

Phylum Firmicutes

2-Class Bacilli

The class Bacilli is very large but includes only **two** orders, **Bacillales** and **Lactobacillales**. These include genera representing cocci, endospore-forming rods and cocci, and nonsporing rods.

1-Order Bacillales

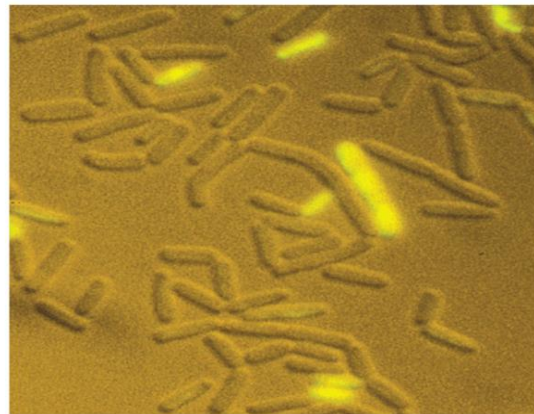
Family Bacillaceae

The largest family in the order **Bacillales**. The genus (**Bacillus**) contains endospore-forming, chemoheterotrophic rods that are usually motile with peritrichous flagella (Figure.1).

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(a) *Bacillus anthracis*



(b) *B. cereus*

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Figure 1:Bacilli

Members of this genus are aerobic or facultative and catalase positive. *Bacillus subtilis*, the type species for the genus, is the most well-studied Gram-positive bacterium. It is a facultative anaerobe that can use nitrate as a terminal electron acceptor or perform mixed acid fermentation with lactate, acetate, and acetoin as major end products. It is nonpathogenic and a great model organism for the study of gene regulation, cell division, quorum sensing, and cellular differentiation.

Many species of *Bacillus* are of considerable importance. They are the source of the antibiotics **bacitracin**, **gramicidin**, and **polymyxin**. *B. cereus* can cause food poisoning.

Scientific classification

Domain Bacteria
Phylum Firmicutes
Class Bacilli
Order Bacillales
Family Bacillaceae
Genus *Bacillus*
Species *B. subtilis*

Sporosarcina this distinguished **genus** in order **Bacillales** is one of **five genera** in the family ***Panococcaceae***, and it contains the only known endospore-forming bacterium that has a coccoid rather than rod shape. ***S. ureae*** is particularly interesting because it is tolerant of very alkaline conditions (up to **pH 10**), which it creates when it degrades urea to **C02** and **NH3**. Interestingly, it is easily isolated from agricultural soils on which animals frequently urinate.

Family Staphylococcaceae

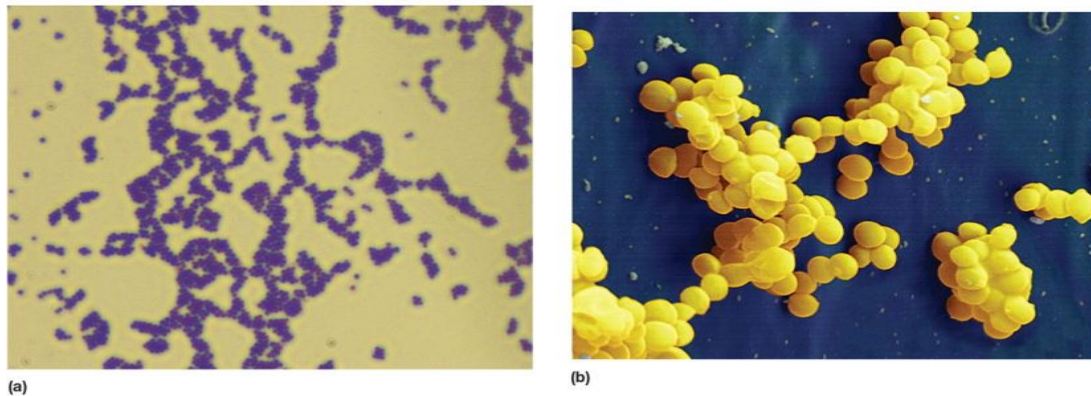
Facultatively anaerobic, nonmotile, Gram-positive cocci .Usually form irregular clusters

(Figure .2) . Staphylococci are normally associated with the skin and mucous membranes of warm-blooded animals. They 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, surgical and 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.

In addition to causing skin and wound infections, *S. aureus* is a major cause of food poisoning. The most common source is contaminated dairy products. However, because *S. aureus* is salt tolerant, another important source is sliced luncheon meats.

One important virulence factor produced by *S. aureus* is the enzyme coagulase, which causes blood plasma to clot. Growth and hemolysis patterns on blood agar are also useful in identifying these staphylococci.

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a: Joanne M. Willey Ph.D.; b: © Photo Researchers, Inc.

Figure 2 :Staphylococci

Scientific classification

Domain Bacteria
Phylum Firmicutes
Class Bacilli
Order Bacillales
Family Staphylococcaceae
Genus Staphylococcus
Species *S. aureus*

Family Listeriaceae

The family Listeriaceae includes **two** genera: **Brochothrix** and **Listeria**. *Brochothrix spp.* are most commonly found in meat but are not pathogenic. *Listeria* is the medically important genus in this family. It contains short rods that are facultatively anaerobic, catalase positive, and motile by peritrichous flagella. In addition to aerobic respiration, these

microbes ferment glucose mainly to lactate. *Listeria spp.* are widely distributed

in nature, particularly in decaying matter. *L. monocytogenes* is a pathogen of humans and other animals, and causes **listeriosis**, an important food-borne infection.

