Mitosis & Meiosis

- Chromosomal structure
- Cell Cycle
- Interphase & Mitosis
- Meiosis--Reduction Division
Chromosomal structure

- DNA (2 strands)
- Associated with proteins (Euk= Histones)
- Chromatin
- Centromere
- Haploid
- Diploid
- Homologous chromosomes
Prokaryotic cells
Cell Cycle

- Production of new cells for repair, growth
- Interphase (3 stages)
- Mitosis = separation of chromosomes
- Go
- Environmental factors
- Hormonal factors
Interphase & Mitosis

- Stages of Mitosis
- Prophase
- Metaphase
- Anaphase
- Telophase
- Cytokinesis
- Results: 2 identical cells
Mitosis

(a) Interphase
Chromosomes are extended and uncoiled, forming chromatin.

(b) Prophase
Chromosomes coil up and shorten; centrioles divide and move apart.

(c) Prometaphase
Chromosomes are clearly double structures; centrioles reach the opposite poles; spindle fibers form.

(d) Metaphase
Centromeres align on metaphase plate.

(e) Anaphase
Centromeres split and daughter chromosomes migrate to opposite poles.

(f) Telophase
Daughter chromosomes arrive at the poles; cytokinesis commences.

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Cytokinesis

a) Animal cell

b) Plant cell

Cleavage furrow

Cell plate
Regulation of Cell Cycle

- CDC mutations: 3 checkpoints involved with cyclins
- Cyclin + CDK causes phosphorylation to activate proteins to advance through the cell cycle
- G1/S: cell size, DNA damage, cannot proceed to S
- G2/M: Replication or damage
- M: formation of spindle fiber system, not attached properly
- Tumor suppressor genes: P53 (transcription factor) program cell death or arrest cell cycle, senses DNA damage
Meiosis--Reduction Division

- Only in diploid cells
- Diploid to haploid
- Replicate DNA once
- 2 cell divisions
- Production 4 haploid cells
- Increase genetic variability
- Recombination
- Independent assortment of homologues
- Non-disjunction

### Table 2.1

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Haploid Number</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Haploid Number</th>
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<tbody>
<tr>
<td>Black bread mold</td>
<td>Aspergillus nidulans</td>
<td>8</td>
<td>House mouse</td>
<td>Mus musculus</td>
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<td>Broad bean</td>
<td>Vicia faba</td>
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<td>Human</td>
<td>Homo sapiens</td>
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<tr>
<td>Cat</td>
<td>Felis domesticus</td>
<td>19</td>
<td>Jimson weed</td>
<td>Datura stramonium</td>
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<tr>
<td>Cattle</td>
<td>Bos taurus</td>
<td>30</td>
<td>Mosquito</td>
<td>Culex pipiens</td>
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<tr>
<td>Chicken</td>
<td>Gallus domesticus</td>
<td>39</td>
<td>Mustard plant</td>
<td>Arabidopsis thaliana</td>
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<td>Chimpanzee</td>
<td>Pan troglodytes</td>
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<td>Pink bread mold</td>
<td>Neurospora crassa</td>
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<td>Corn</td>
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<td>Potato</td>
<td>Solanum tuberosum</td>
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<td>Cotton</td>
<td>Gossypium hirsutum</td>
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<td>Rhesus monkey</td>
<td>Macaca mulatta</td>
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<td>Dog</td>
<td>Canis familiaris</td>
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<td>Roundworm</td>
<td>Caenorhabditis elegans</td>
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<tr>
<td>Evening primrose</td>
<td>Oenothera biennis</td>
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<td>Silkworm</td>
<td>Bombyx mori</td>
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<tr>
<td>Frog</td>
<td>Rana pipiens</td>
<td>13</td>
<td>Slime mold</td>
<td>Dictyostelium discoideum</td>
<td>7</td>
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<tr>
<td>Fruit fly</td>
<td>Drosophila melanogaster</td>
<td>4</td>
<td>Snapdragon</td>
<td>Antirrhinum majus</td>
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<tr>
<td>Garden onion</td>
<td>Allium cepa</td>
<td>8</td>
<td>Tobacco</td>
<td>Nicotiana tabacum</td>
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</tr>
<tr>
<td>Garden pea</td>
<td>Pisum sativum</td>
<td>7</td>
<td>Tomato</td>
<td>Lycopersicon esculentum</td>
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<tr>
<td>Grasshopper</td>
<td>Melanoplus differentialis</td>
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<td>Water fly</td>
<td>Nymphaea alba</td>
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<tr>
<td>Green alga</td>
<td>Chlamydomonas reinhardi</td>
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<td>Wheat</td>
<td>Triticum aestivum</td>
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<td>Horse</td>
<td>Equus caballus</td>
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<td>Yeast</td>
<td>Saccharomyces cerevisiae</td>
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<tr>
<td>House fly</td>
<td>Musca domestica</td>
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<td>Zebrafish</td>
<td>Danio rerio</td>
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</tr>
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# Meiosis

