0905423
Biochemical Engineering

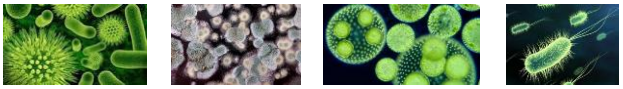
Instructor
Dr. Linda Al-Hmoud

First Semester 2016/2017

ELEMENTARY BIOCHEMISTRY & MICROBIOLOGY

Overview of Microbiology

- **Microbiology**
  (in Greek micron = small and
  biologia = studying life) is the study of microorganisms at the cell level.
- **Microorganism** refers to any organism too small to be viewed by the unaided eye, as bacteria, fungi, algae and protozoa.



  - It is often illustrated using single-celled, or unicellular organisms

Overview of Microbiology

- Cells are packages of living matter surrounded by membranes or walls.
- Within the cell are various organelles in controlling life processes:
  - for the cell intake of nutrients,
  - production of energy,
  - discharge of waste materials, and
  - reproduction.

Microbial diversity

- Cell adaptation to the environment
  - Temperature
  - pH
  - Moisture
  - Oxygen
  - Nutrient resources

Microbial diversity

- Temperature
  - **Psychrophiles** grow best at low temperature (below 20 °C)
    - e.g. Leifsonia rubra isolated from Antarctica
  - **Mesophiles** grow between 20 °C and 50 °C
    - important uses in food preparation such as cheese, yoghurt, beer and wine making, e.g. Saccharomyces cerevisiae.
  - **Thermophiles** grow best at temperatures greater than 50 °C
  - Thermus aquaticus is a species of bacterium that can tolerate high temperatures. It thrives at 70° C, but can survive at temperatures 50 °C – 80 °C .
  - Regular sterilization at 121 °C .

Microbial diversity

- **pH**
  - **Acidophiles** are microbes that tends toward acidic conditions pH (at or below 3)
    - e.g. Acidithiobacillus ferrooxidans in acid mine drainage.
  - **Alkaliphiles** are microbes that thrive in alkaline environments with a pH of 9 or above.
    - e.g. Bacillus okhensis living in carbonate soil.

Microbial diversity

- **Moisture**
  - Some organisms can grow
    - where the water activity is high (e.g. algae)
    - on barely moist solid surface (mold)
    - in solutions with high salt concentrations

Microbial diversity

- **Oxygen**
  - Some microorganism requires oxygen for growth and metabolism, and they are called **aerobic**.
  - Other organism can be inhibited by the presence of oxygen and grow only **anaerobically**.
  - **Facultative** can switch the metabolic pathway to allow them to grow under either circumstance.
    - e.g. Saccharomyces cerevisiae.
  - ***Almost all animals, most fungi and several bacteria are aerobes.***
  - ***Most anaerobic organism are bacteria.***

Microbial diversity

- **Nutrient sources**
  - Microorganism can be classified into two categories on the basis of their carbon sources:
    - **Heterotrophs** use organic compounds such as carbohydrates, lipids, and hydrocarbons as a carbon and energy source.
    - **Autotrophs** use carbon dioxide as a carbon source.
      - e.g. cyanobacteria

Microbial diversity

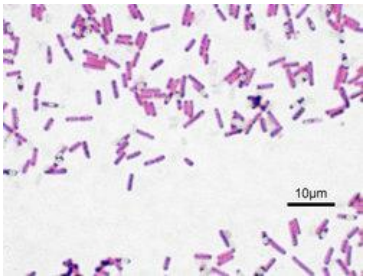
- **Extremophiles**
  - Organism from those extreme environments
  - Often provide the human race with important tools for processes to make useful chemicals and medicinal
    - Acidophile vs. Alkaliphile
    - Psychrophile vs. Thermophile
    - Halophile: An organism requiring at least 0.2M of NaCl for growth.

Microbial diversity

- **Shape (Bacteria)**
  - **coccus** (cocci, pl): A cell with a spherical or elliptical shape.
    - e.g. Streptococcus is a genus of spherical bacteria

Microbial diversity

- **Shape (Bacteria)**
  - **bacillus** (bacilli, pl): a cylindrical cell or rod
    - e.g. Bacillus subtilis is a bacterium that is commonly found in soil.



