Non proteobacteria: *Deinococcus, Chlamydia, Chlorobium and Spirochaetes*

By-

Dr. Ekta Khare

Non proteobacteria

- **Proteobacteria:** They are a broad group of bacteria that include all Gram-Negative bacteria among which a very few species of proteobacteria can perform photosynthesis to produce energy.
- **Non-proteobacteria:** They are a broad group of bacteria that include both Gram-positive and Gram-Negative bacteria. All species in this group can perform photosynthesis and produce energy.
- The second edition of *Bergey's Manual places photosynthetic* bacteria into six major groups.
- The phylum *Chloroflexi contains* the green nonsulfur bacteria, and
- The phylum *Chlorobi, the green* sulfur bacteria.
- The cyanobacteria are placed in their own phylum, *Cyanobacteria.*
- *Purple bacteria are divided between three groups.*
  - Purple sulfur bacteria are placed in the γ-proteobacteria, families *Chromatiaceae and Ectothiorhodospiraceae.*
  - *The purple nonsulfur* bacteria are distributed between the α-proteobacteria (five different families) and
  - one family of the β-proteobacteria.

Phylum *Chlorobi*

- The phylum Chlorobi has only one class (Chlorobia), order (Chlorobiales), and family (Chlorobiaceae).
- The green sulfur bacteria are a small group of obligately anaerobic photolithoautotrophs that use hydrogen sulfide, elemental sulfur, and hydrogen as electron sources.
- The elemental sulfur produced by sulfide oxidation is deposited outside the cell.
- Their photosynthetic pigments are located in ellipsoidal vesicles called chlorosomes or chlorobium vesicles, which are attached to the plasma membrane but are not continuous with it.
- The chlorosome membrane is not a normal lipid bilayer or unit membrane.
- Chlorosomes contain accessory bacteriochlorophyll pigments, but the reaction center bacteriochlorophyll is located in the plasma membrane and must be able to obtain energy from chlorosome pigments.

Chlorobia

- These bacteria flourish in the anaerobic, sulfide-rich zones of lakes.
- Although they lack flagella and are nonmotile, some species have gas vesicles to adjust their depth for optimal light and hydrogen sulfide.
- Those forms without vesicles are found in sulfide-rich muds at the bottom of lakes and ponds.
- The green sulfur bacteria are very diverse morphologically.
- They may be rods, cocci, or vibrios; some grow singly, and others form chains and clusters (figure 21.5*b,c).*
- They are either grass-green or chocolate-brown in color. Representative genera are *Chlorobium, Prosthecochloris,* and *Pelodictyon.*

