Chapter 4
The Cell: Basic Unit of Life

Cell Theory
- All organisms are made up of cells
- The cell is the basic living unit of organization for all organisms
- All cells come from pre-existing cells...

Biological diversity & unity
- Underlying the diversity of life is a striking unity
  - DNA is universal genetic language
  - Cells are the basic units of structure & function
    - lowest level of structure capable of performing all activities of life

Activities of life
- Most everything you think of a whole organism needing to do, must be done at the cellular level...
  - reproduction
  - growth & development
  - energy utilization
  - response to the environment
  - homeostasis

How do we study cells?
- Microscopes opened up the world of cells
  - Robert Hooke (1665)
    - the 1st cytologist
  - Drawings by Hooke

How do we study cells?
- Microscopes
  - light microscopes
  - electron microscope
  - transmission electron microscopes (TEM)
  - scanning electron microscopes (SEM)
**Light microscopes**
- 0.2µm resolution
- ~size of a bacterium
- visible light passes through specimen
- can be used to study **live** cells

**Electron microscope**
- 1950s
- 2.0nm resolution
- 100 times > light microscope
- reveals organelles
- but can only be used on **dead** cells

**Transmission electron microscopes**
- TEM
  - used mainly to study internal structure of cells
    - aims an electron beam through thin section of specimen
  - rabbit trachea
  - cucumber seed leaf

**Scanning electron microscopes**
- SEM
  - studying surface structures
  - sample surface covered with thin film of gold
  - beam excites electrons on surface
  - great depth of field = an image that seems 3-D

**Isolating organelles**
- Cell fractionation
  - separate organelles from cell
  - variable density of organelles
  - ultracentrifuge

**Ultracentrifuge**
- spins up to 130,000 rpm
  - forces > 1 million X gravity (1,000,000g)
**Microcentrifuge**
- Biotechnology research
  - study cells at protein & genetic level

**Cell characteristics**
- All cells:
  - surrounded by a **plasma membrane**
  - have **cytosol**
    - semi-fluid substance within the membrane
    - \( \text{cytoplasm} = \text{cytosol} + \text{organelles} \)
  - contain **chromosomes** which have genes in the form of **DNA**
  - have **ribosomes**
    - tiny "organelles" that make proteins using instructions contained in genes

**Types of cells**
- **Prokaryotic vs. eukaryotic cells**
  - **Location of chromosomes**
    - **Prokaryotic cell**
      - DNA in **nucleoid** region, without a membrane separating it from the rest of cell
    - **Eukaryotic cell**
      - chromosomes in **nucleus**, membrane-enclosed organelle

**Cell types**

<table>
<thead>
<tr>
<th></th>
<th>Prokaryotes</th>
<th>Eukaryotes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smaller</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Simpler</strong></td>
<td></td>
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<tr>
<td><strong>Most do not have membrane-enclosed organelles</strong></td>
<td></td>
<td>Membrane-enclosed organelles</td>
</tr>
<tr>
<td><strong>Bacteria and archaea</strong></td>
<td></td>
<td>Protists, plants, fungi, animals</td>
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</tbody>
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**Eukaryotic cells**
- **Eukaryotic cells are more complex than prokaryotic cells**
  - within **cytoplasm** is a variety of membrane-bounded **organelles**
  - specialized structures in form & function
- **Eukaryotic cells are generally bigger than prokaryotic cells**
Limits to cell size

- **Lower limit**
  - smallest bacteria, mycoplasmas
  - 0.1 to 1.0 micron (µm = micrometer)
  - most bacteria
  - 1-10 microns

- **Upper limit**
  - eukaryotic cells
  - avg. 10-100 microns
  - micron = micrometer = 1/1,000,000 meter
  - diameter of human hair = ~20 microns

What limits cell size?

- **Surface to volume ratio**
  - as cell gets bigger its volume increases faster than its surface area
  - smaller objects have greater ratio of surface area to volume

<table>
<thead>
<tr>
<th>Total surface area</th>
<th>Total volume</th>
<th>Surface to volume ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>(height x width x length x number of boxes)</td>
<td>(height x width x length x number of boxes)</td>
<td>(area x volume)</td>
</tr>
<tr>
<td>6</td>
<td>105</td>
<td>750</td>
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</tbody>
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How to get bigger?

- **Become multi-cellular (cell divides)**

Cell membrane

- **Exchange organelle**
  - **plasma membrane** functions as **selective barrier**
    - allows passage of $O_2$, nutrients & wastes

Organelles & Internal membranes

- **Eukaryotic cell**
  - internal membranes
    - partition cell into compartments
    - create different local environments
    - compartmentalize functions
    - membranes for different compartments are specialized for their function
      - different structures for specific functions
      - unique combination of lipids & proteins