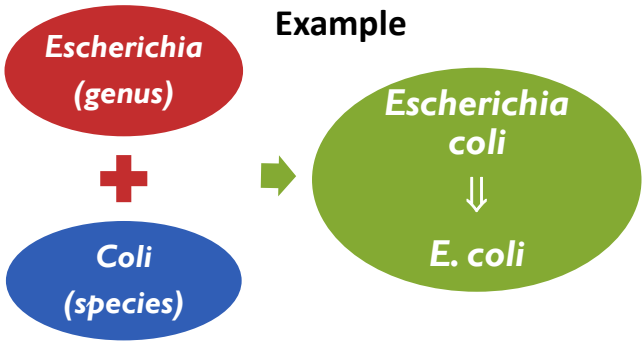
Microbial diversity

- **Shape (Bacteria)**
  - **spirillum** (spirilla, pl): a spiral-shaped cell.
    - e.g. Rhodospirillum is a bacterium.

  - Some cells may change shape in response to changes in their local environment.

Naming Cells

- Dual name (binary nomenclature) is used
- Names are given in Latin or Latinized
- Microorganism name includes genus & species:
  - **A genus:** a group of related species
  - **A species:** includes organisms that are substantially alike.



Naming Cells

- ***Escherichia*** is the *genus*, the first letter is capitalized
- ***coli*** is the *species* in lower case
- *Abbreviation: E. coli*
- Various strain and substrains are designated by the addition of letters and numbers.
  - e.g. *E. coli* K12, *E. coli* B/rA

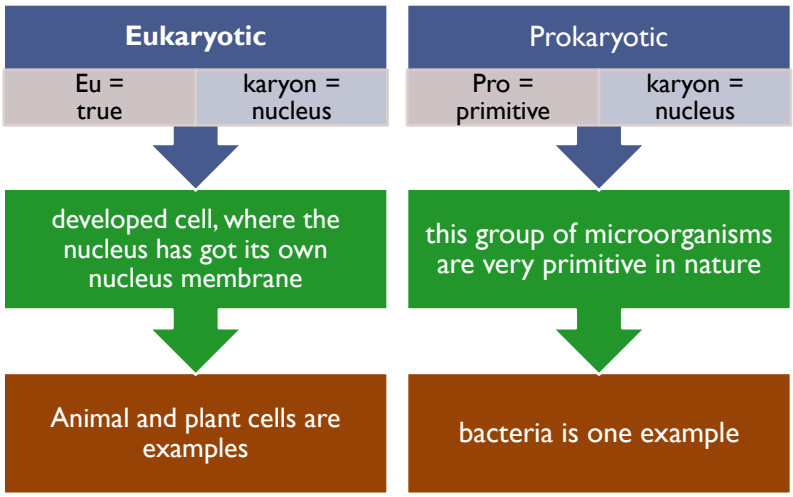
Exercise

What is GMP and how does it relate to the regulatory process for pharmaceuticals?

Work in groups of two!

Search the net, and write a paragraph to answer the question.

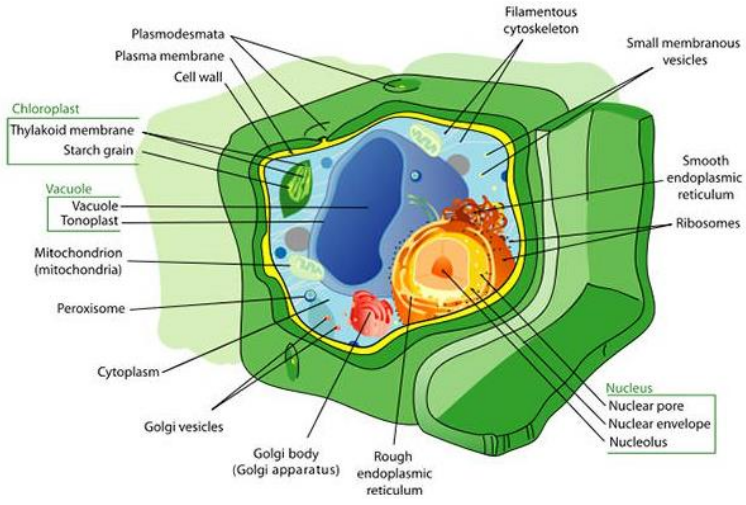
Classification of Cells (according to cell structure)



