Chapter 7
(7-1 and 7-2)
A Tour of the Cell
Microscopes as Windows to the World of Cells

- **Cells** were first described in 1665 by Robert Hooke.

- By the mid-1800s, the accumulation of scientific evidence led to the ***cell theory***, which states that
  
  - all living things are composed of cells and
  
  - cells are the basic units of structure and function of living things.
  
  - all cells come from other cells.
Light microscopes can be used to explore the structures and functions of cells.

When scientists examine a specimen on a microscope slide

- light passes through the specimen
- lenses enlarge, or magnify, the image.
Microscopes as Windows on the World of Cells

• The electron microscope (EM) uses a beam of electrons, which results in 100-fold better resolution than light microscope.

• Two kinds of electron microscopes reveal different parts of cells.
  • Scanning electron microscopes (SEMs) examine cell surfaces.
  • Transmission electron microscopes (TEMs) are useful for studying the internal structure of a cell.
### TYPES OF MICROGRAPHS

<table>
<thead>
<tr>
<th>Light Micrograph (LM)</th>
<th>Scanning Electron Micrograph (SEM)</th>
<th>Transmission Electron Micrograph (TEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Light Micrograph" /></td>
<td><img src="image2" alt="Scanning Electron Micrograph" /></td>
<td><img src="image3" alt="Transmission Electron Micrograph" /></td>
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THE MICROSCOPIC WORLD OF CELLS

- **Organisms** are either
  - single-celled
    - bacteria and protists
  - multicellular
    - plants
    - animals
    - most fungi
The Two Major Categories of Cells

- There are 2 basic categories of cells:
  1. Prokaryotic cells
     A. Bacteria and Archaea
  2. Eukaryotic cells
     A. protists, plants, fungi, and animals.
Differences Between Prokaryotic and Eukaryotic Cells

- **Prokaryotic** cells are
  - usually smaller and more simple in structure
  - genetic material (DNA) **not** contained in the nucleus

- **Eukaryotic** cells are
  - larger and more complex
  - Genetic material (DNA) **contained in the nucleus**
  - have **organelles**, membrane-enclosed structures that perform specific functions. (like organs in our bodies)
What the two types of cells have in common.

- All cells have 4 basic features.
  1. They are all bounded by a thin plasma membrane.
  2. Inside all cells is a thick, jelly-like fluid called the cytoplasm, in which cellular components are suspended.
  3. All cells have one or more chromosomes carrying genes made of DNA.
  4. All cells have ribosomes, tiny structures that build proteins according to the instructions from the DNA.
<table>
<thead>
<tr>
<th>Prokaryotes vs. Eukaryotes</th>
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<tbody>
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<tr>
<td><strong>Prokaryotes</strong></td>
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<tr>
<td>Smaller</td>
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<tr>
<td>Simpler</td>
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<tr>
<td>Most do not have organelles</td>
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<tr>
<td>Found in bacteria and archaea</td>
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</tbody>
</table>

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Prokaryotic Cell - Bacteria

- Plasma membrane (encloses cytoplasm)
- Cell wall (provides rigidity)
- Capsule (sticky coating)
- Prokaryotic flagellum (for propulsion)
- Ribosomes (synthesize proteins)
- Nucleoid (contains DNA)
- Pili (attachment structures)
Eukaryotic Cell - Animal

IDEALIZED ANIMAL CELL

- Cytoskeleton
- Ribosomes
- Centriole
- Lysosome
- Plasma membrane
- Nucleus
- Mitochondrion
- Rough ER
- Smooth ER
- Golgi apparatus
Comparison between prokaryotic and eukaryotic cells
Eukaryotic Cell Structures

- Eukaryotic cells are fundamentally similar.
  - They are divided into 2 types
    - Plant
    - Animal

- The region between the nucleus and plasma membrane is the **cytoplasm**.

- The cytoplasm consists of various **organelles** suspended in the liquid **cytosol**.
PLASMA MEMBRANE STRUCTURE

• The plasma membrane (cell membrane) separates the living cell from its nonliving surroundings.

• Found in ALL CELLS!!!!!!!!!
The Plasma Membrane: A Fluid Mosaic of Lipids and Proteins

- The remarkably thin (only 2 molecules thick) membranes of cells are composed mostly of:
  - lipids
  - proteins
  - carbohydrates
- The lipids belong to a special category called phospholipids.
- Phospholipids form a two-layered membrane, the phospholipid bilayer.
Figure 4.6a

(a) Phospholipid bilayer of membrane

Outside of cell

Hydrophilic head

Hydrophobic tail

Phospholipid

Cytoplasm (inside of cell)
Most membranes have specific proteins embedded in the phospholipid bilayer.

