Firmicutes

By-

Dr. Ekta Khare

Firmicutes

- The third volume of the second edition of Bergey's Manual describes the low G+C gram-positive bacteria.
- These are placed in the phylum Firmicutes and divided into three classes:
  - Clostridia,
  - Mollicutes, and
  - Bacilli
- The phylum Firmicutes is large and complex; it has 10 orders and 33 families.

Class Mollicutes (the Mycoplasmas)

- The class Mollicutes has five orders and six families.
- The best studied genera are found in the orders Mycoplasmatales *(Mycoplasma, Ureaplasma).*
- Members of the class *Mollicutes are commonly called* ***mycoplasmas.***
- These bacteria lack cell walls and cannot synthesize peptidoglycan precursors.
- Thus they are penicillin resistant but susceptible to lysis by osmotic shock and detergent treatment.
- Because they are bounded only by a plasma membrane, these procaryotes are pleomorphic and vary in shape from spherical or pear-shaped organisms, about 0.3 to 0.8 μm in diameter, to branched or helical filaments.
- Some mycoplasmas (e.g., *M. genitalium*) have a specialized terminal structure that projects from the cell and gives them a flask or pear shape.
- This structure aids in attachment to eucaryotic cells.

- They are the smallest bacteria capable of self-reproduction (Before discovery of nanoarcheota).
- Although most are nonmotile, some can glide along liquid-covered surfaces.
- Most species differ from the vast majority of bacteria in requiring sterols for growth.
- They usually are facultative anaerobes, but a few are obligate anaerobes.
- When growing on agar, most species will form colonies with a “fried-egg” appearance because they grow into the agar surface at the center while spreading outward on the surface at the colony edges (**figure 23.3).**
- **Their genome is** one of the smallest found in procaryotes, about 5 to $10x10^8$ daltons; the G + C content ranges from 23 to 41%.
- Mycoplasmas can be saprophytes, commensals, or parasites, and many are pathogens of plants, animals, or insects.

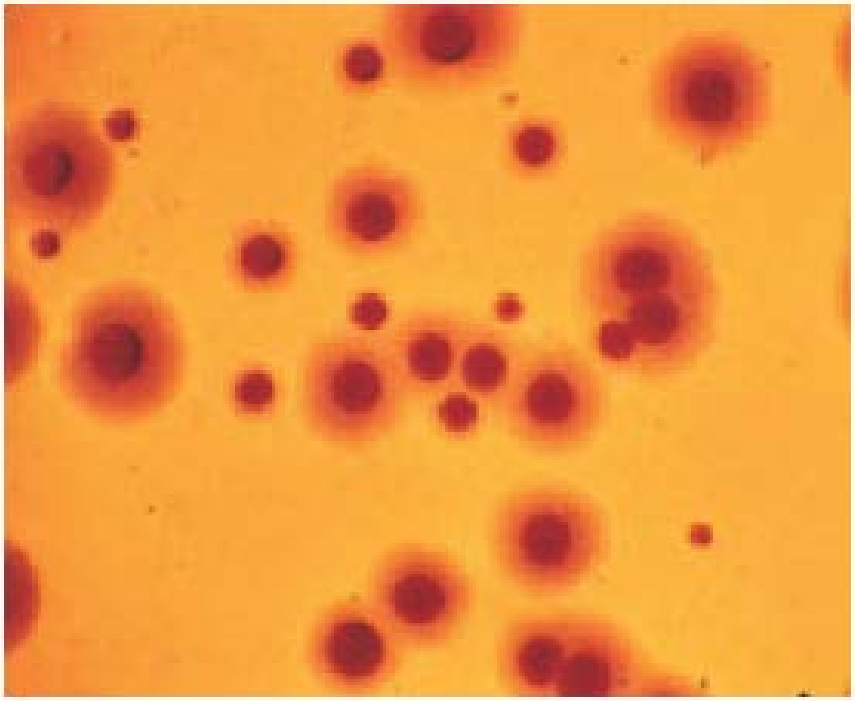

Figure 23.3 ***Mycoplasma*** **Colonies.** Note the "fried egg" appearance, colonies stained before viewing (×100).

- The metabolism of mycoplasmas is not particularly unusual, although they are deficient in several biosynthetic sequences and often require sterols, fatty acids, vitamins, amino acids, purines, and pyrimidines.
- Those mycoplasmas needing sterols incorporate them into the plasma membrane.
- Mycoplasmas are usually more osmotically stable than bacterial protoplasts, and their membrane sterols may be a stabilizing factor.
- Mycoplasmas are remarkably widespread and can be isolated from animals, plants, the soil, and even compost piles.
- Mycoplasmas cause several major diseases in livestock, for example, contagious bovine pleuropneumonia in cattle (*M. mycoides),* chronic respiratory disease in chickens (*M. gallisepticum),* and pneumonia in swine (*M. hyopneumoniae).*
- *M. pneumoniae* causes primary atypical pneumonia in humans, and there is increasing evidence that *M. hominis and Ureaplasma* urealyticum also are human pathogens.