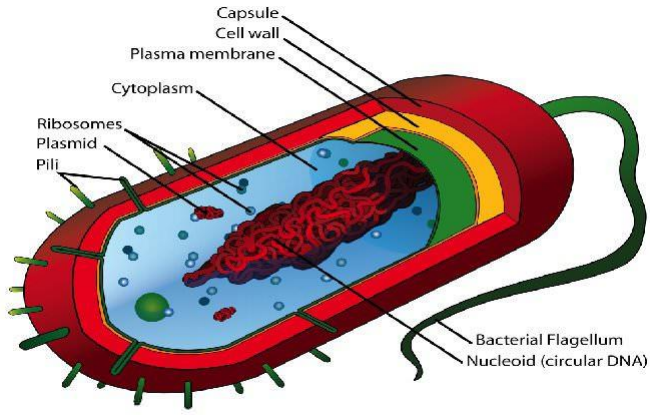
Classification of Cells (according to cell structure)

Cell	
Eukaryotic	**Prokaryotic**
Have nuclear membrane and membrane–bound organelles	Have no nuclear membrane and no organelles
More complex internal structure	Simple structure
More than one chromosome	Single chromosome

Eukaryotes



Prokaryotes



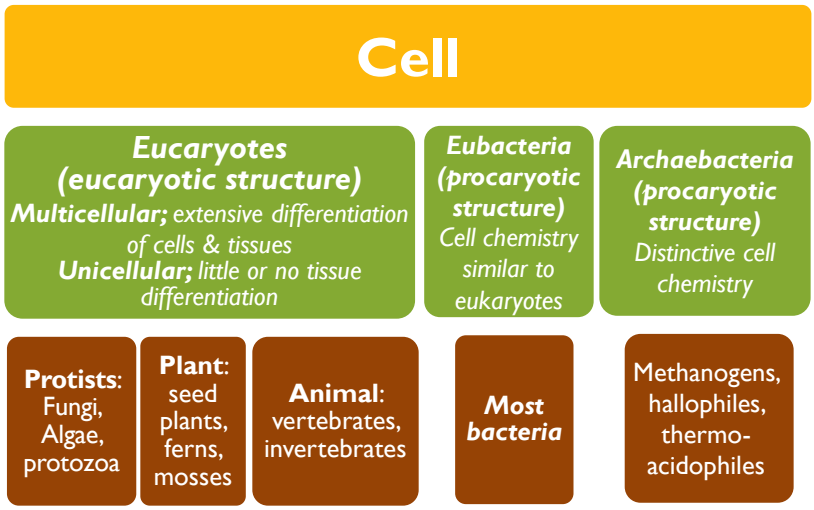
A comparison of Procaryotes and Eucaryotes

Characteristic	Eucaryotic	Procaryotic
Genomes (العوامل الوراثية)		
No. of DNA molecules	More than one	One
DNA in organelles	Yes	No
DNA observed as chromosome	Yes	No
Nuclear Membrane	Yes	No
Mitotic and meiotic division of the nucleus	Yes	No

A comparison of Procaryotes and Eucaryotes

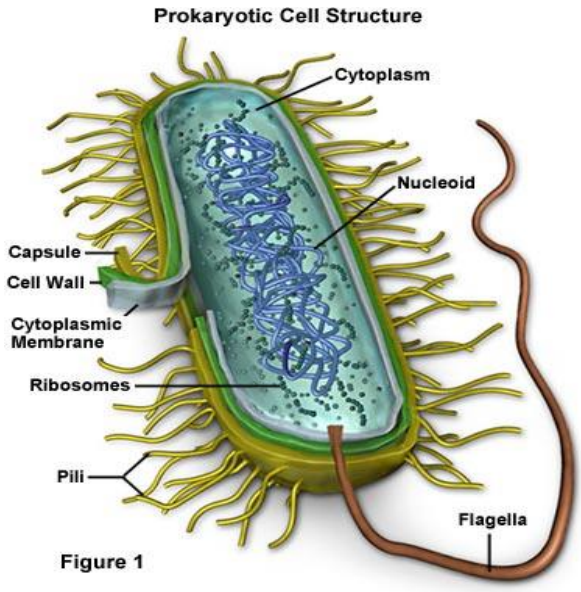
Characteristic	Eucaryotic	Procaryotic
Organelles		
Mitochondria	Yes	No
Endoplasmic reticulum	Yes	No
Golgi apparatus	Yes	No
Photosynthetic apparatus	Chloroplasts	Chlorosomes
Flagella	Complex structure, with microtubules	Single protein, simple structure

