Chapter 2: Chromosomes and cellular reproduction

I. Contrast between prokaryotes and eukaryotes.
See Figure 2.1

- Nucleus absent
- Small diameter – 1 to 10 µm
- Genome usually 1 circular molecule
- Small genome; DNA not complexed with histones
- No cytoskeleton or membrane-bound organelles

- Nucleus present
- Larger diameter – 10 to 100 µm
- Genome multiple linear molecules
- Larger genome; DNA complexed with histones
- Cytoskeleton and membrane-bound organelles

Eukaryotic DNA is complexed with histones (Fig. 2.2)

Eukaryotic DNA (Fig. 2.3)
Viruses consist of nucleic acid and protein (Fig. 2.4)

II. Prokaryotic cells replicate by simple division. See Figure 2.5

Diploid eukaryotic cells have two sets of chromosomes. (Fig. 2.6)
- Homologous pairs
- Diploid somatic cells
- Haploid germline cells

Cell division in eukaryotes is more complicated, so we need a language to describe the chromosomes.
III. The cell cycle consists of
• interphase
  a period of cell growth
• M phase
  a period of nuclear and cell division

Prophase:
• centrioles migrate to opposite ends of the cell; spindle fibers are organized
• nuclear membrane breaks down; nucleolus disintegrates
• chromosomes condense
• chromosome two sister chromatids connected at the centromere
**Fig. 2.10**

**Metaphase:**
- chromosomes attached to spindle fibers at the centromeres
- centromeres line up on the metaphase plate.

**Fig. 2.11**

**Anaphase:**
- centomeric regions divide
- sister chromatids pull themselves to opposite ends of the cell.

The spindle fibers do not pull the chromosomes to the poles of the cell…

Instead, the kinetochore disassembles the tubulin subunits, and the chromosome pulls itself toward the centrosome.
Telophase:
- nuclear membrane reforms
- cytoplasm partitioned (cytokinesis).

IV. Meiosis consists of two cell divisions
- Meiosis I
  a reductional division
- Meiosis II
  an equational division
Prophase I:
- chromosomes condense
- telomeres are attached to nuclear membrane
- homologous chromosomes synapse
- synaptonemal complex forms
- crossing over occurs
- chiasmata move to ends of chromosomes
- nucleolus and nuclear membrane break down
- centromeres are attached to spindle fibers

Metaphase I:
- centromeres do not divide
- tetrads move to the metaphase plate

Anaphase I:
- one chromosome (pair of sister chromatids) moves to each pole.

Telophase I:
- variable
- nuclei haploid, but with two chromatids for each chromosome

Prophase II:
- very brief
Metaphase II:
• centromeres line up on metaphase plate

Anaphase II:
• centromeres divide
• each sister chromatid pulls itself to opposite poles of the cell

Telophase II:
• nuclear membrane forms
• 4 products of meiosis
V. Crossing over (recombination) occurs during prophase I and produces genetic variation.

- Alleles are shuffled
- Chromosomes can be produced that carry different alleles than those that gave rise to the individual.

V. Genetic variation is produced by the random assortment of chromosomes during meiosis.

3 homologous pairs gives rise to 8 different gametes
V. Genetic variation is produce by the random assortment of chromosomes during meiosis. Ignoring recombination, if $n$ is the number of homologous pairs of chromosomes (the dipliod number), then the number of different gametes that can be produced is $2^n$.

In humans

\[ n = 23 \]

\[ 2^n = 8,388,608 \]

Crossing over shuffles alleles on the same chromosome, random assortment shuffles alleles on different chromosomes. Both processes increase the genetic variation among gametes produced during meiosis.

Contrast $♂$ and $♀$ gametogenesis

- Spermatogenesis has ongoing meiosis from progenitor cells in each generation; oogenesis has single meiosis from each progenitor cell in each generation.
- Spermatogenesis produces 4 gametes per meiosis; oogenesis produces 1 gamete per meiosis.

Meiosis produces four haploid products that are genetically variable.
Contrast of mitosis and miosis (Fig. 2.19):

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<tr>
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<th>Mitosis</th>
<th>Meiosis</th>
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<tbody>
<tr>
<td>1.</td>
<td>One cell division, resulting in two daughter cells.</td>
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<td>2.</td>
<td>Chromosome number per nucleus maintained.</td>
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<td>3.</td>
<td>One premitotic S phase per cell division.</td>
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<td>4.</td>
<td>Normally, no pairing of homologs.</td>
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<td>5.</td>
<td>Normally, no crossing over.</td>
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<td>6. Centromeres divide at anaphase.</td>
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<td>7. Conservative process: daughter cell genotypes identical to parental cell's genotype.</td>
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<td>8. Cell undergoing mitosis can be diploid or haploid.</td>
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