These proteins help regulate traffic across the membrane and perform other functions.
Figure 4.UN12

Outside of cell

Phospholipid

Protein

Hydrophilic

Hydrophobic

Hydrophilic

Cytoplasm (inside of cell)
(b) Fluid mosaic model of membrane
The Plasma Membrane: A Fluid Mosaic of Lipids and Proteins

- The plasma membrane is a fluid mosaic.
  - Fluid because molecules can move freely past one another.
  - A mosaic because of the diversity of proteins in the membrane.
Plant Cells – Plasma Membrane Plus Added Protection!!!

- Plant cells have rigid **cell walls** surrounding the membrane.
- Plant **cell walls**
  - are made of cellulose
  - protect the cells
  - maintain cell shape
  - keep cells from absorbing too much water
The nucleus is the chief executive of the cell.

- Genes in the nucleus store information necessary to produce proteins.
- Proteins do most of the work of the cell.
Structure and Function of the Nucleus

- The nucleus is separated from the cytoplasm by a double membrane called the **nuclear envelope**.
- Pores in the envelope allow materials to move between the nucleus and cytoplasm.
- The nucleus contains a **nucleolus** where ribosomes are made.
Stored in the nucleus are long DNA molecules and associated proteins that form fibers called chromatin.

Each long chromatin fiber constitutes one chromosome.

The number of chromosomes in a cell depends on the species.
Figure 4.9

DNA molecule

Proteins

Chromatin fiber

Chromosome
Ribosomes

- **Ribosomes** are responsible for making proteins.

- They are small particles of RNA and protein found throughout the cytoplasm and the **endoplasmic reticulum**.

- They make proteins by following the instructions that come from the nucleus.
Figure 4.10

Ribosome

mRNA

Protein
Figure 4.12-3

1. Synthesis of mRNA in the nucleus

2. Movement of mRNA into cytoplasm via nuclear pore

3. Synthesis of protein in the cytoplasm
IDEALIZED ANIMAL CELL

- Cytoskeleton
- Ribosomes
- Plasma membrane
- Mitochondrion
- Centriole
- Lysosome
- Nucleus
- Rough ER
- Smooth ER
- Golgi apparatus
The Endoplasmic Reticulum

- The **endoplasmic reticulum (ER)** is one of the main manufacturing facilities in a cell.

- The ER
  - produces an enormous variety of molecules for export
  - is connected to the nuclear envelope
  - is composed of smooth and rough ER
Rough ER

- The “rough” in **rough ER** refers to ribosomes that stud the outside of this portion of the ER membrane.

- These ribosomes produce proteins.

- Some products manufactured by rough ER are dispatched to other locations in the cell by **transport vesicles**, sacs made of membrane that bud off from the rough ER.
Proteins are modified in the ER.

A ribosome links amino acids.

Secretory proteins depart.

Vesicles bud off from the ER.

Ribosome

Transport vesicle

Polypeptide

Protein

Rough ER
Smooth ER

- The smooth ER
  - no ribosomes found on its surface.
  - contains collections of enzymes that perform specialized tasks.
  - produces lipids, including steroids.
  - helps liver cells detoxify circulating drugs.
The Golgi Apparatus

- The **Golgi apparatus**
  - works in partnership with the ER
  - receives, modifies, sorts, packages and distributes proteins and chemical products from the ER for storage in the cell or secretion outside the cell.
  - like FedEx.
Transport vesicle from rough ER

"Receiving" side of the Golgi apparatus

New vesicle forming

Transport vesicle from the Golgi apparatus

"Shipping" side of the Golgi apparatus

Plasma membrane

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Lysosomes

- **Lysosomes** are small organelles filled with enzymes that bud from the Golgi Apparatus
  - digest (breakdown) carbohydrates, lipids and proteins into small molecules that can be used by the rest of the cell.
  - break down organelles that are old and no longer functioning.
  - the cell’s clean up crew.
  - not found in plant cells.
IDEALIZED ANIMAL CELL

- Cytoskeleton
- Ribosomes
- Centriole
- Lysosome
- Plasma membrane
- Mitochondrion
- Rough ER
- Golgi apparatus
- Nucleus
- Smooth ER
Figure 4.16a

Plasma membrane

Digestive enzymes

Lysosome

Food vacuole

Digestion

(a) A lysosome digesting food

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Figure 4.16b

(b) A lysosome breaking down the molecules of damaged organelles
Vacuoles

- **Vacuoles** are large sacs that store materials
  - water, salts, and food for the cell

- **Central Vacuoles** in plants fill with liquid and give plants extra support for structures like leaves and flowers.
  - Some central vacuoles of plants are filled with pigments that attract pollinators or poisons that help in plant defense.

