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

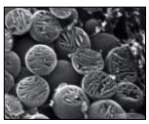
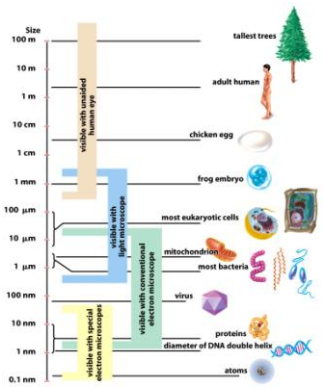



Figure 4.1 – Audesirk² & Byers



Basic Features of All Cells:

1) Plasma membrane encloses cell and mediates interactions between the cell and its environment (remember Chapter 5…)

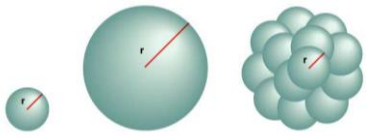
2) Cells contain cytoplasm
   - All materials / structures inside the plasma membrane
     - Location of metabolic activity (e.g., energy production / protein synthesis)

3) Genetic Information = DNA — Karyote = "nucleus"
   - 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

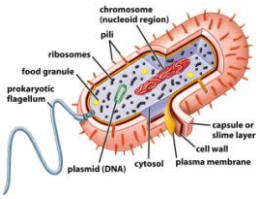
Surface Area to Volume Ratio:



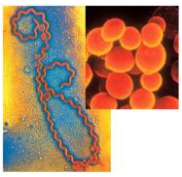
distance to center (r)	1.0	3.0	1.0
surface area ($4\pi r^2$)	12.6	113.1	339.4
volume ($4/3\ \pi r^3$)	4.2	113.1	113.1
area/volume	3.0	1.0	3.0

Figure 4.20 – Audesirk² & Byers

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

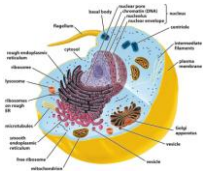
Figure 4.3 / 4.4 – Audesirk² & Byers

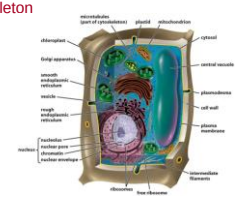
Eukaryotic Cells (Table 4.1 – Comparison):

- Large; complex in structure

Internal Features:

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





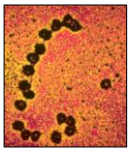
The Cell as A City:

City Limits — Plasma Membrane

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)

Eukaryotic Cells (Table 4.1 – Comparison):

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

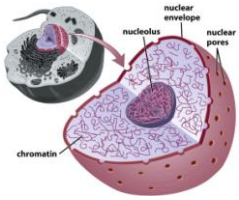
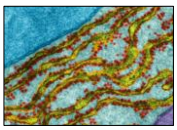


Figure 4.9 / 4.10 / 4.11 – Audesirk² & Byers

Membrane System

Eukaryotic Cells (Table 4.1 – Comparison):

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)



Vesicles = Membrane-bound sacs

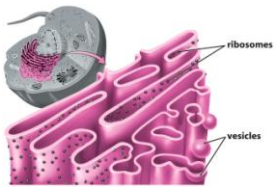


Figure 4.12 – Audesirk² & Byers

Membrane System

Eukaryotic Cells (Table 4.1 – Comparison):

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

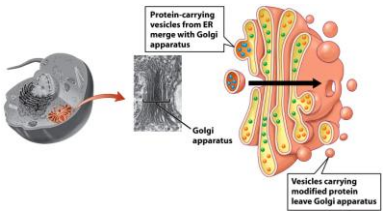


Figure 4.13 – Audesirk² & Byers

Eukaryotic Cells (Table 4.1 – Comparison):

Membrane System in Action:

Manufacturing / Export Of Antibodies

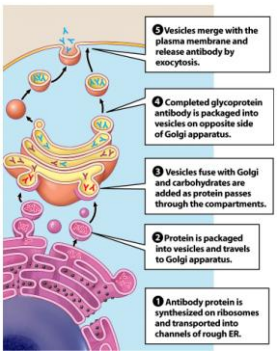


Figure 4.14 – Audesirk² & Byers

Eukaryotic Cells (Table 4.1 – Comparison):

Membrane system also responsible for intracellular digestion

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

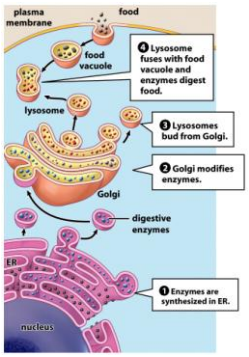
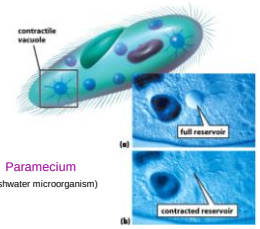


Figure 4.15 – Audesirk² & Byers

Eukaryotic Cells (Table 4.1 – Comparison):

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



Paramecium
(freshwater microorganism)

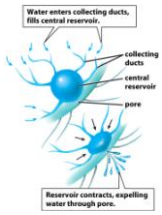


Figure 4.16 – Audesirk² & Byers

Eukaryotic Cells (Table 4.1 – Comparison):

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)
- 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

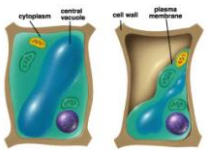


Figure 5.11 – Audesirk² & Byers

Eukaryotic Cells (Table 4.1 – Comparison):

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!

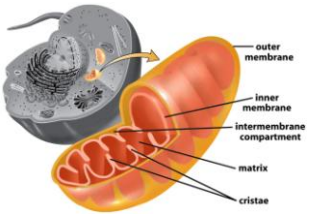


Figure 4.17 – Audesirk² & Byers

Specialized plastids
(Plastid = Plant storage organelle)

Eukaryotic Cells (Table 4.1 – Comparison):

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

Endosymbiont 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

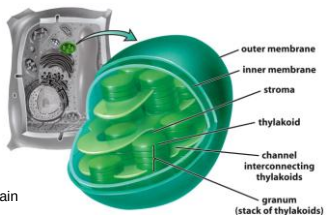


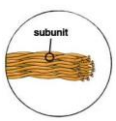
Figure 4.17 – Audesirk² & Byers

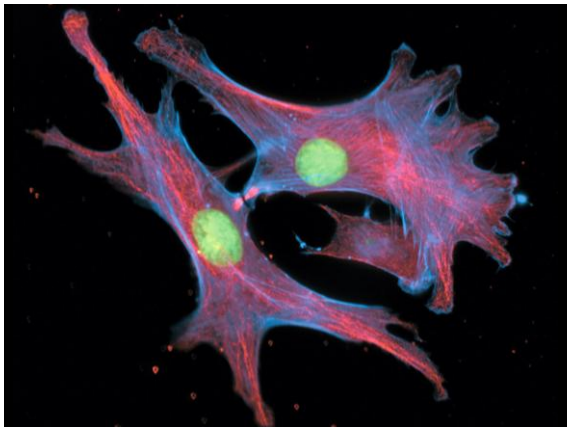
Eukaryotic Cells (Table 4.1 – Comparison):

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
- C) Microtubules: Spiraled double-strands of protein
  - Allow for cell movement
  - Allow for organelle movement
  - Allow for cell division





Eukaryotic Cells (Table 4.1 – Comparison):

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

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

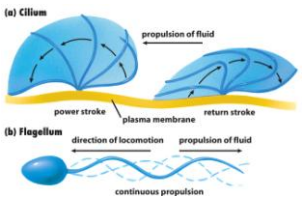


Figure 4.8 – Audesirk² & Byers

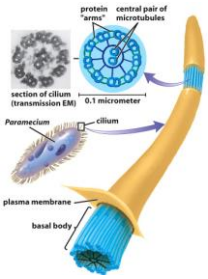


Figure 4.7 – Audesirk² & Byers