New Classification of Cellular Organisms



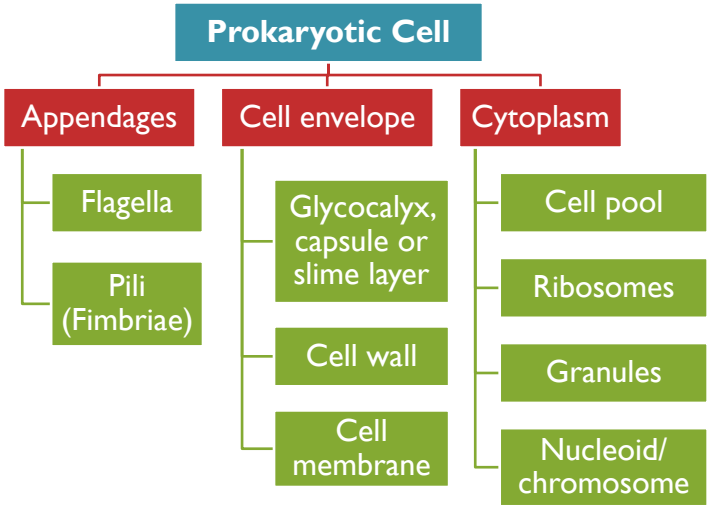
Prokaryote

- Prokaryotic cells are the earliest organism in this universe, and evolved alone for 1.5 billion years.
- Prokaryotes have NO membrane around the cell genetic information and NO membrane-bound organelles .
- Size: 0.5 – 3 micrometers (μm) in equivalent radius
- Shape: spherical (coccus), cylindrical (bacillus), spiral (spirillum)
- Grow rapidly: one cell can replicate into over a million cells in just 12 hours. In contrast, a human cell takes 24 hours to split.
- Utilize nutrients as carbon sources: carbohydrates, hydrocarbon, proteins and CO_2.



Picture courtesy of
http://micro.magnet.fsu.edu/cells/procaryotes/images/procaryote.jpg

Prokaryote Cell Structure



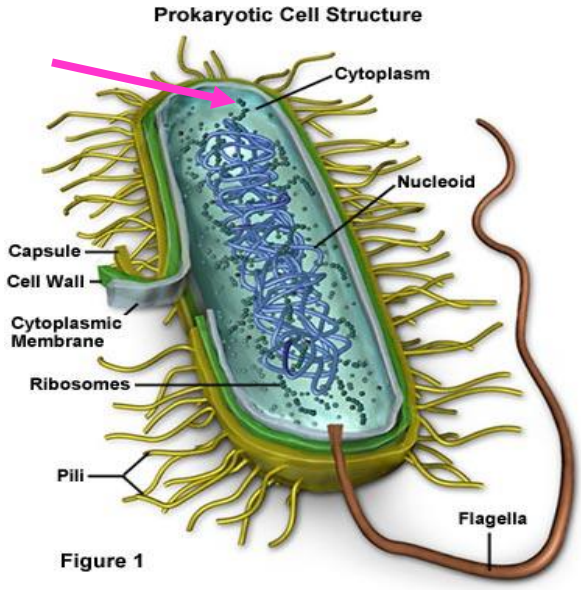
Procaryote Cell Structure

Nuclear region

- There is liquid around the nuclear region containing genetic materials such as chromosomes and DNA (deoxyribonucleic acid).

Chromosomes

- Contain many genes, regulatory elements and other intervening nucleotide sequences.
- The DNA which carries genetic information in biological cells is normally packaged in the chromosomes.