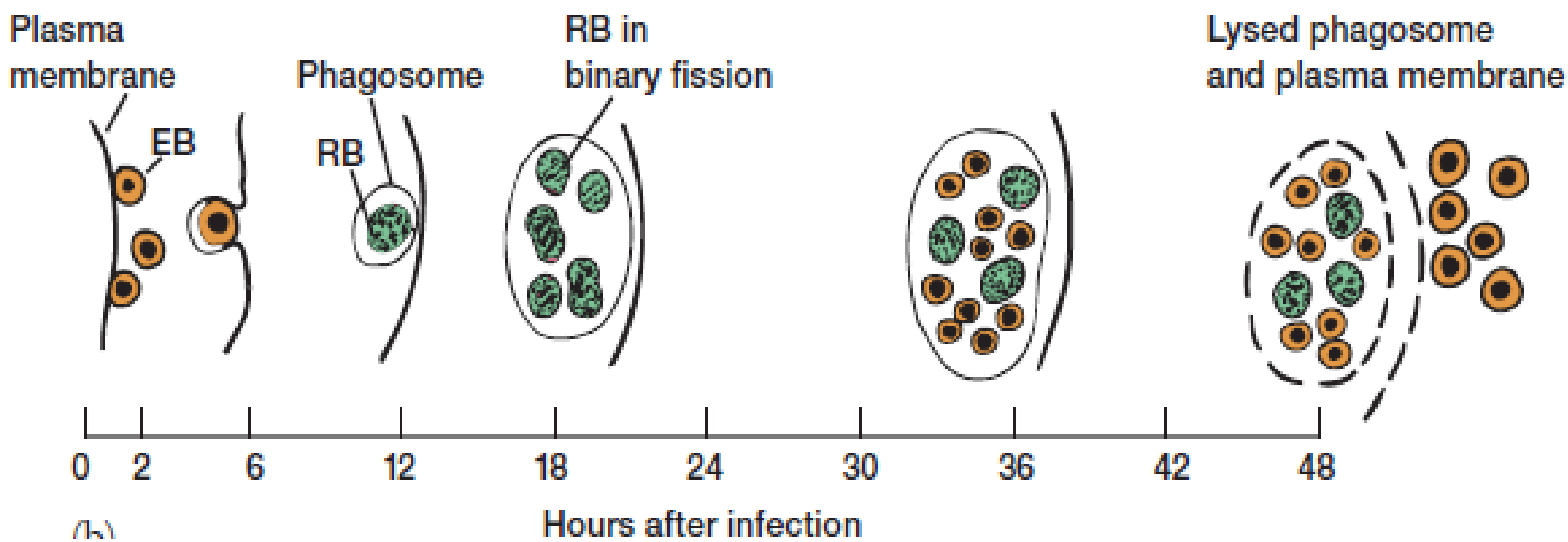
- *Chlorobium aggregatum* is a species which exists in a symbiotic relationship with a colorless, nonphotosynthetic bacteria.
- This species looks like a bundle of green bacteria, attached to a central rod-like cell which can move around with a flagellum.
- The green, outer bacteria use light to oxidize sulfide into sulfate.
- The inner cell, which is not able to perform photosynthesis, reduces the sulfate into sulfide.
- These bacteria divide in unison, giving the structure a multicellular appearance which is highly unusual in bacteria.

Chlorobium	
Scientific classification	
Domain:	Bacteria
Phylum:	Chlorobiota
Class:	"Chlorobia"
Order:	Chlorobiales
Family:	Chlorobiaceae
Genus:	***Chlorobium*** Nadson 1906
Type species	
Chlorobium limicola Nadson 1906	

Phylum *Chlamydiae*

- The phylum *Chlamydiae* has one class, one order, four families, and only five genera.
- Chlamydiae are gram-negative, obligately intracellular parasites: they grow and reproduce only within host cells.
- The genus Chlamydia is by far the most important and best studied; it will be the focus of our attention.
- Chlamydiae are nonmotile, coccoid, gram-negative bacteria, ranging in size from 0.2 to 1.5 μm.
- They can reproduce only within cytoplasmic vesicles of host cells by a unique developmental cycle involving the formation of elementary bodies and reticulate bodies.
- Although their envelope resembles that of other gram-negative bacteria, the wall differs in lacking muramic acid and a peptidoglycan layer.

- The elementary bodies achieve osmotic stability by cross-linking their outer membrane proteins, and possibly periplasmic proteins, with disulfide bonds.
- Chlamydiae are extremely limited metabolically and are obligately intracellular parasites of mammals and birds.
- However, chlamydia like bacteria have recently been isolated from spiders, clams, and freshwater invertebrates.
- The size of their genome is 4 to 6 $x10^8$ daltons, one of the smallest of all procaryotes, and the G+C content is 41 to 44%.



A schematic representation of the infectious cycle of chlamydiae.

- Chlamydial metabolism is very different from that of other gram-negative bacteria.
- It has been thought that chlamydiae cannot catabolize carbohydrates or other substances and synthesize ATP.
- *Chlamydia psittaci, one of the best-studied species, lacks both flavoprotein* and cytochrome electron transport chain carriers, but does have a membrane translocase that acquires host ATP in exchange for ADP.
- Thus chlamydiae seem to be energy parasites that are completely dependent on their hosts for ATP.
- However, this might not be the complete story.
- The complete sequence of the *C. Trachomatis* genome indicates that the bacterium may be able to synthesize at least some ATP.
- Although there are two genes for ATP/ADP translocases, there also are genes for substrate-level phosphorylation, electron transport, and oxidative phosphorylation.
- When supplied with precursors from the host, RBs can synthesize DNA, RNA, glycogen, lipids, and proteins.
- The EBs have minimal metabolic activity and cannot take in ATP or synthesize proteins. They seem to be dormant forms concerned exclusively with transmission and infection.

