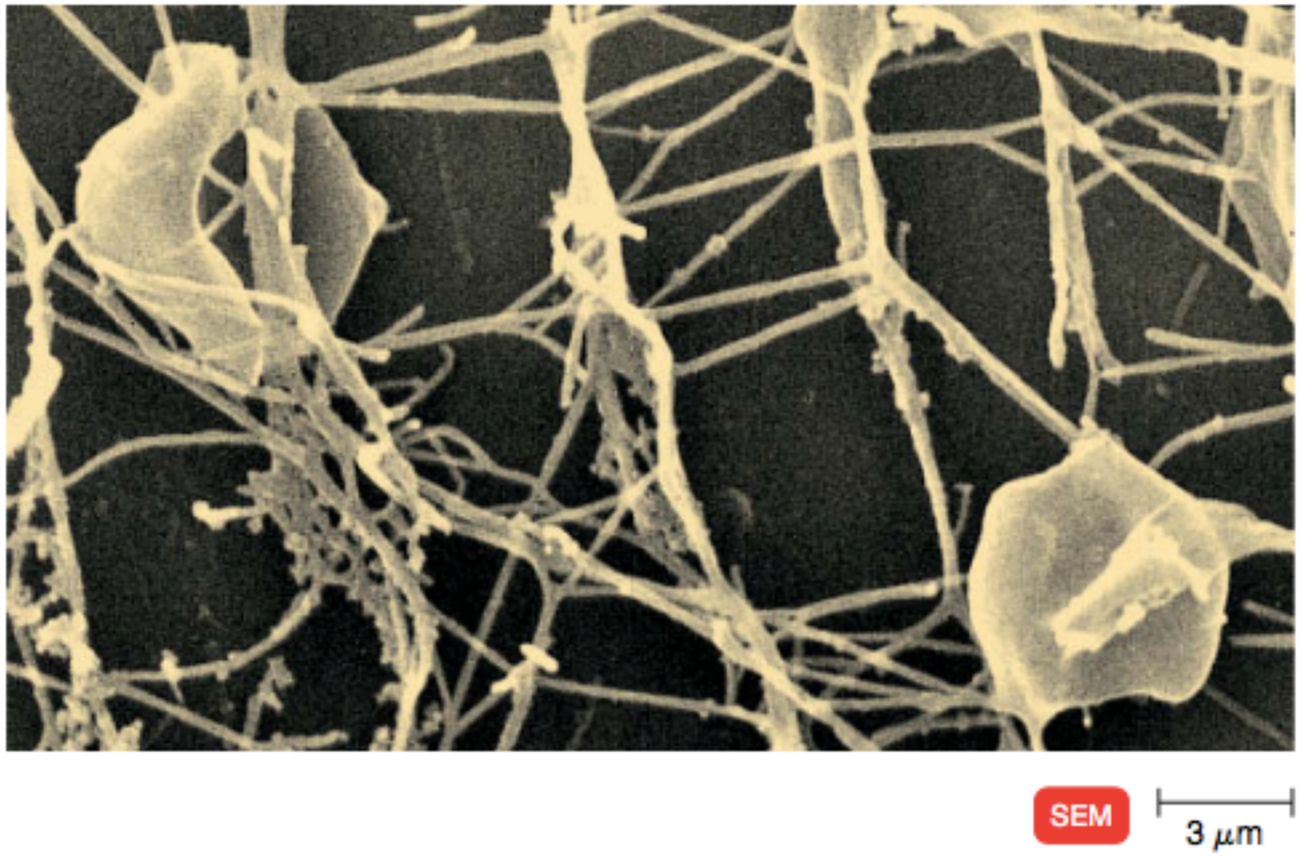


Figure 11.27 Archaea. *Pyrodictium abyssi*, an unusual member of the archaea found growing in deep-ocean sediment at a temperature of 110°C. The cells are disk-shaped with a network of tubules (cannulae). Most archaea are more conventional in their morphology.

Q Do the terms included in the name, *pyro* and *abyssi*, suggest a basis for the naming of this bacterium?

