4.7 Organelles That Contain DNA

- Two cell-like organelles contain DNA
  - Mitochondria
    - Found in almost all eukaryotes
  - Chloroplasts
    - Found only in plants and algae
Mitochondria

- Mitochondria carry out cellular respiration
  - This process uses the energy in sugars, fats and proteins to make ATP
  - ATP is used for cellular work

  *Do cells breathe?*
  - *Why is it called cellular respiration?*
  - *Why do animals need oxygen to live?*
  - Mitochondria need oxygen to make ATP

- Sausage-shaped organelles, about the size of a bacterial cell
- Like bacteria, they
  - 1. Possess circular DNA
  - 2. Divide by simple fission
Fig. 4.16a

Contains the mtDNA

Increase surface area
Chloroplasts

• Chloroplasts convert solar energy to chemical energy in sugars
  – Sites of photosynthesis in plants, some protists and bacteria
• Like bacteria, they
  – 1. Possess circular DNA
  – 2. Divide by simple fission

Fig. 4.17
• Chloroplasts in plant cells

Figure 4.5Bx2
The Endosymbiotic Theory

- Proposes that mitochondria and chloroplasts arose by symbiosis from ancient bacteria
- This theory is supported by a wealth of evidence
4.8 The Cytoskeleton: Interior Framework of the Cell

- A dense network of protein fibers that
  - 1. Supports the shape of the cell
  - 2. Anchors organelles
- Three different kinds of protein fibers
  - Microfilaments
  - Microtubules
  - Intermediate filaments
• Microfilaments of actin enable cells to change shape and move
• Intermediate filaments reinforce the cell and anchor certain organelles
• Microtubules
  – give the cell rigidity
  – provide anchors and tracks for organelles
Centrioles

- Anchor and assemble microtubules
- Not found in higher plants and fungi
- May have originated as symbiotic bacteria
Cell Movement

- **Flagella and cilia**
  - Consist of a *9 + 2 arrangement* of microtubules
  - Anchored in the cell by a *basal body*

- **Flagella**
  - long and few in number
  - move cells (sperm)

- **Cilia**
  - short and numerous
  - move fluid past the cells (ciliated epithelium that line our air passages moves debris towards the throat)
The 9+2 pattern of microtubules in a single cilium seen in cross section.

See Fig. 4.21a
Eukaryotic flagellum

Basal body (structurally identical to centriole)
Moving Material Within the Cell

- Eukaryotic cells have developed high speed locomotives that run along microtubular tracks

- **Kinesin**
  - Motor protein that moves vesicles to the cell’s *periphery*

- **Dynein**
  - Motor protein that moves vesicles to the cell’s *interior*
4.9 Outside the Plasma Membrane

- Animal cells have an extracellular matrix
  - A mixture of glycoproteins secreted by cells
  - Helps coordinate the behavior of all cells in a tissue

Fig. 4.25
• Tight junctions can bind cells together into leakproof sheets

• Anchoring junctions link animal cells

• Communicating junctions allow substances to flow from cell to cell
4.9 Outside the Plasma Membrane

- Plant cells have cell walls
  - Offer protection and support
  - Fungal cell walls are made up of chitin
  - Plant cell walls are made up of cellulose

Fig. 4.24
4.10 Diffusion and Osmosis

- **Diffusion** is the movement of molecules **down** their concentration gradient.

**Fig. 4.26**

1. A lump of sugar is dropped into a beaker of water.
2. Sugar molecules begin to break off from the lump.
3. More and more sugar molecules move away and randomly bounce around.
4. Eventually, all of the sugar molecules become evenly distributed throughout the water.

Equilibrium
Osmosis

**Fig. 4.27**

1. Diffusion causes water molecules to distribute themselves equally on both sides of a semipermeable membrane.

2. Addition of solute molecules that cannot cross the membrane reduces the number of free water molecules on that side, as they bind to the solute.

3. Diffusion then causes free water molecules to move from the side where their concentration is higher to the solute side, where their concentration is lower.
Osmosis

- The control of water balance (osmoregulation) is essential for organisms.

- Movement of water into a cell creates osmotic pressure:
  - Osmosis causes cells to shrink in a hypertonic solution.
  - And swell in a hypotonic solution. This can cause a cell to swell and burst.

Fig. 4.28 Osmotic pressure in a red blood cell
Water balance between cells and their surroundings is crucial to organisms.