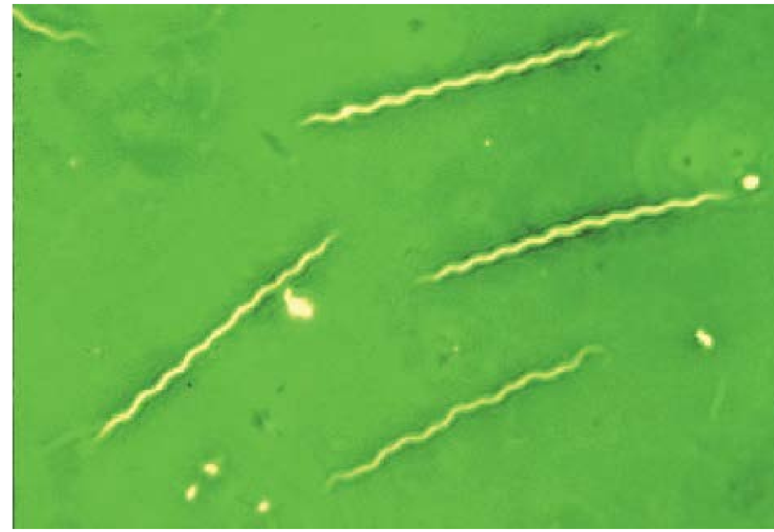
- Three chlamydial species are important pathogens of humans and other warm-blooded animals.
- *C. trachomatis infects* humans and mice.
- In humans it causes trachoma, nongonococcal urethritis, and other diseases*.*
- *C. psittaci causes* psittacosis in humans. However, unlike *C. trachomatis, it also infects* many other animals (e.g., parrots, turkeys, sheep, cattle, and cats) and invades the intestinal, respiratory, and genital tracts; the placenta and fetus; the eye; and the synovial fluid of joints.
- *Chlamydia pneumoniae is a common cause of human pneumonia.*
- There is now indirect evidence that infections by *C. pneumoniae* may be associated with the development of atherosclerosis and that chlamydial infections may cause severe heart inflammation and damage.
- Recently a fourth species, *C. pecorum, has been* recognized.

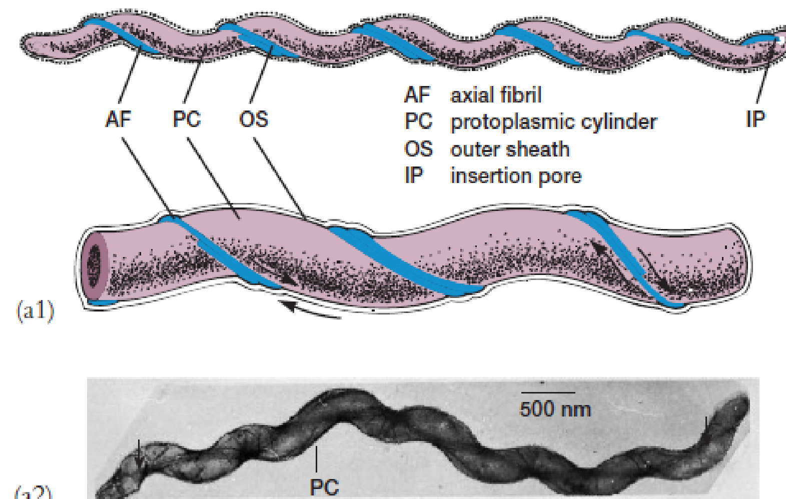
Phylum *Spirochaetes*

- The phylum Spirochaetes [Greek spira, a coil, and chaete, hair] contains gram-negative, chemoheterotrophic bacteria distinguished by their structure and mechanism of motility.
- They are slender, long bacteria (0.1 to 3.0 μm by 5 to 250 μm) with a flexible, helical shape (**figure 21.15).**
- Many species are so slim that they are only clearly visible in a light microscope by means of phase contrast or dark-field optics.
- Spirochetes differ greatly from other bacteria with respect to motility and can move through very viscous solutions though they lack external rotating flagella.
- When in contact with a solid surface, they exhibit creeping or crawling movements.
- Their unique pattern of motility is due to an unusual morphological structure called the axial filament.