- **Contractile vacuoles** found in animal cells like that of the single celled paramecium, pump out excess water in the cell.
IDEALIZED PLANT CELL

- Cytoskeleton
- Mitochondrion
- Nucleus
- Rough ER
- Ribosomes
- Smooth ER
- Central vacuole
- Cell wall
- Chloroplast
- Plasma membrane
- Channels between cells
- Golgi apparatus

Figure 4.5b
Vacuoles

Plant Cell

Animal Cell

1. Water enters due to osmosis
2. Excess water enters contractile vacuole
3. Contractile vacuole swells
4. Contractile vacuole moves to edge of cell
5. Contractile vacuole bursts and expels water
6. The cycle is repeated
CHLOROPLASTS AND MITOCHONDRIA: ENERGY CONVERSION

• Cells require a continuous energy supply to perform the work of life.

• Cells get energy from food or from the sun.

• Two organelles act as cellular power stations:
  1. chloroplasts
  2. mitochondria

• Both contain their own DNA!!!!!!
  • What can you infer from that??????
Mitochondria

- are found in almost all eukaryotic cells both plant and animal cells.
- Convert chemical energy stored in food into compounds that the cell can use.

The cell's energy factories, the mitochondria manufacture ATP to fuel all of life's activities.
IDEALIZED ANIMAL CELL

- Cytoskeleton
- Ribosomes
- Centriole
- Lysosome
- Plasma membrane
- Mitochondrion
- Rough ER
- Golgi apparatus
- Smooth ER
- Nucleus
Mitochondria

- Enclosed by two membranes
  1. an outer smooth membrane
  2. an inner membrane that
     - has numerous infoldings called **cristae**
     - encloses a thick fluid called the **matrix**.
Mitochondria

- Mitochondria contain their own DNA, which encodes some of their proteins.
- All of our mitochondria come from the cytoplasm of the egg cell, which means we get all of our mitochondria from our moms.
Chloroplasts

- Most of the living world runs on the energy provided by photosynthesis.

- Photosynthesis is the conversion of light energy from the sun to the chemical energy of sugar and other organic molecules.

- **Chloroplasts**
  - capture the energy from sunlight and convert it to chemical energy
  - unique to the photosynthetic cells of plants and algae
Chloroplasts

Chloroplasts are surrounded by two membranes and are divided into three major compartments by internal membranes:

1. the space between the two membranes
2. the stroma, a thick fluid within the chloroplast
3. the space within grana, membrane-enclosed discs and tubes that trap light energy and convert it to chemical energy.
Figure 4.19a

- Inner and outer membranes
- Space between membranes
- Stroma (fluid in chloroplast)
- Granum
Figure 4.UN13

Light energy

Chloroplast

PHOTOSYNTHESIS

Chemical energy (food)

Mitochondrion

CELLULAR RESPIRATION

ATP
The cytoskeleton is a network of fibers extending throughout the cytoplasm
- that supports the cell
- gives it shape
- provides internal organization for organelles
The cytoskeleton contains several types of fibers made from different proteins:

- **Microfilaments** are threadlike structures made of a protein called actin. Help cells move.

- **Microtubules** are straight and hollow tubes that guide the movement of organelles and chromosomes. Made of proteins called tubulins.

- **Centrosomes and Centrioles** formed from tubulin are not found in plant cells. Help separate chromosomes during cell division.
Cilia and Flagella

• Cilia and flagella are motile appendages that aid in movement and are made from microtubules.

  - **Flagella** propel the cell through their undulating, whiplike motion.

  - **Cilia** move in a coordinated back-and-forth motion.

  - Cilia and flagella have the same basic architecture, but cilia are generally shorter and more numerous than flagella.
Figure 4.22

(a) Flagellum of a human sperm cell

(b) Cilia on a protist

(c) Cilia lining the respiratory tract
Animal vs. Plant Cells

- Only animal cells have
  - Contractile vacuoles
  - Cilia and flagella (make from microtubules)
  - Lysosomes, bubbles of digestive enzymes surrounded by membranes
  - Centrioles, microtubules that aid in cell division

- Only plant cells have
  - Chloroplasts
  - Central vacuoles
  - Cell walls composed of cellulose (polysaccharides)
Euglena- A Weird Combo of Both Plant and Animal

- a single cell eukaryotic organism with chloroplasts!!!
- Has the ability to make its own food (autotroph) as well as eat food (heterotroph).