Chaper 3 Prokaryotes

Section 1 Bacteria

1 Shape

There are a few basic shapes-spherical coccus (plural, cocci, meaning berries), rod-shaped bacillus (plural, bacilli, meaning little staffs), and spiral spirallum，which include Vibrio, Spirillum and Spirochete.

Some bacteria are shaped like long rods twisted into spirals or helices; they are called vibrios (like commas or incomplete spirals), spirillium if rigid and spirochetes when flexible

2 Size

Most bacteria fall within a range from 0.2 to 2.0 μm in diameter or width and from 2 to 8μm in length.

3 Arrangement of the cells

1) Arrangement of cocci

Based on the arrangement of cells, cocci could be divided into diplococci, streptococci, tetracocci, sarcinae and staphylococci.

2) Arrangement of bacilli

Bacilli can be divided only across their short axis, so there are fewer groupings of bacilli than of cocci. They are Single bacillus, Diplobacilli, Streptobacilli and Coccobacillus.

4 Typical species of bacteria

Micrococcus – aerobic, gram-positive, catalase positive. Cell arranges mainly in pairs, tetrads, or irregular clusters, nonmotile. They are often yellow, orange or red in colour

Staphylococcus - facultatively anaerobic, gram-positive, usually form irregular clusters, nonmotile, catalase positive but oxidase negative, ferment glucose anaerobically.

Streptococcus - facultatively anaerobic or microaerophilic, catalase negative, gram-positive. Cell arranges in pairs or chains, usually nonmotile.

A few species are anaerobic rather than facultative.

Spore-forming bacilli

Almost all Spore-forming bacteria are Gram+

Bacillus – Aerobic

Bacillus subtilis,

B. Mycoides

B. Pastturii

B. megaterium

B. Thuringiensis

B. Anthracis

B. Botulinus

B. cereus

Clostridium – Anaerobic

Clostridium botulinus

C. butyricum
C. aceticum
C. tetani
C. putrificum
Nonspore - forming bacilli
Most nonspore – forming rod shaped bacteria are Gram-
Representatives:
Escherchia coli
Alcaligenes
Proteus
Flavobacteria
Pseudomonas
Rhizobium
Azotobacter

Section 2 Actinomycetes

Actinomycetes are filamentous procaryotes, which distribute widely in nature, especially in soil. We have much more interest in them for many types of antibiotics are produced by them.

1 Features of actinomycetes
They are filamentous, contain no photosynthetic pigment.
They have high G + C content- 63 – 78% GC.
They are Gram-positive.
They produce only asexual spores.

2 Morphology of actinomycetes
Substrate mycelium, mycelium that grows in the substate.
Aerial mycelium, mycelium that derives from substrate mycelium and grows in the air.
Spore bearing chain, mycelium that developes from aerial mycelium and can be turned in spores.
Conidiospore or spore.

3 Reproduction of Actinomycetes
Actinomycetes reproduce asexually by forming spores or fragments of hyphae.

4 Representive of Actinomycetes
Representive genera:
Streptomyces
Nocardia
Actinomyces
Micromonospora
Streptosporangium
Actinoplanes
Frankia

Over 500 distinct antibiotic substances have been shown to be produced by streptomycete.
Ecology of Streptomyces
Alkaline and neutral soils are more favorable for the development of Streptomyces than acid soils.
Streptomyces require a lower water potential for growth than many other soil bacteria.
Media often selective for streptomyces contain the usual assortment of inorganic salts

Section 3 Cyanobacteria

1 Shape and size

* The cells of cyanobacteria are spherical or rod -shaped.
* They have typical prokaryotic cell structures and a normal gram-negative cell wall.
* They have chlorophyll
* They occur in two states (morphological diversity) :

--Unicellular cell.
--Filament with a sheath outside cell wall.
They range in diameter from about 3 – 10 μm.

2 Heterocyst
Heterocyst, the larger cells in the filament of cyanobateria, with thicker cell wall and less photosynthetic pigment that can carry out nitrogen-fixing.
Heterocysts have intercellular connections with adjacent vegetative cells, and there is mutual exchange of materials between these cells, with products of photosynthesis moving from vegetative cells to heterocysts and products of nitrogen fixation moving from heterocysts to vegetative cells.

3 Main function of Cyanobacteria
Photosynthesis
Nitrogen fixation
They are one of the ancient procaryotes that play a very important role in forming and developing of life on the earth, by producing carbonhydrate and oxygen and fixing nitrogen.

4 Economic value and problems caused

1) Economic value
   * *Nostoc flagelliforme* and *Nostoc commune* could be used as vegetables.
   * Spirulina platensis could be used as healthy food.
2) Problems caused

*They can cause red tide and water bloom when water body is polluted by nitrogen, phosphorus, and so on.