... Phylum *Spirochaetes*

- The distinctive features of spirochete morphology are evident in electron micrographs (**figure 21.16).**
- **The central protoplasmic** cylinder contains cytoplasm and the nucleoid, and is bounded by a plasma membrane and gram-negative type cell wall.
- It corresponds to the body of other gram-negative bacteria.
- Two to more than a hundred procaryotic flagella, called **axial fibrils, periplasmic flagella or endoflagella, extend from both ends** of the cylinder and often overlap one another in the center third of the cell.
- The whole complex of periplasmic flagella, the **axial filament, lies inside a** flexible outer sheath or outer membrane.
- The outer sheath contains lipid, protein, and carbohydrate and varies in structure between different genera.





… Phylum *Spirochaetes*

- Presumably the periplasmic flagella rotate like the external flagella of other bacteria.
- This could cause the corkscrew-shaped outer sheath to rotate and move the cell through the surrounding liquid.
- Spirochetes can be anaerobic, facultatively anaerobic, or aerobic.
- Carbohydrates, amino acids, long-chain fatty acids, and long-chain fatty alcohols may serve as carbon and energy sources.
- The group is exceptionally diverse ecologically and grows in habitats ranging from mud to the human mouth.
- Members of the genus *Spirochaeta* are free-living and often grow in anaerobic and sulfide-rich freshwater and marine environments.
- The second edition of Bergey's Manual divides the phylum Spirochaetes into one class, one order (Spirochaetales), and three families (*Spirochaetaceae, Serpulinaceae, and Leptospiraceae).*
- At present, there are 13 genera in the phylum.

Deinococcus

Scientific classification	
Domain:	Bacteria
Phylum:	Deinococcota
Class:	Deinococci
Order:	Deinococcales
Family:	Deinococcaceae Brooks and Murray 1981
Genus:	***Deinococcus*** Rainey et al. 1997
Type species	
Deinococcus radiodurans	

- These bacteria have thick cell walls that give them Gram-positivestains, but they include a second membrane and so are closer in structure to Gram-negative bacteria.
- *Deinococcus* survive when their DNA is exposed to high doses of gamma and UV radiation.
- Whereas other bacteria change their structure in the presence of radiation, such as by forming endospores, *Deinococcus* tolerate it without changing their cellular form and do not retreat into a hardened structure.
- They are also characterized by the presence of the carotenoid pigment deinoxanthin that give them their pink color.
- In August 2020, scientists reported that bacteria from Earth, particularly Deinococcus bacteria, were found to survive for three years in outer space, based on studies conducted on the International Space Station.

These findings support the notion of panspermia, the hypothesis that life exists throughout the Universe, distributed in various ways, including space dust, meteoroids, asteroids, comet, planetoids or contaminated space-craft

… *Deinococcus*

- The genome structure of *Deinococcus radiodurans* is made up of two chromosomes, a megaplasmid, and a small plasmid.
- The megaplasmid and chromosomes qualities are in part what allows the organism to withstand γ-radiation, desiccation, and oxidizing agents as well as many other DNA-damaging conditions such as starvation.
- *Deinococcus* typically forms a tetrad shape, allowing a second division to begin before the first is complete during cell division.
- *Deinococcus* is chemoorganotrophic.
- *Deinococcus* have been grown from a variety of materials including soil, animal feces, and meat.
- It is speculated that these aerobic bacteria are likely to live in rich organic habitats, such as feces or intestinal contents.