10.2 - Cell Division

- Zygote (fertilized egg)
- Eight cells
- Blastula (cross section)
- Gastrula (cross section)
- Gut cavity
- Adult animal (sea star)
Objectives

- Identify the major events of the **five phases** of the cell cycle.

- Summarize the events of the **four stages of mitosis**.
Where it all began...

You started as a cell smaller than a period at the end of a sentence...
How?

... to here.
Getting from there to here...

- Going from egg to baby... to you
- the original fertilized egg has to divide... and divide... and divide...
Why do cells divide?

- Unicellular organisms divide for **asexual** reproduction (**clones**)
- Multicellular organisms divide
  - for **growth** and **development**
  - for **repair** and **replacement**

http://www.youtube.com/watch?v=QDdVs4qM1XU
Wall lizards
What needs to be divided equally?
Organizing & packaging DNA

DNA in chromosomes in everyday “working” cell

4 chromosomes in *this* organism

DNA in chromosomes in cell getting ready to divide

DNA has been “wound up”
Chromosomes of Human Female

46 chromosomes
23 pairs
Chromosomes of Human Male

46 chromosomes
23 pairs
## Chromosome Number of Various Organisms

<table>
<thead>
<tr>
<th>Organism</th>
<th>Number of chromosomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Penicillium</em></td>
<td>1–4</td>
</tr>
<tr>
<td><em>Saccharomyces</em> (yeast)</td>
<td>18</td>
</tr>
<tr>
<td>Mosquito</td>
<td>6</td>
</tr>
<tr>
<td>Housefly</td>
<td>12</td>
</tr>
<tr>
<td>Garden pea</td>
<td>14</td>
</tr>
<tr>
<td>Corn</td>
<td>20</td>
</tr>
<tr>
<td>Adder’s tongue fern</td>
<td>1,262</td>
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<tr>
<td>Frog</td>
<td>26</td>
</tr>
<tr>
<td>Human</td>
<td>46</td>
</tr>
<tr>
<td>Orangutan</td>
<td>46</td>
</tr>
<tr>
<td>Dog</td>
<td>78</td>
</tr>
</tbody>
</table>
Homologous chromosomes (homologues) are chromosomes that are SIMILAR in size, shape, and genetic content.

- Each homologue comes from one parent.
- The 46 chromosomes in human somatic (non-sex) cells are actually two sets of 23 chromosomes.
When chromosomes duplicate themselves, they produce two **EXACT copies** of DNA that make up each chromosome called **chromatids**.

- The chromatids separate during cell division (mitosis).
- Each new cell has the same genetic information as the original cell.
Chromosome Number and Development

- A **diploid** cell, such as a **somatic** (non-sex) cell, contains **TWO sets** of chromosomes.
- A **haploid** cell, such as a **gamete** (sperm or egg), contains **ONE set** of chromosomes.
- The fusion of two haploid gametes – a process called **fertilization** – forms a diploid zygote. A **zygote** is a fertilized egg cell.
The Cell Cycle

- a series of events that cells go through as they grow and divide
- During the cell cycle, a cell
  - grows
  - prepares for division
  - divides to form two daughter cells (each of which begins the cycle again)
Cell cycle

- Cell has a “life cycle”

  cell is formed from a **mitotic** division

  cell grows & matures to divide again

  G₁, S, G₂, M

  epithelial cells, blood cells, stem cells

  liver cells

  brain/nerve cells, muscle cells

  G₁ → G₀

Regents Biology
1. **First growth ($G_1$) phase**: cell grows rapidly and carries out its routine functions.

2. **Synthesis (S) phase**: cell’s DNA is copied (replicated). (Once in S phase, a cell often completes the rest of cycle)

3. **Second growth ($G_2$) phase**: organelles and molecules required for cell division are produced; nucleus prepares to divide.

4. **Mitosis**: the nucleus of a cell is divided into two nuclei.