* Many cyanobacteria produce potent neurotoxins, and during water blooms when massive accumulations of cyanobacteria may develop, animals ingesting such water may succumb rapidly

Section 4 Archaebacteria

Archaeobacteria differ from eubacteria in a number of ways.

Their cell walls never contain peptidoglycan.
They often live in extreme environments, and they carry out unusual metabolic processes.

1 Pseudopeptidoglycan

Some species of archaebacteria have walls composed of pseudopeptidoglycan, which resembles the peptidoglycan of eubacteria. However, there are some differences,

* They contains N-acetyltalosaminuronic acid instead of N-acetylmuramic acid and L-amino acids instead of the D-amino acids in eubacterial cell walls.

* The peptide bridge has only one L-amino acids .

* The bonds between the carbohydrates in pseudopeptidoglycan are β 1-3 instead of' β 1-4 as in peptidoglycan. So it can not be digested by lysozyme.

2 Archaebacteria under extreme condition

Archaebacteria usually live in extreme circumstance, so they are also called extremophile.
The methanogens are strict anaerobes that produce methane (CH4) from carbon dioxide and hydrogen.
Extreme halophiles require high concentrations of salt for survival.
Thermoacidophiles normally grow in hot, acidic environments.
More about the extremophiles.
Methanogenic bacteria are strict anaerobes that obtain energy by converting $C0_2$, H_2, format, acetate, and other compounds to either methane or methane and $C0_2$.

$C0_2 + 4\ H_2$ ------ $CH_4 + 2\ H_2O$

CH_3 C00 H ------ $C0_2 + CH_4$

Sewage treatment plants use the methane produced from the sewage to generate heat and electricity, and methanogenesis may eventually serve as a major source of pollution-free energy.
Extremely thermophilic bacteria are gram-negative, aerobic, irregularly lobed spherical bacteria with a temperature optimum around 70-80 ℃ and a pH optimum of 2 to 3. Their cell wall contains lipoprotein and carbohydrates but lacks peptidoglycan.
The most distinctive characteristic of thermoacidophiles is their requirement of a high concentration of sodium chloride for growth.
They are aerobic chemoheterotrophs with respiratory metabolism and require complex nutrients, usually proteins and amino acids, for growth.

Section 5 Other prokaryotes

1 Rickettsia

They are 0.2-0.5μm in diameter, obligate intracellular parasites. The majority of them are gram-negative and multiply only within host cells.
They show binary fission within host cells. They lack the enzymatic capability to produce sufficient amounts of ATP to support their reproduction. They obtain the ATP from host cells.
Many species of them cause disease in humans and other animals.

2 Chlamydia

There are two forms of Chlamydia, and they are elementary body which is infectious, 0.3μm in diameter and initial body which is non-infectous, 0.8-1.2μm in diameter.
They are obligate intracellular parasites, unable to generate sufficient ATP to support their reproduction.
They are Gram-negative and their cells can be divided by binary fission
The Chlamydia cause human respiratory and genitourinary tract disease, and in birds they cause respiratory disease.

3 Mycoplasma

* They are 0.1-0.25 μm in diameter.
* They lack cell wall, and they are bounded by a single triple-layered membrane.
* They are the smallest organisms capable of self-reproduction.
* The colony is "fried egg" appearance.
* Several of them cause diseases in humans. (pneumoni, respiratory tract disease)

4 Bdellovirio

They are 0.3-0.6μm in width and 0.8-1.2μm in length.

5 Myxobacteria

Their vegetative cells are rod-shaped, 1.5μm in diameter.
Vegetative cells can form visible fruiting body, which can produce myxospore.
Myxospores germinate and then develop into vegetative cells.

Section 6 Identification of bacteria

The thousands of species of bacteria are differentiated by many factors, including,

* Morphology, but many microorganisms appear too similar to be classified by their structures.
* Chemical composition (often by staining reactions)
* Nutritional requirements
* Biochemical activities
* Source of energy (sunlight or chemicals).
* Genetic material.

NUMERICAL TAXONOMY is often used for identification of bacteria.
The taxonomic classification scheme for bacteria may be found in Bergey's Manual of Systematic Bacteriology. In Bergey's Manual, bacteria（Kingdom Procaryotae）are divided into four divisions. Three divisions consist of eubacterial cells, and the fourth division consists of the archaeobacteria. Each division is divided into classes.

Kingdom,
 Division,
  Classes,
   Orders,
    Families,

Genera,

Species.

Bacterial **species** is defined simply as a population of cells with similar characteristics.

Strain is a group of cells all derived from a single cell.