<table>
<thead>
<tr>
<th>STAGE</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interphase I</td>
<td>Chromosome replication takes place.</td>
</tr>
<tr>
<td>Prophase I</td>
<td>Chromosomes become visible, homologous chromosomes pair, and sister chromatids become visible; recombination takes place.</td>
</tr>
<tr>
<td>Metaphase I</td>
<td>Paired chromosomes align at equator of cell.</td>
</tr>
<tr>
<td>Anaphase I</td>
<td>Homologous chromosomes separate; members of each chromosome pair move to opposite poles.</td>
</tr>
<tr>
<td>Telophase I</td>
<td>Cytoplasm divides, producing two cells.</td>
</tr>
<tr>
<td>Interphase II</td>
<td>Following a brief pause, chromosomes uncoil slightly; this is not a real interphase as such.</td>
</tr>
<tr>
<td>Prophase II</td>
<td>Chromosomes re-coil.</td>
</tr>
<tr>
<td>Metaphase II</td>
<td>Unpaired chromosomes become aligned at equator of cell.</td>
</tr>
<tr>
<td>Anaphase II</td>
<td>Centromeres split; daughter chromosomes pull apart.</td>
</tr>
<tr>
<td>Telophase II</td>
<td>Chromosomes uncoil, nuclear membrane reforms, cytoplasm divides, meiosis is complete.</td>
</tr>
</tbody>
</table>
Meiosis—Reduction Division

- **Leptonema**: condensation of chromatin
- **Zygonema**: homolog search (300nm)
- **Pachynema**: synapsis (100 nm), tetrad stage
- **Diplonema**: chiasma, non-sister chromatids
- **Diakinesis**: pull apart, nucleolus and envelope breakdown, chiasmata move to ends
Meiosis--Reduction Division

Metaphase I

Anaphase I

Telophase I

Prophase II

Metaphase II

Anaphase II

Telophase II

Haploid gametes

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Spermatogenesis & Oogenesis

Spermatogenesis:
- Spermatogonium (2N)
- Primary spermatocyte (2N)
  - Meiotic division
    - Secondary spermatocytes
  - Meiotic division II
    - Spermatids (N)
      - Differentiation
        - Spermatozoa (N)

Oogenesis:
- Oogonium (2N)
- Primary oocyte (2N)
  - Meiotic division
    - Secondary oocyte
    - First polar body
  - Meiotic division II
    - Ootid (N)
      - Second polar body (N)
      - Polar bodies (N)
    - Ovum (N)
Genetic Variability

- Sites of crossing over and chiasma

- Homologous pair of chromosomes with two chromatids per chromosome

- Two pairs of homologous chromosomes

- Direction of separation

- Possible pairing arrangements
## Mitosis vs. Meiosis

### Mitosis

**In somatic cells**
- One cell division, resulting in two daughter cells
- Chromosome number per nucleus maintained (e.g., for a diploid cell)
- One premeiotic S phase per cell division (e.g., for a diploid cell)
- Normally, no pairing of homologs
- Normally, no crossovers
- Centromeres divide at anaphase

**Conservative process:** daughter cells’ genotypes identical to parental cell’s genotype

**Cell undergoing mitosis can be diploid or haploid**

### Meiosis

**In cells in the sexual cycle**
- Two cell divisions, resulting in four products of meiosis
- Chromosome number halved in the products of meiosis
- One premeiotic S phase for both cell divisions
- Full synopsis of homologs at prophase I
- At least one crossover per homologous pair
- Centromeres do not divide at anaphase I but do at anaphase II

**Promotes variation among the products of meiosis**

**Cell undergoing meiosis is diploid**