5. **Cytokinesis**: the cytoplasm divides.
Stages of Mitosis

- **Prophase (P)**
  - Chromosomes become visible
  - Nuclear envelope dissolves
  - Spindles form

- **Metaphase (M)**
  - Chromosomes line up along the equator

- **Anaphase (A)**
  - Centromeres divide
  - Chromatids (now called chromosomes) move toward opposite poles

- **Telophase (T)**
  - Nuclear envelope forms at each pole
  - Chromosomes uncoil
  - Spindles dissolve
  - Cytoplasmic division (Cytokinesis) begins

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**Regents Biology**
Mitosis in action

http://www.youtube.com/watch?v=ZeW8HaCUtOQ
Bozeman on Mitosis

http://www.youtube.com/watch?v=1cVZBV9tD-A
- First and longest phase of mitosis
- Nuclear envelope dissolves
- **Spindles** (structure that will separate chromosomes) form
- **DUPLICATED** chromosomes line up along the equator of the cell
- microtubules connect the centromere of each chromosome to the poles of the spindle
- **sister chromatids** separate into individual chromosomes
- chromosomes continue to move until they have separated into two groups
Nuclear envelope reforming

Telophase

- the fourth and final phase of mitosis
- chromosomes gather at opposite ends of the cell and lose their distinct shape
- a new nuclear envelope forms around each cluster of chromosomes
Cytokinesis

- **cytokinesis** begins when mitosis ends
- cytoplasm pinches in half and the cell membrane grows to enclose each cell, forming two separate cells
- each daughter cell has an **identical** set of chromosomes
Cytokinesis in Plants

- In plants, **cell plate** forms midway between the divided nuclei.
- The cell plate gradually develops into a separating membrane.
- A cell wall then begins to appear in the cell plate.
Mitosis in plant cell

- Interphase
- Prophase
- Prometaphase
- Metaphase
- Anaphase
- Telophase
Mitosis in onion root tips
10.3 - Regulating the Cell Cycle
Internal Regulators

- are proteins that respond to events inside the cell
- **Ex**: $G_1$ in cell cycle
- cell must grow to a certain size during $G_1$ before DNA synthesis (cytoplasmic volume-to-genome size ratio)
- **restriction point** is point of no return
Cell Cycle Regulators

- The cell cycle is regulated by the protein **cyclin**
- The amount of cyclin in the cell rises and falls in time with the cell cycle
External Regulators

- are proteins that respond to events outside the cell
- External regulators direct cells to speed up or slow down the cell cycle
- **Ex:** Platelet-derived growth factor (PDGF)

1. A sample of connective tissue was cut up into small pieces.

2. Enzymes were used to digest the extracellular matrix, resulting in a suspension of free fibroblast cells.

3. Cells were transferred to sterile culture vessels containing a basic growth medium consisting of glucose, amino acids, salts, and antibiotics (as a precaution against bacterial growth). PDGF was added to half the vessels. The culture vessels were incubated at 37°C.
   - (a) In a basic growth medium without PDGF (the control), cells failed to divide.
   - (b) In a basic growth medium plus PDGF, cells proliferated. The SEM shows cultured fibroblasts.
Control on Cell Division

- Normal (vs. cancer) cells will reproduce until they come into contact with other cells (contact inhibition).
- Controls on cell growth and division can be regulated (turned on/off, speed up or slow down).
Cells anchor to dish surface and divide (anchorage dependence).

When cells have formed a complete single layer, they stop dividing (density-dependent inhibition).

If some cells are scraped away, the remaining cells divide to fill the gap and then stop (density-dependent inhibition).

(a) Normal mammalian cells

Cancer cells do not exhibit anchorage dependence or density-dependent inhibition.

(b) Cancer cells
Cancer Cells

- exhibit *neither* contact inhibition nor anchorage dependence
- do **NOT** respond to control mechanisms

http://www.youtube.com/watch?v=Y2kTEbyMvXA
Cancer Cells

- form **tumors**, invade surrounding tissues (**metastasize**)
- Cancer cells may break loose from tumors and spread throughout the body, disrupting normal activities and causing serious medical problems or even death.