Keanekaregaman Mikroba

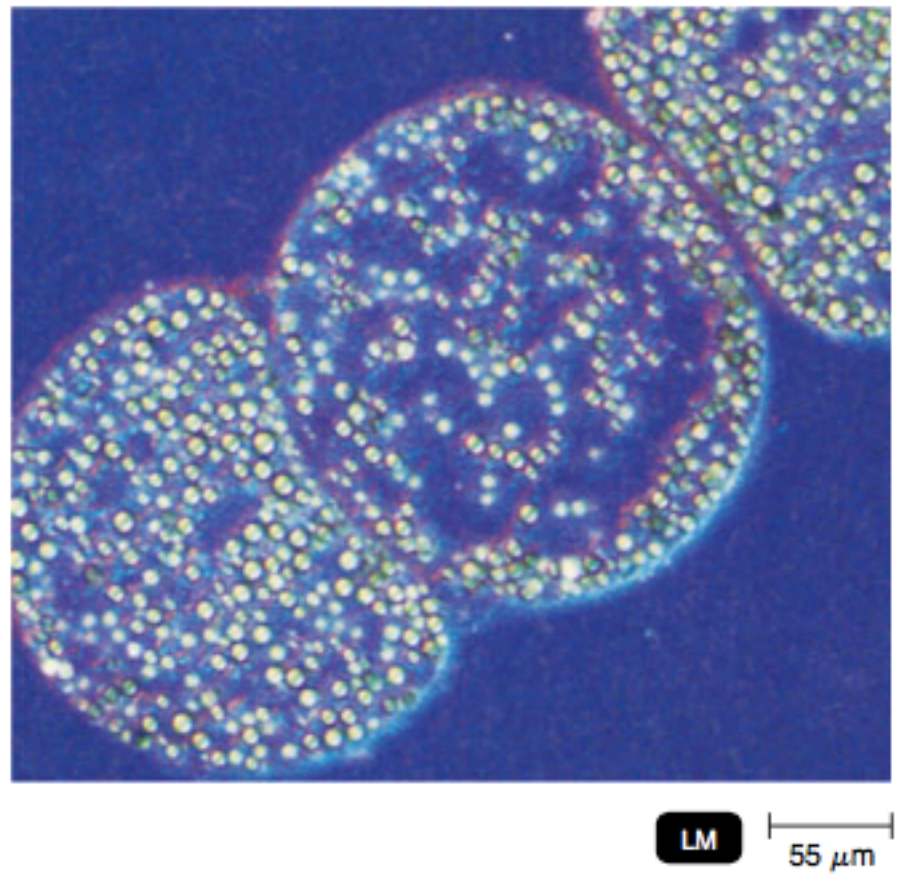


Figure 11.28 ***Thiomargarita namibiensis.*** This micrograph shows the intracellular sulfur granules in the thin layer of cytoplasm near the cell membrane. Sulfur accumulates when the bacteriium oxidizes H_2S.

Q **Would a bacterium of this size be theoretically possible if the interior were cytoplasm rather than a fluid-filled vacuole?**

Microbiome in Space

Since space exploration began, scientists have worried about potential human-microbe interactions beyond Earth. In the 1960s, caution over "space germ" contamination led to 30-day quarantines of astronauts, equipment, and samples upon return from lunar missions. Today, scientists are equally concerned that spacecraft such as the Mars landers might inadvertently contaminate other planets we visit. But although equipment can often be sterilized before entering space, the human microbiome travels with us wherever we go and spreads to the surfaces we frequently touch.

The physical environment within a space craft is different from Earth's—there's less gravity and more ionizing radiation. Being in space depresses cells in the immune system, and antibiotics seem to lose potency. Meanwhile, *Salmonella* Typhimurium and *Pseudomonas aeruginosa* grown on the Atlantis space shuttle were more virulent than the same strains grown on Earth. Studies have shown that bacteria grown in space often take on different biofilm structures from those seen on Earth.

To date, only one astronaut has developed a serious microbial infection while in space, with the cause identified as *P. aeruginosa*. But could the microbiome that is so essential to us on Earth become a traitor in space? Astronauts stationed on the International Space Station are conducting the Astronaut Microbiome Project to find out. Since air within the space station is filtered, it's possible to examine the debris that is strained out and identify microbes in it. Actinobacteria are the most abundant bacteria on the International Space Station. *Ralstonia eutropha* and *P. aeruginosa* were also detected. Samples taken from various body sites, as well as fecal samples of astronauts before, during, and after a space mission, will also be analyzed during the Astronaut Microbiome Project, so we can identify other microbial changes that may take place in space.

Cultures of *Pseudonomas aeruginosa* grown in space showed a "column and canopy" structure never seen before in cultures grown on Earth.

DAFTAR PUSTAKA

1. Tortora GJ, Funke BR, Case CL, 2007, Microbiology an Introduction, 13th edition, Benjamin Cummings, Animprint of Addison Wesley, Longman Inc., USA