- **Solute** are substances dissolved in a solution
  - **Hyperosmotic solution** contains higher concentration of solutes than the cell
  - **Hypoosmotic solution** contains lower concentration of solutes than the cell
  - **Isotonic solution** contains equal concentration of solutes as the cell

### Solute Concentration and Cell Response

<table>
<thead>
<tr>
<th>Solution</th>
<th>Animal Cell Response</th>
<th>Plant Cell Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Isotonic</strong></td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Hypotonic</strong></td>
<td>Lysing</td>
<td>Shriveled</td>
</tr>
<tr>
<td><strong>Hypertonic</strong></td>
<td>Shriveled</td>
<td>Flaccid</td>
</tr>
</tbody>
</table>

**Diagram:**

- **Animal Cell**
  - (1) Normal
  - (2) Lysing
  - (3) Shriveled

- **Plant Cell**
  - (4) Flaccid
  - (5) Turgid
  - (6) Shriveled

**Plasma membrane**
4.11 Bulk Passage into and out of Cells

- Large amounts of material can be moved in and out of cells by membrane-bound vesicles

- Exocytosis
  - Discharge of material from vesicles at the cell surface

- Endocytosis
  - The plasma membrane envelopes particles and brings them into the cell interior
Exocytosis

Fig. 4.30

- Means by which hormones, neurotransmitters and digestive enzymes are secreted in animal cells
Endocytosis

- Has three major forms

1. **Phagocytosis**
   - Engulfment of particulate material

2. **Pinocytosis**
   - Engulfment of liquid material

Fig. 4.29a

Fig. 4.29b
3. Receptor-Mediated Endocytosis

- The process is highly specific and very fast
- How low density lipoprotein (LDL) molecules bring cholesterol into animal cells
- Harmful levels of cholesterol can accumulate in the blood if membranes lack cholesterol receptors
4.12 Selective Permeability

- Cell membranes have **selective permeability**
  - They contain protein channels that allow only certain molecules to pass

- **Selective Diffusion**
  - Allows molecules to pass through open channels in either direction
    - Ion channels
      - If the ion fits the pore, it goes through
Facilitated Diffusion

- Net movement of a molecule **down its concentration gradient** facilitated by specific carrier proteins.

**Fig. 4.32**

1. Particular molecules can bind to special protein carriers in the plasma membrane.
2. The protein carrier helps (facilitates) the diffusion process and does not require energy.
3. The molecule is released on the far side of the membrane. Protein carriers transport only certain molecules across the membrane but will take them in either direction down their concentration gradients.
Facilitated Diffusion

- The rate can be saturated
  - It increases up to a certain level and then levels off

**Fig. 4.32**

1. Particular molecules can bind to special protein carriers in the plasma membrane.
2. The protein carrier helps (facilitates) the diffusion process and does not require energy.
3. The molecule is released on the far side of the membrane. Protein carriers transport only certain molecules across the membrane but will take them in either direction down their concentration gradients.
Active Transport

• The movement of molecules across a membrane against a concentration gradient
  – This is possible by the expenditure of energy

• Two types of channels are mainly used
  – 1. Sodium-Potassium Pump
  – 2. Proton Pump
- The Sodium-Potassium Pump
  - Uses the energy of one ATP molecule to pump 3 Na\(^+\) outward and 2 K\(^+\) into the cell

**Fig. 4.33**

The sodium-potassium pump binds three sodium ions and a molecule of ATP.

The splitting of ATP provides energy to change the shape of the channel. The sodium ions are driven through the channel.

The sodium ions are released to the outside of the membrane, and the new shape of the channel allows two potassium ions to bind.

Release of the phosphate allows the channel to revert to its original form, releasing the potassium ions on the inside of the membrane.
• The Sodium-Potassium Pump
  – Leads to fewer Na$^+$ in the cell

  – This concentration gradient is exploited in many ways, including
    
    • 1. The conduction of signals along nerve cells
       – Chapter 28

    • 2. The transport of material into the cell against their concentration gradient
       – Coupled channels
Fig. 4.34  A coupled channel

Can enter against its concentration gradient
• The Proton Pump
  – Expends metabolic energy to pump protons across membranes

This process is termed chemiosmosis.

Fig. 4.35
How Cells Get Information

• Cells sense **chemical information** by means of cell surface **receptor proteins**
  – These bind specific molecules and transmit information to the cell

• Cells sense **electrical information** by means of **voltage-sensitive channels**
  – These allow ions into or out of the cell in response to electric signals