Part 2

The Basics of Biology: An Engineer's Perspective



Chapter 2 An Overview of Biological Basics



2.1 Are all cells the same?

Cells

- Basic unit of living organism
- First named by Robert Hooke in the 17th century
- Different types but the same essential properties





Microbial Diversity

- **psychrophile**: optimum temp < 20°C</p>
- mesophile: 20°C < optimum temp < 50°C</p>
- thermophile: 50°C < optimum temp</p>
- **aerobic**: growth in the presence of oxygen
- anaerobic: growth without oxygen
- facultative: growth under either circumstances
- coccus: spherical or elliptical
- bacillus: cylindrical or rod
- spirillum: spiral

Naming Cells

Escherichia coli (E. coli)

- written in italic
- Escherichia: genus
- *coli*: species
- various strains of *E. coli* --- (ex) *E. coli* K12

Viruses

- Not cells
- No independent reproduction (not alive by itself)
 - Genetic material (DNA or RNA)
 - Proteins (Capsid)



- "Viruses are in the semantic fog between life and non-life."
 (Campbell and Reece, *Biology*, 6e, p 339.)
- Are viruses living beings?
 - "The answer to that question is 'no', inasmuch as viruses are incapable of independent life." (de Duve, *Life Evolving,* p.313)
- Conclusion:
 - Viruses do not fit the basic definition of cellular life.
 - Require host for all cellular activities
 - No metabolic capability of their own

Bacteriophage

Bacteriophage: virus infecting bacteria

- Iytic cycle: reproduction of virus (Fig. 2.1)
- Iysogenic cycle: Phage DNA is incorporated into the host DNA



Two Fundamental Cell Types

Procaryote & Eucaryote

 Primary Difference: presence or absence of nucleus (more details in Table 2.1 and 2.2)



Procaryotic Cells

- Procaryote
 - (pro; before, karyon: kernel or nucleus)
- No nuclear membrane
- Small (0.5-3 μm), mostly single-celled organisms
 - Eubacteria : common bacteria

(e.g. *E. coli*, blue-green algae)

 Archaea (Archaebacteria): methanogens (methane-producing), thermoacidophiles,

and halobacteria (high salt)

- Live in extreme environments.
- Possess unusual metabolism.

Eubacteria

- Divided into two groups by gram stain.
 - Gram-negative cell (e.g. *E. coli*)
 - Outer membrane
 - Peptidoglycan
 - Cytoplasmic (inner) membrane —
 - Periplasm
 - Between inner and outer membranes



- Gram-positive cell (e.g. Bacillus subtilis)
 - No outer membrane
 - Peptidoglycan
 - Teichoic acid
 - Cytoplasmic membrane



Cellular Membranes

- Provide structural organization
 - Lipid bilayer with hydrophobic core and hydrophilic face
 - Plasma (cell) membrane: Hydrophobic barrier between inside (cytoplasm) and outside of the cell
 - Internal membranes for eucaryote
 - Nucleus
 - Endoplasmic reticulum, Golgi apparatus
 - Mitochondria
 - Chloroplast



Eucaryote

Eucaryotic cells

- Eukaryote (well-formed nucleus)
- Larger than procaryotes (10-100 μm)
 - Single-celled: yeast, green algae, amoebae
 - Multicellular: fungi, plant, animal
- Nuclear and internal membranes \rightarrow organelles
 - Nucleus --- contains chromosomes as nuclear material
 - Mitochondria --- powerhouse of a cell
 - Golgi body --- responsible for the secretion of certain proteins
 - Vacuole --- responsible for food digestion, osmotic regulation, and waste-product storage
 - Chloroplast --- responsible for photosynthesis
 - endoplasmic reticulum, lysosome, glyoxysome



Cell Cycle in a Eucaryote

Cell Cycle (Fig. 2.4)

- S phase:
 - --- DNA synthesis
- M phase:
 - --- mitosis
- G₁, G₂:
 - --- G strands for gap between
 - S and M phase
 - --- Cell growth



Mitosis

- DNA replication
- Mitosis
 - Prophase
 - Condensation of chromosomes and disappearance of nuclear membrane
 - Metaphase
 - Alignment of chromosome in the center
 - Pulling by spindle fibers attached to the kinetochore
 - Anaphase
 - Splitting of chromatids and pulling to the opposite ends of the cell
 - Telophase
 - Decondensation of chromosome
 - Formation of new nuclear membrane
- Cytokinesis
 - Cell division after mitosis
- Interphase
 - The time between cell division and the next mitosis (G₁, S, G₂)

Mitosis and Cytokinesis



Chromosome

Tightly packed complex of DNA and histone proteins



Eucaryotic Cells

Fungi

- Yeasts --- single small cells of 5- to 10-μm size
- Molds --- filamentous fungi, have a mycelial structure
- Algae
 - Unicelluar algae (microalgae) --- 10 to 30 μm
 - Plantlike multicelluar algae

Protozoa

- Unicellular, motile, relatively large (1 50 mm) --- amoeba
- Plant cells
- Animal cells

The Scale of Life

