

Student Name _____

Date _____ Group _____

Laboratory 1 - DNA Replication and Mitosis

Pre-Lab Report

Write a one- or two-sentence summary of the purpose, methods, and most importantly, expected results, for each investigation.

INVESTIGATION 1:

PURPOSE:

MATERIALS & METHODS:

EXPECTED RESULTS:

INVESTIGATION 2:

PURPOSE:

MATERIALS & METHODS:

EXPECTED RESULTS:

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INVESTIGATION 3:

PURPOSE:

MATERIALS & METHODS:

EXPECTED RESULTS:

Meiosis and Mendelian Genetics

SCENARIO: A MOTHER'S CONCERN



Elaine didn't know who the author was, but she certainly was interested in what the magazine article had to say. It was actually possible to prenatally detect a fetus with certain types of genetic conditions, in particular one that used to be called mongolism or Down Syndrome. It was Down Syndrome that especially interested Elaine, since this condition occurred with increased frequency among the children of older women. Elaine hated to admit it, but she was (by the standards applied in these cases) an "older woman."

Don and Elaine had been married for nearly twenty years. They had two teenage daughters, aged 17 and 14. Don was 42, and Elaine was 39 on her last birthday. Yesterday, Elaine's doctor confirmed what she had suspected for two weeks—she was pregnant; she would become a mother for the third time before her 40th birthday! Needless to say, Elaine had mixed feelings about having an addition to their family at this stage of life. What especially disturbed her was the prospect that the baby might have some birth defect or genetic condition. She knew about Down Syndrome in particular, because the Johnsons, who lived down the street, had a son with Down Syndrome. Elaine frequently saw the boy and knew something about the challenges that the Johnsons had in trying to raise him. She wasn't sure that she and Don could cope with a similar situation, nor was she sure it would be fair to the other children in the family.

Elaine learned that one method of prenatal diagnosis of genetic conditions is amniocentesis. In this procedure, a needle is inserted into the pregnant woman's abdominal wall, through the uterine wall, and into the amniotic sac that surrounds the developing fetus. This sac is filled with fluid that contains living cells that can be grown in glass containers and tested for specific genetic conditions. Since "amnio," as this test is sometimes known, isn't performed until the second trimester, more women are choosing to be tested with an alternative available in the first trimester: First Trimester Maternal Serum Biochemistry and Fetal Nuchal Translucency Screening.

With either test, if the fetus is shown to have a genetic condition, the parents can then decide on whether to “terminate the pregnancy.” Elaine realized that this would be a difficult and controversial decision—the couple would have to elect to have an abortion if they did not want to give birth to a child with a chromosome abnormality.

A Down Syndrome diagnosis can be made through a procedure known as karyotyping: the living fetal cells are grown in laboratory dishes and induced to go through mitotic divisions, which can be seen with a microscope. An individual with Down Syndrome does not have the typical 46 chromosomes, but has an extra chromosome, for a total of 47. Scientists have learned that it is a specific chromosome—number 21, one of the smallest chromosomes that, when present in an extra dose, causes Down Syndrome. Individuals who have the normal chromosomal number 46, have two number 21 chromosomes in each of their cells—one 21 comes from the mother through the egg cell, and one comes from the father through the sperm cell. A baby with Down Syndrome usually has three number 21 chromosomes.

After she and her husband discussed the magazine article, Elaine decided they should discuss the matter further with their family physician. They wanted a great deal more information before they could decide intelligently on whether Elaine should have amniocentesis.

Adapted with permission from <http://bsuvc.bsu.edu/~d000tadlldwn> case.html, A series of bioethical case studies from Ball State University, Developed by Dr. J. R. Hendrix and Dr. T. R. Mertens[®] 1980.

DISCUSSION:

Respond to the first three questions on the response/data sheet.

1. What causes a fetus to have an extra chromosome?
2. Why do you think that Down Syndrome occurs more often in older women?
3. If you were faced with this decision, what questions would you ask of your doctor?

ETHICAL CONSIDERATIONS:

1. Do you think Elaine should have amniocentesis? Are there risks to this procedure?
2. If prenatal diagnosis were to indicate that the fetus had Down Syndrome, do you think Elaine should have an abortion?
3. What rights, if any, does the fetus have in all of these considerations?
4. Should society be expected to care for a child with a chromosomal abnormality, if it were known prior to the child's birth that (he/she) would have this defect?

Laboratory Investigations

OBJECTIVES:

From this experience, you should be able to

- name the types of cells in which meiosis occurs
- identify the stages of meiosis
- apply your understanding of meiosis to the study of inheritance
- describe the similarities and differences between mitosis and meiosis
- construct a simple Punnett square
- analyze human karyotypes for possible disease

INTRODUCTION:

Meiosis is a specialized type of cell division that starts with a **diploid** ($2n$) cell, a cell containing pairs of homologous chromosomes. This cell undergoes two stages of division and results in four cells each having half the number of chromosomes than the original cell, because the chromosomes are no longer in pairs. These cells with only half the genetic material of a typical cell are called **haploid** ($1n$) cells. Meiosis in animals is the process by which gametes (sperm and eggs) are formed, and it takes place only in the gonads (reproductive organs). It is the mechanism which ensures that the correct amount of parental DNA is passed on to the next generation by fertilization. Under normal conditions, both parents pass on one of each chromosome pair to their offspring. Whether or not an individual has the correct number of chromosomes can be determined by a technique called karyotyping, whereby the chromosomes are isolated, photographed, and analyzed to determine if there are the necessary 23 pairs (in humans).

