

Genes, Mutations and Diseases: Understanding the Origins of Genetic Disorders through Experiential Learning

A five week series of lessons and experiments designed for cohesiveness as unit, but can be done individually.

Unit Product of ASBMB HOPES 2013 Grant by:
Edwin Li, Brian Forster, and Caitlin Fritz, St. Joseph University &
Matthew Jurkiewicz, Bishop McDevitt High School

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Lesson 3

Inheritance: Mitosis and Meiosis

Overview

The fundamentals of cell division through mitosis and meiosis are taught in this activity through lecture, hands-on modeling and experimental observation. This activity teaches how the cell maintains proper chromosome number while it replicates, how parents are able to donate half their chromosomes to their offspring, and the relationship between chromosomes and genes.

Quick Guide and Materials:

- **Age Range:** High School
- **Preparation Time:** ~ 30 minutes
- **In Class Time:** ~ 1.5 hours
- **Duration:** 1 week
- **Materials List:** Microscopes, Onion root tip slides, Pop-bead chromosomes, Sordaria, Phenylthiocarbamide test paper

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Activity Outline

Sequence	Activity	Timing
Activity Breakdown Below	A. Lecture Slides 1-8	10 min
	B. Mitosis (Slide 9)	15 min
	C. Lecture Slides 10-12	10 min
	D. Meiosis (Slide 13)	15 min
	E. Lecture Slide 14-21	10 min
	F. Inheritance (Slide 19)	15 min

Materials

Mitosis Activity

- Microscopes
- Slides of onion root tips
(carolina.com cat# 302396)

Meiosis Activity

- Pop-bead chromosomes
(carolina.com cat# 171100)
- Sordaria- prepared cards
(flinnsci.com cat# FB1973)

Inheritance Activity

- Phenylthiocarbamide test paper
(carolina.com cat# 974896)

Lecture Slides and Handouts

Lecture Material

Lecture-

This lecture will cover how the cell maintains the proper chromosome number while it replicates during cell division, or mitosis, how parents are able to donate half of their chromosomes to their offspring, and the relationship between chromosomes and genes
Example found at: www.asbmb.org/912activity/

Handouts

Printable handouts contain protocols, pictures, questions for student during the experiment and further explanation of the science behind certain steps.

Instructor manual found at:
www.asbmb.org/912activity/

(contains answer key and reference pictures)

Printable student lab instructions/notebook is found at: www.asbmb.org/912activity/

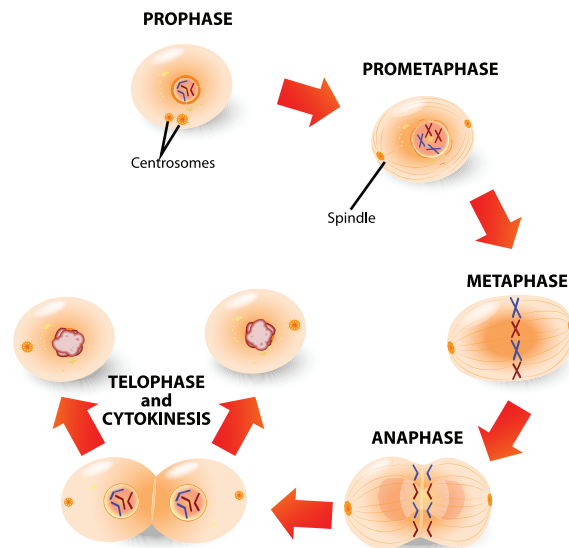
Sickle Cell Anemia is a recessive genetic disorder. Encourage students to consider patterns of inheritance and the difference between dominant and recessive disorders through this activity.

Mitosis

During cell replication, the cell must divide its nucleus, which houses the chromosomes. The division of a single nucleus into two genetically identical daughter nuclei is known as mitosis.

Use onion root tip cells to observe the phases of mitosis.

