Chapter 4: Cell Structure and Function

The Cell is the Basic Unit of Life

Early History:
A) Robert Hooke (1660's): Made first observation of cells (cork)
   - Cell = "Tiny rooms" occupied by monks
B) Anton van Leeuwenhoek (1670's): Early observations of protists

C) Theodor Schwann (1830's): First observed of animal cells
   - Lack of cell wall delayed discovery (made viewing difficult...)

Principles of Modern Cell Theory
1) Every living organism is made up of 1 or more cells
   - Smallest organisms = Single cells
   - Cells are functional units of multi-cellular organisms
2) All cells arise from pre-existing cells

Past / present discoveries of cell nature enabled via microscopy:
1) Light Microscopes
2) Electron Microscopes

Basic Features of All Cells:
1) Plasma membrane encloses cell and mediates interactions between the cell and its environment (remember Chapter 5...)
2) Cells contain cytoplasm
   - All materials / structures inside the plasma membrane
     - Location of metabolic activity (e.g., energy production / protein synthesis)
3) Genetic Information = DNA
   - Eukaryotic cells: DNA contained in membrane-bound nucleus
     - "True nucleus"
   - Prokaryotic cells: DNA located in nucleoid region (not membrane-bound)
     - "Before nucleus"
4) Obtain energy and nutrients from environment
5) Cell function limits cell size
   - Diffusion too slow in large cells
   - Surface area to volume ratio too low to receive nutrients

Surface Area to Volume Ratio:

Prokaryotic Cells:
- Small (e.g., bacteria)
- Relatively simple in structure

External features:
- Cell walls
- Flagellum (movement)
- Pili (attachment / genetic exchange)
- Capsule / Slime Layer (host attachment)

Internal features:
- Plasma membrane
- Cytoplasm (w/ ribosomes): Food granules
- Nucleoid: Central region of coiled DNA
Eukaryotic Cells (Table 4.1 – Comparison):

- Large; complex in structure

Internal Features:
- Plasma membrane
- Cytoplasm (w/ ribosomes)
- Organelles (membrane-bound) / cytoskeleton

City Limits

- City Hall
  (Nucleus)
- City Workers
  (Ribosomes)
- Road System
  (Endoplasmic reticulum)
- Post Office
  (Golgi Apparatus)
- Recycling Service
  (Lysosomes)
- Storage Units
  (Vacuoles)
- Power Plants
  (Mitochondria)
- Food Production
  (Chloroplasts)
- City Infrastructure
  (Cytoskeleton)

1. Nucleus: Large organelle housing genetic information
   A) Nuclear Envelope: Double membrane containing pores
   B) Chromatin (“colored substance”):
   • DNA and associated proteins (chromosomes)
   C) Nucleolus: Site of ribosome synthesis

2. Ribosomes: Small structures that function as “workbenches” for building proteins

3. Endoplasmic reticulum: Series of interconnected tubes / passageways in the cytoplasm (continuous with nuclear membrane)
   A) Rough ER: Major site of protein synthesis (contains ribosomes)
   B) Smooth ER: Major site of lipid synthesis (e.g., cholesterol)

4. Golgi Apparatus: Series of flattened, stacked membranes
   - Sorts proteins / lipids received from the ER
   - Modifies proteins (e.g., adds sugar units – glycoproteins)
   - Packages material into vesicles for transport

Membrane System in Action:

- Manufacturing / Export Of Antibodies

Manufacturing / Export Of Antibodies
- Antibodies are packaged into vesicles that bud off from the ER
- Vesicles fuse with the plasma membrane and release antibodies by exocytosis
- Antibody production continues in the ER and Golgi apparatus, with the final product being secreted to the cell surface
- Antibodies are transported to various tissues and organs in the body
Membrane system also responsible for intracellular digestion

5) Lysosomes:
Vesicles filled with digestive enzymes that break down food / cellular debris

6) Vacuoles:
Fluid-filled sacs surrounded by a single membrane
A) Temporary storage (e.g., Food vacuoles – see previous slide…)
B) Water regulation (e.g., Contractile vacuoles)
   • Store / excrete water

C) Structure support and long-term storage (e.g., Central vacuoles – plants)
   • Maintains water balance (turgor pressure)
   • Dump site for waste
   • Storage of sugars and amino acids

7) Mitochondria:
Tubular sacs composed of a paired membrane
• Convert food products into energy (in the form of ATP…)
• Rely on oxygen (aerobic respiration)
• Abundant in cells requiring high levels of energy (e.g., muscle)

Structure:
Cristae: Deep folds in the inner membrane
Matrix: Space within the inner membrane
Intermembrane compartment: Space between membranes
Mitochondria present in all eukaryotic cells!

8) Chloroplasts:
Spherical sacs composed of a paired membrane
• Convert energy (sun) into food products (sugars)

Endosymbiotic Hypothesis:
Mitochondria / Chloroplast originally free-living organisms
• Own DNA
• Own ribosomes

Structure:
Stroma: Fluid in inner membrane
Thylakoids: Hollow sacs that contain chlorophyll
Granum: Stacks of thylakoids

9) Cytoskeleton:
Internal framework of cell – composed of proteins
Types of Protein Fibers:
A) Intermediate filaments: 8 proteins woven together
   • Join together to form cell shape
B) Microfilaments: Twisted double-strands of protein
   • Allow for cell movement
   • Allow for organelle movement
   • Allow for cell division
C) Microtubules: Spiraled double-strands of protein
   • Allow for cell movement
   • Allow for organelle movement
   • Allow for cell division
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Eukaryotic Cells (Table 4.1 – Comparison):

Cilia ("eyelash") / Flagella ("whip") : Slender extensions of plasma membrane that function for movement

- Composed of microtubules arranged in a ring structure
- ↑ mitochondria at base