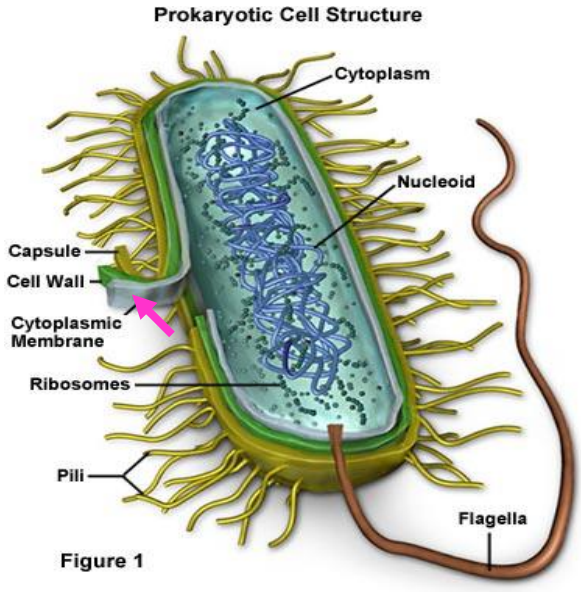


http://micro.magnet.fsu.edu/cells/procaryotes/images/procaryote.jpg

Procaryote Cell Structure

Cytoplasm

- In cytoplasm, there are some visible structures:
  - **Ribosome:** organelles for protein synthesis. About 10,000 ribosomes per cell, 10-30 nm, 63% RNA and 37% protein.
  - **Granules:** source of key metabolites, containing polysaccharides, lipids and sulfur granules. Sizes vary between 0.5-1 µm.
  - **Nucleoid:** DNA molecules separate from the chromosomal DNA and capable of autonomous replication.

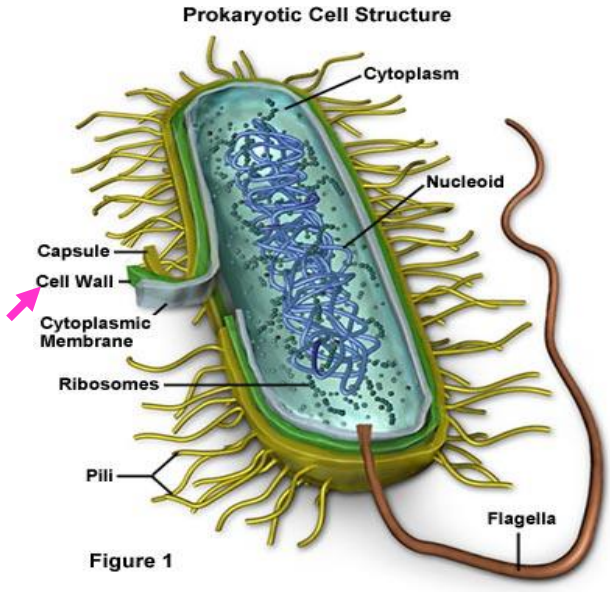


http://micro.magnet.fsu.edu/cells/procaryotes/images/procaryote.jpg

Procaryote Cell Structure

Cytoplasmic membrane

- The cytoplasm is surrounded by a membrane called cytoplasmic membrane.
- The cytoplasmic membrane contains 50% protein, 30% lipids and 20% carbohydrates.



