

Comparing Bacteria, Archaea and Eucarya

1. Basic unit of living organisms is the cell; the smallest unit capable of life. Features found in all cells:

- **Ribosomes** are a universal feature to all cells. These are the sites for protein synthesis. Translate from one cell language to the other.
- **Cell Membrane**: separates the chaos outside the cell from the high order of organization within the cell.
- **Genetic Material**: all cellular life contains DNA as its genetic material. DNA is responsible for the retaining of heredity or storage of information. All cells contain several varieties of RNA and PROTEINS, most of latter function as enzymes with specific catalytic activity.
- All cells require **cytoplasm (including cytosol)**, or the internal highly ordered cellular soup where metabolic reactions can occur.
- All cells require **Energy**, and this is universally supplied in the form of **ATP**.
- All cells are regulated by and respond to **External Stimuli**.
- All cells **Regulate** the flow of nutrients and wastes that enter and leave.
- All cells **Reproduce** and are the result of reproduction.

2. Basic chemical components/elements of a cell:

●	Major bio-elements:			Everything Else:
	Carbon	50%	Phosphorus	3%
	Oxygen	20%	Sulfur	1%
	Nitrogen	15%	Potassium	1%
	Hydrogen	8%	Calcium	0.5%
			Iron	0.5%
			Magnesium	0.5%
				~ 0.5%

- Major Classes of Biological Macro-molecules:

Type	Monomers	Polymers
Carbohydrates	Monosaccharides (e.g., glucose)	Polysaccharides (e.g., glycogen)
Lipids	Fatty acids & Glycerol	Triacylglycerols or Phospholipids
Proteins	Amino Acids	Polypeptides
Nucleic Acids	Nucleotides	DNA & RNA

- Water: 70-85% depending upon the amount of reserve material such as lipids, polysaccharides, polyphosphates, or sulfur. Therefore, 15-30% dry weight.
- The microbial cell is a “bag of enzymes” in an aqueous environment.

3. Classification of microbial cellular features:

Invariant Structures: Those components found in every type of microbial cell or are common to all microorganisms.

Variant Structures: Those components found in some selective types of microbial cells.

Invariant Structures:

1. Ribosomes (the grand translators)
2. Cell Membrane (the barrier between order and chaos)
3. Nucleoid region (Curator of the Info)

Variant Structures:

1. Cell Wall (multiple barrier support themes)
2. Endospores (heavy-duty life support strategy)
3. Bacterial Flagella (appendages for movement)
4. Gas Vesicles (buoyancy compensation devices)
5. Capsules/Slime Layer (exterior to cell wall)
6. Inclusion Bodies (granules for storage)
7. Pili (conduit for genetic exchange)

4. Ribosomes: Sites for protein synthesis – aka the grand translators.

- Typical Bacteria and Archaea have 10 to 20,000 ribosomes per cell depending upon their growth rates, whereas Eucarya will have considerably more.
- Locations: In Bacteria and Archaea, found floating in the cytosol or loosely attached to the internal side of the cell membrane. In Eucarya, found in cytoplasm and intercalated in rough ER.
- Ribosomes contain roughly $\frac{1}{3}$ protein and $\frac{2}{3}$ RNA. Varying complexity.
- Ribosomes of mitochondria and chloroplasts similar to that of Bacteria.
- Bacterial ribosomes are susceptible to antibiotics streptomycin and erythromycin, whereas archaeal ribosomes are susceptible to diphtheria toxin and anisomycin (as are Eucarya).
- Define modern phylogenetic-based hierarchical classification scheme.

5. Cell Membranes: The barrier between order and chaos.

- The general structure for most biological membranes is a matrix composed of a phospholipid bilayer. **Integral proteins** span the bilayer membrane whereas **peripheral proteins** attach on the surface of either side of the bilayer.
- Differences among Bacteria, Archaea and Eucarya cell membranes are:
 - A. Chemical bonds that link lipid monomers. Ester linkages found in Bacteria and Eucarya. Ether linkages are found in Archaea.
 - B. Presence of sterols in Eucarya (5–25%). Analogous strengthening agents in bacteria are **hopanoids**.
 - C. Lipids found in Bacteria and Eucarya are straight chain fatty acids. Archaea have branched chains of isoprenoid lipids.

6. Nucleoid Region: Curator of the Information.

- Location of the cellular genetic information. Aggregated region of supercoiled DNA (500x length of cell), but NOT stored within a membrane bound nucleus.
- Ribosomes absent in dense nucleoid region. Regions of DNA being transcribed into mRNA project out into cytosol.
- Archaeal chromosome is circular with introns and histone-like proteins both common.
- Bacterial chromosome is circular with introns and histone-like proteins both rare or less frequent.
- Eucarya chromosomes are linear and diploid, contained in a true membrane bound nucleus, and have extensive introns and histone proteins.

Mechanisms for microbial genetic exchange leading to the plastic nature of microbial genomes: **Fragmentary, uni-directional, and specialized.**

Conjugation: DNA transfer resulting from cell-to-cell contact, which most closely resembles sex in Eucarya.

Transduction: DNA transfer is mediated by viruses.

Transformation: Free or naked DNA is taken up directly by the recipient cell.