Class Clostridia

- The class *Clostridia* has a very wide variety of gram-positive bacteria distributed into three orders and 11 families.
- By far the largest genus is *Clostridium.*
- It includes obligately anaerobic, gram-positive bacteria that form endospores and do not carry out dissimilatory sulfate reduction.
- Members of the genus *Clostridium* have great practical impact.
- Because they are anaerobic and form heat-resistant endospores,
- They are responsible for many cases of food spoilage, even in canned foods.
- *C. botulinum* is the causative agent of botulism.
- Clostridia often can ferment amino acids to produce ATP by oxidizing amino acid.
- This reaction generates ammonia, hydrogen sulfide, fatty acids, and amines during the anaerobic decomposition of proteins.
- These products are responsible for many unpleasant odors arising during putrefaction. Several clostridia produce toxins and are major disease agents.
- *C. tetani* is the causative agent of tetanus, and *C. perfringens* , of gas gangrene and food poisoning.
- Clostridia also are industrially valuable; for example, *C. acetobutylicum* is used to manufacture butanol in some countries.

Class Clostridia: *Heliobacterium*

- The heliobacteria, genera *Heliobacterium* and *Heliophilum,* are a group of unusual anaerobic photosynthetic bacteria characterized by the presence of bacteriochlorophyll *g.*
- They have a photosystem I type reaction center like the green sulfur bacteria, but have no intracytoplasmic photosynthetic membranes; pigments are contained in the plasma membrane.
- They have a gram-positive type cell wall with lower than normal peptidoglycan content, and they stain gram negative.
- Some heliobacteria form endospores.

Order Bacillales

- The genus *Bacillus,* family Bacillaceae, is the largest in the order.
- The genus contains gram-positive, endospore-forming, chemoheterotrophic rods that are usually motile and peritrichously flagellated.
- It is aerobic, or sometimes facultative, and catalase positive.
- The 4.2 million base pair genome of *Bacillus subtilis,* the type species of the genus *Bacillus,* has been sequenced.
- For example, members of the genus *Bacillus* produce the antibiotics bacitracin, gramicidin, and polymyxin. *B. cereus* causes some forms of food poisoning and can infect humans.
- *B. anthracis* is the causative agent of the disease anthrax, which can affect both farm animals and humans.
- Several species are used as insecticides. For example, *B. thuringiensis* and *B. sphaericus*

Family Staphylococcaceae

- The family *Staphylococcaceae* contains four genera, the most important of which is the genus *Staphylococcus.*
- Members of this genus are facultatively anaerobic, nonmotile, gram positive cocci that usually form irregular clusters*.*
- They are catalase positive, oxidase negative, ferment glucose, and have teichoic acid in their cell walls.
- Staphylococci are normally associated with the skin, skin glands, and mucous membranes of warm-blooded animals.
- Staphylococci are responsible for many human diseases.
- *S. epidermidis* is a common skin resident that is sometimes responsible for endocarditis and infections of patients with lowered resistance (e.g., wound infections, surgical infections, urinary tract infections).
- *S. aureus* is the most important human staphylococcal pathogen and causes boils, abscesses, wound infections, pneumonia, toxic shock syndrome, and other diseases.
- Recently strains of multiple drug resistant *S. aureus* have appeared and proven very difficult to treat medically.
- Unlike other common staphylococci, *S. aureus produces* the enzyme **coagulase, which causes blood plasma to clot.**
- Growth and hemolysis patterns on blood agar are also useful in identifying these staphylococci.

Order Lactobacillales

- Many members of the order *Lactobacillales* produce lactic acid as their major or sole fermentation product and are sometimes collectively called **lactic acid bacteria.**
- *Streptococcus, Enterococcus, Lactococcus, Lactobacillus, and Leuconostoc* are all members of this group.
- Lactic acid bacteria are nonsporing and usually nonmotile.
- They lack cytochromes and obtain energy by substratelevel phosphorylation rather than by electron transport and oxidative phosphorylation.
- They normally depend on sugar fermentation for energy.
- Nutritionally they are fastidious and many vitamins, amino acids, purines, and pyrimidines must be supplied because of their limited biosynthetic capabilities.
- Lactic acid bacteria usually are categorized as facultative anaerobes, but some classify them as aerotolerant anaerobes.

Lactobacillus

- The largest genus in this order is *Lactobacillus* with almost 80 species.
- *Lactobacillus* contains nonsporing rods and sometimes coccobacilli that lack catalase and cytochromes, are usually facultative or microaerophilic, produce lactic acid as their main or sole fermentation product, and have complex nutritional requirements.
- Lactobacilli carry out either a homolactic fermentation or a heterolactic fermentation.
- They grow optimally under slightly acidic conditions, when the pH is between 4.5 to 6.4.
- The genus is found on plant surfaces and in dairy products, meat, water, sewage, beer, fruits, and many other materials.
- Lactobacilli also are part of the normal flora of the human body in the mouth, intestinal tract, and vagina.
- They usually are not pathogenic.
- Lactobacilli are used in the production of fermented vegetable foods (sauerkraut, pickles, silage), beverages (beer, wine, juices), sour dough, Swiss cheese and other hard cheeses, yogurt, and sausage.

Family Streptococcaceae

- *Streptococcus,* which is Gram positive facultatively anaerobic and catalase negative.
- The streptococci occur in chains when grown in liquid media.
- They do not form endospores, and usually are nonmotile.
- They are all chemoheterotrophs that ferment sugars with lactic acid, but no gas, as the major product—that is, they carry out homolactic fermentation.
- A few species are anaerobic rather that facultative.
- Pyogenic streptococci usually are pathogens and associated with pus formation (pyogenic means pus producing).