http://micro.magnet.fsu.edu/cells/procaryotes/images/procaryote.jpg

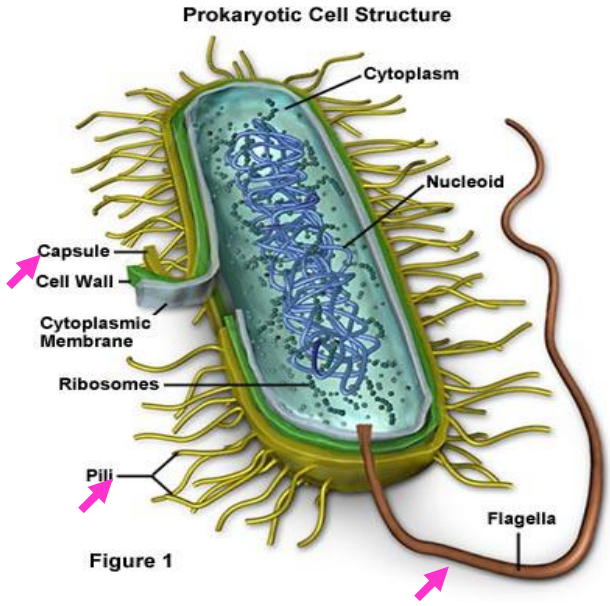
Procaryote Cell Structure

Cell wall

- Eubacteria cell walls contain lipids and peptidoglycan which is a complex polysaccharide with amino acids and forms a structure somewhat like chain-link fence.
- Archaebacteria cell walls do not have peptidoglycan.

Outer membrane

- Some bacteria (gram negative cells) have.



http://micro.magnet.fsu.edu/cells/procaryotes/images/procaryote.jpg

Procaryote Cell Structure

Capsule

- Extracellular products can adhere to or become incorporated within the surface of the cell.
- Certain cells have a coating outside the cell wall called capsule.
- It contains polysaccharides or polypeptide and forms biofilm response to environmental challenges.

Procaryote Cell Structure

- **Flagellum:** is for cell motion.
- **Pilus** (Pili, pl.)
  - A pilus is a hair like structure on the surface of a cell.
  - Pili enable the transfer of plasmids between the bacteria.
  - An exchanged plasmid can add new functions to a bacterium, e.g. an antibiotic resistance.

Procaryotes

- Procaryotes can be classified to:
  - Eubacteria
  - Archaebacteria

Eubacteria

- Cell chemistry of eubacteria is similar to eucaryotes.
- Classification
  - Gram stain: Hans Christian Gram in 1884 developed the technique of gram stain which has been used to classify the eubacteria.
  - Gram staining procedure:
    - Fixing the cells by heating
    - Dye with crystal violet – all bacteria will stain purple
    - Iodine followed by ethanol are added
      a. **Gram-negative cells** become colorless.
      b. **Gram-positive cells** remain purple after gram staining

Eubacteria

- Finally counterstaining with safranin is done:
  a. **Gram-negative cells** will appear red or pink
  b. **Gram-positive cells** remain purple

- **Gram-negative cells** have outer membrane supported by peptidoglycan (e.g. E. coli)
- **Gram-positive cells** don't have outer membrane. Rather they have a rigid cell wall with multiple layers of peptidoglycan (e.g. Bacillus subtilis)

Eubacteria

- **Other types of eubacteria:**
  - Non gram bacteria: some bacteria are not gram-positive or negative.
    - e.g. Mycoplasma is non gram bacteria lack of cell wall.
      - It is an important cause of pneumonia and other respiratory disorders.
  - Actinomycetes: bacteria but morphologically resembles molds with their long and high branched hyphae.
    - They are important source of antibiotics.

Archaebacteria

- Archaebacteria cells differ greatly from eubacteria at the molecular level:
  - no peptidoglycan
  - The nucleotide sequences in the ribosomal RNA are similar within the archaebacteria but distinctly different from eubacteria.
  - The lipid composition of the cytoplasm membrane is very different for the two groups.

Archaebacteria

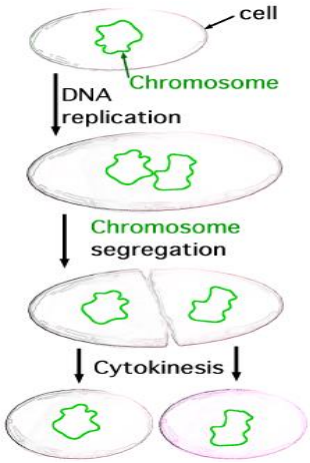
- Archaebacteria includes:
  - Methanogen: methane-producing bacteria
  - Halobacteria: living only in very strong salt solutions
  - Thermoacidophile: growing at _____temperatures and _____ pH.

Procaryote Reproduction

Reproduction

- Exclusively asexual through ***binary fission***
- The chromosome is duplicated and attaches to the cell membrane, and then the cell divides into two equal cells.

Binary Fission



http://www.beyondbooks.com/lif72/2a.asp