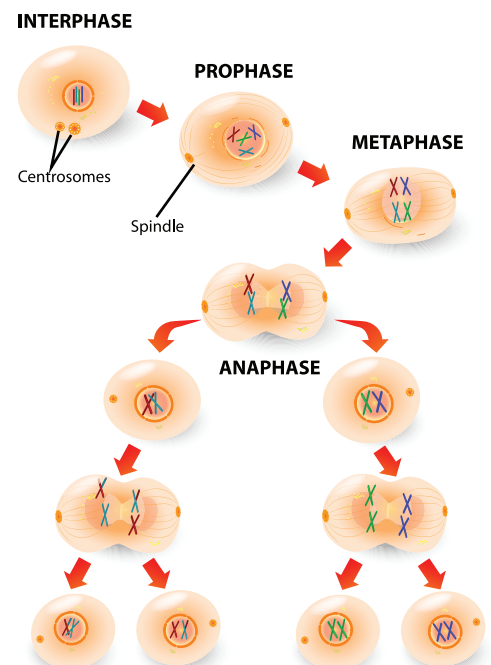
1. Look for the phases of mitosis in an onion root tip. Examine the slide and try to identify each stage of mitosis.
2. Make sketches of each phase, remembering to label the parts of the cell and describe what is happening.
3. Consider, the human body produces 300 million cells/minute. Why is it important that mitosis must be precise and accurate?



Meiosis

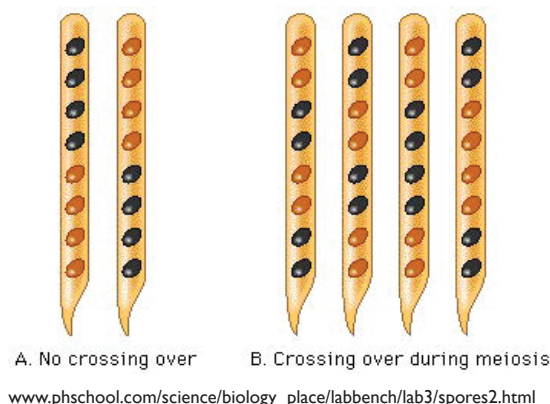
With the exception of sex cells, each cell has 22 pairs of autosomal chromosomes and 1 pair of sex chromosomes. Females have 2 “X” chromosomes (XX) and males have an “X” and “Y” chromosome (XY). With the exception of sex cells, each cell has 22 pairs of autosomal chromosomes and 1 pair of sex chromosomes. Females have 2 “X” chromosomes (XX) and males have an “X” and “Y” chromosome (XY). Objective: model meiosis using pop-bead chromosomes.

In groups, work to build a model of meiosis using the pop-bead chromosomes.



Even though chromosomes are inherited, they are not the same due to genetic diversity, which occurs during meiosis. Crossing-over of the non-sister chromatids of homologous chromosomes in Prophase I, and independent assortment of homologous chromosomes in Metaphase I allow for genetic diversity. Look at meiosis and crossing over events in *Sordaria*, a fungus.

1. *Sordaria fimicola* is a haploid fungus for most of its life cycle. It becomes diploid only when two haploid cells fuse together. The diploid nucleus must then undergo meiosis to resume its haploid state. Meiosis, followed by mitosis, in *Sordaria* results in the formation of eight haploid ascospores contained within a sac called an ascus.
2. To observe crossing-over in *Sordaria*, one can fuse two haploid cells, one that produces black ascospores (+) and the other that produces tan ascospores (tn). When the diploid cells undergo meiosis, the asci that develop will contain four black ascospores and four tan ascospores.
3. The arrangement of the spores directly reflects whether or not crossing over has occurred. Examine the cards showing a mating between (+) and (tn). Count the # of crossing-over asci and determine the percentage of asci showing crossing over. Show all work.



Inheritance

Although homologous chromosomes are composed of genes for the same traits in the same order, they may have different forms of the gene. Different versions of the same gene are referred to as alleles. Homozygous is two of the same allele. Heterozygous if you have two different alleles.

The alleles one has for a particular gene is known as the genotype. What is actually expressed is known as the phenotype.

Some alleles are expressed only when the genotype is homozygous. These alleles are said to produce recessive phenotypes. Alleles that are expressed whether the genotype is homozygous or heterozygous produce dominant phenotypes. Check off individual and classroom wide phenotype.

Phenotype.

1. Earlobes- attached or free
2. Hairline- widows peak or straight
3. Tongue Roller- TYes or no
4. Phenylthiocarbamide taster- Yes or no
5. Freckles- Yes or no
6. Mid-digital hair- Yes or no
7. Facial dimples- Yes or no
8. Finger lacing- Left/Right thumb or Right/Left thumb

Does the majority of the class exhibit dominant phenotypes?

Contact Information

Regarding the lessons or curriculum, please contact Dr. Edwin Li (eli@sju.edu)

Regarding the lab exercises, troubleshooting or technical issues, please contact Dr. Brian Forster (bforster@sju.edu)

For additional lessons in this unit and others, please visit www.asbmb.org/912activity/