Announcements

- After the easy past week, this week’s material is complex. Please keep up with reading!

- Problem Set 3 now posted. Answers will be up Friday.

- Problem Set 4 will be based on this week’s material. Will be posted next week.

- GMO Essays due by Tuesday at end of class. 1-2 pages, double spaced, 11 point font. Justify positions.

- Dr. Christine Hochmuth will guest lecture next week.

Follow up to “Harvest of Fear” - 2001

- http://environmentaljusticetv.wordpress.com/2013/03/02/novafrontline-harvest-of-fear-12-parts/

- World population predictions: 8 billion people by 2025.

- Papayas and GMOs in Hawaii: [http://www.huffingtonpost.com/tag/hawaii-gmo](http://www.huffingtonpost.com/tag/hawaii-gmo)


Chapter 6: Chromosomes and Cell Division

Continuity and variety
Outline

• Chromosomes.
• Cell Cycle.
• DNA Replication.
• Mitosis.
• Cancer = Cell Cycle out of control.
• Meiosis.

Cell division in sickness and health.

Telomeres

- The telomere is like a protective cap at the end of the DNA.
- Every time a cell divides, the telomere gets a bit shorter.
“Cancer cells are those which have forgotten how to die.”
—Harold Pinter

Cell Cycle

- The total length of DNA in a typical eukaryotic cell is ~ 2 meters!!
  This is 250,000 X greater than the diameter of the cell!

- How does the cell copy this vast amount of information with every cell division??

- One factor is the packaging of this DNA into chromosomes, making replication and equal distribution to daughter cells more manageable.

Why is Cell Division so important?

- In Unicellular organisms
  - Reproduction

- In Multicellular organisms
  - Development
  - Tissue renewal
  - Reproduction

sand dollar embryo after fertilization, forming two cells. Dividing blood cells

Figure 6-7

The tip of the root is a site of particularly rapid cell division in most plants.

The act of shaving damages thousands of cells, which must be replaced.
Apoptosis

- The pre-planned process of cell suicide
- Certain cells are targeted for apoptosis.

Overview of Cell Division

1. DNA duplication (Replication)
2. Chromosome condensation
3. Division of chromosomes into 2 nuclei (Mitosis)
4. Division of the cytoplasm into 2 cells (Cytokinesis)

All steps are highly regulated to ensure precise cell division, resulting in two identical daughter cells.
Cell division is preceded by replication.

Persistence and propagation

Replication

- The process of DNA duplication

Complementarity

- Every “A” (adenine) pairs with “T” (thymine) and vice-versa.
- Every “G” (guanine) pairs with “C” (cytosine) and vice-versa.

Mitosis

- The number of (somatic) cells that must be replaced by mitosis every day is huge.
- The rate at which mitosis occurs varies dramatically.
Overview

Mitosis leads to duplicate cells.

Parent cells $\rightarrow$ daughter cells

The Details

Mitosis is a four-step process.

Preparation for Mitosis: The Chromosomes Replicate

Animal chromosomes are linear.

So why do they look like the letter “X” in pictures?
Sister Chromatids

A chromosome and its identical replicated copy, joined at the centromere.
Cell division out of control means cancer.
Cancer

- Unrestrained cell growth and division...

- ...can lead to tumors...

- ...the second leading cause of death in the United States!

Cancer cells have several features that distinguish them from normal cells, including...

Benign and Malignant Tumors
Why is the treatment for cancer often considered as bad as the disease?

Sexual reproduction requires special cells made by meiosis.

Meiosis
- Gametes
- Diploid
- Haploid
- Maintains a stable genome size in a species

Meiosis has two important features:
1. It reduces the amount of genetic material in gametes.
2. It produces gametes that all differ from each other with respect to the combinations of alleles they carry.
Meiosis generates sperm and eggs and a great deal of variation.

Sperm and egg are produced by meiosis: the details, step-by-step.

Mitosis occurs almost everywhere in an animal’s body. Meiosis only occurs in one place. Where?

Meiosis starts with a diploid cell.

- One of the specialized diploid cells in the gonads

Meiosis starts with a diploid cell.

- A **homologous pair**, or **homologues**
  - The maternal and paternal copies of a chromosome

![Diagram of homologues and sister chromatids](image.png)

**Homologues and Sister Chromatids**

Homologues are the maternal and paternal copies of a chromosome. A sister chromatid is one of the two identical copies of a chromosome created during replication. The two sister chromatids are held together at a centromere.
Chromosomes are duplicated.

- Sister chromatids
  - Each strand and its identical duplicate, held together at the centromere

Cells undergoing meiosis divide twice.

There are two major parts to meiosis:

1. The homologues are separated.
2. Each of the two new cells divides again, separating the sister chromatids into two even newer cells.

Meiosis Division 1

Separating the homologues
1. Prophase I

- The most complex of all the phases of meiosis
- **Crossing over**

2. Metaphase I

- Each pair of homologous chromosomes moves to the equator of the cell.

3. Anaphase I

- Beginning of the first cell division that occurs during meiosis
- The homologues are pulled apart toward opposite sides of the cell.
- The maternal and paternal sister chromatids are pulled to the ends of the cell in a *random fashion*. 
4. Telophase I and Cytokinesis

- This phase is marked by the chromosomes arriving at the two poles of the cell.
- The cytoplasm then divides and the cell membrane pinches the cell into two daughter cells.

5. Prophase II

- The genetic material once again coils tightly making the chromatids visible under the microscope.
- It is important to note that in the brief interphase prior to prophase II, there is no replication of any of the chromosomes.
6. Metaphase II

- The sister chromatids (each appearing as an X) move to the center of the cell.

7. Anaphase II

- The fibers attached to the centromere begin pulling each chromatid in the sister chromatid pair toward opposite ends of each daughter cell.

8. Telophase II

- The cytoplasm then divides, the cell membrane pinches the cell into two new daughter cells, and the process comes to a close.

Outcome of Meiosis

- The creation of four haploid daughter cells, each with just one set of chromosomes which contains a completely unique combination of traits
Male and female gametes are produced in slightly different ways.

How do you distinguish a male from a female?

The definition of male vs. female is always the same: females produce the larger gamete, males produce the smaller, more motile gamete.
Crossing over and meiosis are important sources of variation.

What are the costs and benefits of sexual reproduction?

Bacteria reproduce asexually, while most plants and animals reproduce sexually.

Which is a better method?
With asexual reproduction, the advantages and disadvantages are more or less reversed.

Asexual reproduction can be fast! Some bacteria can divide every 20 minutes.

Deviations from the normal chromosome number lead to problems.
Down syndrome can be detected before birth: Karyotypes reveal an individual’s entire chromosome set.

- **Karyotype**
  - A display of an individual’s complete set of chromosomes

- **Nondisjunction**
  - The unequal distribution of chromosomes during meiosis
  - Error of cell division that creates a gamete with zero or two copies of a chromosome rather than a single copy
Life is possible with too many or too few sex chromosomes.

1. Amniocentesis

2. Chorionic Villus Sampling (CVS)

- Tissue is removed from the **placenta**.
- Because the fetus and placenta both develop from the same fertilized egg, their cells contain the same genetic composition.
- Can be done several weeks earlier in the pregnancy, usually between the 10th and 12th weeks.
Learning Objectives

- Understand and be able to describe the different types of cell division
- Understand and be able to explain how through mitosis worn out old cells are replaced with fresh new duplicates

Learning Objectives

- Understand and be able to explain how sperm and eggs are generated through meiosis
- Describe the sex differences in the chromosomes
- Discuss the consequences of deviations from the normal chromosome number