Notes

Biology 102
Karen Bledsoe, Instructor
http://www.wou.edu/~bledsoek/

Chapter 11

Topic: Mitosis

Main concepts:

- Cells must reproduce in order for organisms to grow and to allow cell replacement.
- Prokaryotic cells reproduce by binary fission, a simple division following replication of the DNA ring.
- Eukaryotic cells reproduce by mitosis followed by cytokinesis. Mitosis is an orderly process of reproducing and sorting DNA strands so that each daughter cell ends up with exactly the same genetic material. Cytokinesis is the actual splitting of the cell.
- Animal cells are mostly diploid cells: that is, each has two of each kind of chromosome, one copy from each parent. Only the sex cells are haploid (having one copy of each chromosome).
- Cell division is only a small part of the cell cycle. Most of the cell's live is spent in G1 ("Gap 1"), where cell growth and normal life processes occur.
- The end of G1 is marked by a signal to divide. The cell enters S phase, where all the DNA is replicated.
- During G2, the cell prepares to divide.
- Mitosis consists of a series of identifiable phases:
  - Interphase: This is everything that is **not** actual mitosis: G1, S, and G2 phases of the cell cycle.
  - Prophase: Identical sister chromatids pair up, and are connected by a protein structure called a kinetochore. Chromosomes condense, nuclear membrane and other internal membranes dissolve.
  - Metaphase: Chromosomes line up on spindle fibers down the middle of the cell.
  - Anaphase: The sister chromatids break apart from one another and are guided to opposite poles of the cell by the spindle fibers.
  - Telophase: Chromosomes unwind, nuclear membrane and other membranes re-form. Telophase ends with cytokinesis.
- *The most important thing to remember* is that through mitosis, the daughter cells end up with the exact same chromosome set that the original cell had.
- Asexual reproduction can happen through mitotic division (mitosis), but all offspring will be genetically identical — in other words, clones. Examples: taking cuttings from houseplants, sea anemones that form "buds" that grow into new sea anemones.
- Sexual reproduction requires meiosis (reduction division) to put one single set (haploid number) of chromosomes into each gamete (sex cell). During fertilization, the two sets combine in the fertilized egg (zygote) to create a new organism with two sets (diploid number) of chromosomes.
- The **big, huge, important difference** between meiosis and mitosis, that sets the whole meiotic division in motion, is the formation of **tetrads** in Prophase I of meiosis. In mitosis, identical sister chromatids join together to make chromosomes. In meiosis, all four homologous chromosomes (all four that carry the same genes but possibly different alleles) join together into **tetrads**.
- When tetrads are formed, the arms of homologous chromosomes may trade bits with each other in a process called **crossing over**. The maternal chromatid, for example, may carry a recessive allele while the paternal chromatid carries a dominant one, and they may trade those two alleles.
- The first part of meiosis (from Prophase I to Telophase I) separates the homologous chromosomes from each other.
- The second part of meiosis separates (Prophase II to Telophase II) separates the sister chromatids from each other.
- The result of meiosis is four haploid cells. Each has one set of chromosomes, but each will differ genetically from the others because they may carry different alleles compared with the other.

Common misconceptions:

- "Chromosome" is a problematic word. It refers to strands of DNA that are coiled up around histone proteins prior to mitosis. A single strand is called a chromatid, and can be a chromosome when it is not paired with another strand. Two identical (replicated) strands are paired after S phase, and these identical paired

chromatids are a chromosome. The term is so problematic that some geneticists have suggested doing away with it altogether, and suggest we just talk about chromatids.
- Some students draw the chromosomes breaking apart crosswise at the kinetochore, probably misled by diagrams showing the individual chromatids being dragged in a v-shape in anaphase.
- Students often confuse the terms "sister chromatid" with "homologous chromosome." The sister chromatids are exact copies of one another that are made during S-phase of the cell cycle. Homologous chromosomes are the two forms of a single type of chromosome that were originally inherited from our parents: the maternal and paternal chromosomes. These carry the same set of genes but usually carry different alleles.

Reading notes:

- Describe the phases of the cell cycle. Note which phases the cell spends most of its time in, and in which phase the DNA is doubled.
- Describe the two types of cell division: mitotic and meiotic.
- Describe what a chromosome is made up of. Define: locus, telomere, cetromere, kinetochore, chromatid, diploid, haploid.
- List the phases of mitosis, and describe what happens in each.
- Pay special attention to Figures 11.23 and 11.24 that show Prophase I of meiosis compared with Prophase of mitosis. Notice the arrangement of homologous chromosomes. Also observe the table on page 203 that compared mitosis and meiosis.
- List reasons that sexual reproduction is advantageous over many generations. What is the source of genetic variability in a population?
- Define "homologous chromosomes" and "sister chromatids" using what you read in the text (the glossary definitions aren't as explanatory).
- State what happens to the number of chromosomes in the cells as a result of meiosis. Why is this a necessary step before fertilization?
- Using table 11.1, list the major events of Meiosis I and Meiosis II. (Note that the two parts of meiosis are not separated by the rest of the cell cycle. There is a short "resting" period between called interkinesis where the chromosomes briefly unwind and the cell prepares for Meiosis II, but this happens quickly and there is no DNA replication during interkinesis.)
- Explain how both crossing over and meiosis contribute to genetic variability in organisms.
- Read the section on artificial cloning. Is artificial cloning sexual or asexual reproduction?

Useful websites:

- "The Biology Project" http://www.biology.arizona.edu is full of useful activities related to cell biology and microbiology that is being used with lab this week. If you want to review mitosis, click on "cell biology" in the list of problem sets and tutorials.
- "Cells Alive!" http://www.cellsalive.com has interactive demos of the cell cycle and mitosis.
- "DNA Coiling to form Chromosomes" http://www.biostudio.com/demo_freeman_dna_coiling.htm is a cool animation of the process of condensing DNA into chromosomes.
- "Meiosis Tutorial" http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/main.html has a very nice tutorial explaining the two parts of meiosis.
- "Meiosis animation" http://www.johnkyrk.com/meiosis.html is a nice animation showing chromosome movement during meiosis (except it uses the slightly misleading term "Interphase II" instead of interkinesis).