2-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 (LAB)**. *Streptococcus*, *Enterococcus*, *Lactococcus*, *Lactobacillus*, and *Leuconostoc* are all members of this group. Lactic acid bacteria **do not** form **endospores** and are usually **nonmotile**. They depend on **sugar** fermentation for energy. They lack **cytochromes** and obtain energy by substrate-level phosphorylation, rather than by electron transport and oxidative phosphorylation. Nutritionally, they are fastidious, and many vitamins, amino acids, purines, and pyrimidines must be supplied because of their limited biosynthetic capabilities.

1-Family Lactobacillaceae

Lactic acid bacteria usually are categorized as facultative anaerobes but can be considered aerotolerant. The largest genus in this order is *Lactobacillus*, with about 100 species. Lactobacilli include rods and some coccobacilli. All lack catalase and cytochromes, and produce lactic acid as their main or sole fermentation product. They grow optimally under slightly acidic conditions, at a pH between 4.5 and 6.4, and are found 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 particular they are important normal vaginal flora.

Scientific classification

Domain Bacteria
Phylum Firmicutes
Class Bacilli
Order Lactobacillales
Family Lactobacillaceae
Genus Lactobacillus (Type genus)

2-Family Leuconostocaceae,

Contains facultative Gram-positive cocci, which may be elongated or elliptical and arranged in pairs or chains. *Leuconostoc* lack **catalase** and **cytochromes**. They can be isolated from **plants**, **silage**, and **milk**. They are used in **wine production**, in the fermentation of vegetables, and in the manufacture of **milk**, **butter**, and **cheese**. *L. mesenteroides* synthesizes **dextrans** from **sucrose** and is important in industrial dextran production.

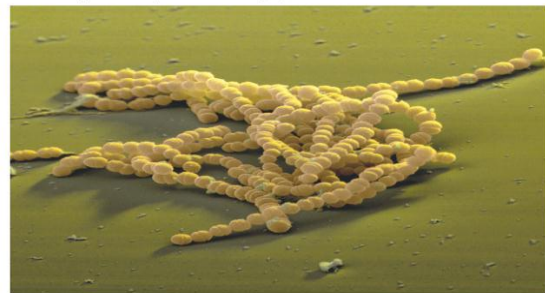
3-Family Streptococcaceae

This family includes only two genera: Lactococcus and Streptococcus. Lactococcus spp. ferment sugars to lactic acid and can grow at 10°C but not at 45°C. *L. lactis* is widely used in the production of buttermilk and cheese because it can curdle milk and add flavor through the synthesis of diacetyl and other products.

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(a) *Streptococcus pyogenes*



(b) *S. agalactiae*

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Figure 3 : Streptococci

The genus **Streptococcus** is large and complex. All species in the genus are form chains of cells (Figure 3), facultatively anaerobic and catalase negative. Many characteristics are used to identify these cocci. One of the most important is the ability to lyse red blood cells when grown on blood agar, an agar medium containing **5%** sheep or horse blood (Figure 4).

Serological studies are also very important in identification because streptococci often have distinctive cell wall antigens. These bacteria produce a surface protein, the M protein, that is important in pathogenesis and species identification.

The Lancefield grouping system, used for many years, was based on structural variations in **M protein** structure. This system has largely been replaced by sequence

analysis of the *emm* gene, which encodes the M protein. Biochemical and physiological tests, and sensitivity to bacitracin, sulfa drugs, and **optochin** (a **quinine analogue**) also are used to identify particular species.

The streptococci have been divided into **three** groups: **pyogenic streptococci**, **oral streptococci**, and **other streptococci**.

Pyogenic streptococci are pathogens associated with pus formation. The major human pathogen in this group is *S. pyogenes*, which causes **streptococcal sore throat**, **acute glomerulonephritis**, and **rheumatic fever**.

The normal habitat of oral streptococci is the **oral cavity** and **upper respiratory tract** of humans and other animals.

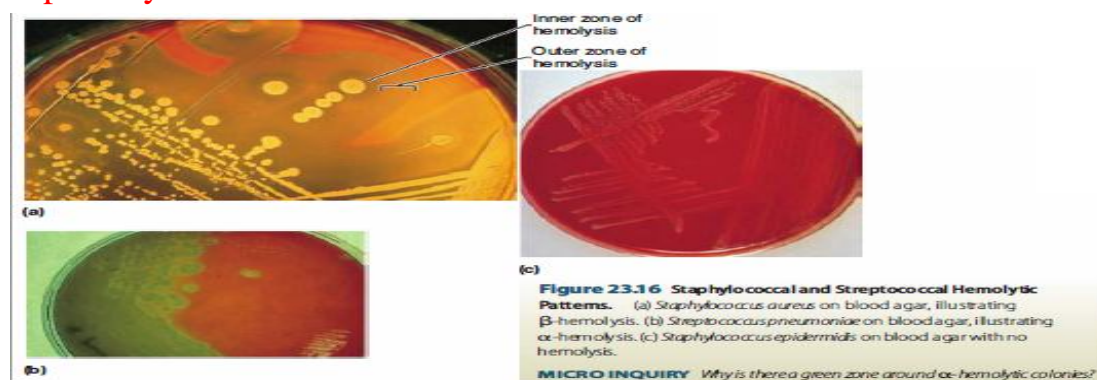


Figure 4 :Hemolysis in the bacteria of class Bacilli