During fertilization, one gamete from the male will join with the gamete from the female to produce the **zygote**, a new offspring with a diploid number of chromosomes. The fact that half of each pair of chromosomes comes from a different parent results in many gene combinations that allow for variations in physical and behavioral traits. The gene pairs are located on homologous chromosomes; alternative forms of a gene are called **alleles**. The genetic makeup (**genotype**) of this new offspring will depend on the alleles inherited from each of its parents. How these alleles are expressed (**phenotype**) will depend on 1) whether they are dominant or recessive and 2) whether the same alleles (**homozygous**) or different ones (**heterozygous**) came from its parents. Punnett squares allow us to predict the likelihood of certain traits being expressed in offspring, depending on whether they are dominant or recessive.

INVESTIGATION 1: MODELING MEIOSIS

OBJECTIVE:

To simulate the process of meiosis and recognize the characteristics of its two divisions, each with four phases.

MATERIALS:

- Chromosome models of homologous chromosomes and sister chromatids
- Website <http://www.dnaftb.org/dnaftb/8/animation/fs.html>

PREDICT:

You will be simulating meiosis in a cell with one pair of homologous chromosomes. How many chromosomes will be in each of the daughter cells after meiosis?

PROTOCOL:

1. You will be given a chromosome from your instructor.
2. Locate the homologous chromosome for your chromosome by finding the classmate at your bench who has an identical chromosome in arm length and centromere location.
3. Notice that these homologous chromosomes have one bead of different colors. These represent different alleles of one gene, which stand for different variations of the same genetic trait (e.g., blue eyes versus brown eyes).
4. “Replicate” your chromosomes by locating their identical twins in the chromosome containers. Make sure these sister chromatids, including the alleles, are the same color with the same alleles.
(Why are they the same? _____)
5. Refer to Figure 1-1 and the website listed above to follow the tutorial and complete Table 1-1.
6. Join these identical replicates (sister chromatids) at their centromeres (magnets) as shown in the tutorial.
7. Using the chromosome models and the white board, your instructor will demonstrate what occurs during the two divisions of meiosis.

QUESTIONS:

1. How many chromosomes are in each of the daughter cells from the example?
2. How many homologous pairs are in each daughter cell?
3. What would happen to the final four cells, if at Anaphase I, both homologous chromosomes migrated to the same centriole?
4. What would happen to the final cells, if at Anaphase II, both sister chromatids migrated to the same centriole?

HYPOTHESIZE:

From the answers to your questions, generate two alternative hypotheses regarding the step at which the mistake leading to Trisomy 21 (Down Syndrome) may occur. Record your hypotheses on the response sheet.

REVIEW:

Review the process of meiosis by going to the following website and clicking on “Animation”
<http://www.dnafb.org/dnafb/8/concept/fs.html>.

MAKE CONNECTIONS:

1. How is meiosis different from mitosis?
2. How is meiosis similar to mitosis?

Complete Table 1-2 to illustrate important differences.

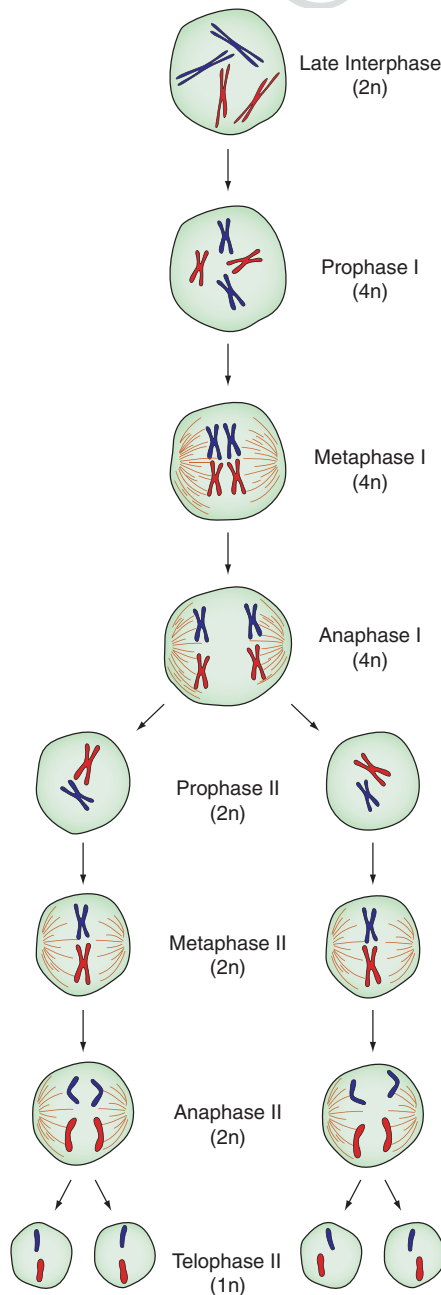


Figure 1-1. Overview of meiosis.

INVESTIGATION 2: HUMAN KARYOTYPING

OBJECTIVE:

To compare examples of human karyotypes (chromosome analyses) in order to see how the technique is performed to diagnose disease.

MATERIALS:

http://www.biology.arizona.edu/human_bio/activities/karyotyping/karyotyping.html

PREDICT:

If an individual is missing a chromosome, is it more likely to be fatal than having an extra chromosome?

PROTOCOL:

1. Read the introductory material on the web page.
2. Evaluate the three patient histories by pressing on the “Patient Histories” button at the bottom of the page.
3. Answer the questions regarding the diagnoses of the patients on the response sheet.

QUESTIONS:

1. Which chromosome numbers carry the least amount of genetic material?
2. What does that tell you about how the chromosomes were originally numbered?
3. How would you describe the sex chromosomes? Are they like the other homologous chromosomes?

HYPOTHESIZE:

From the answers to your questions, generate an hypothesis regarding the likelihood of survival for a fetus which is missing chromosome 1. Record your hypothesis on the response sheet.

MAKE CONNECTIONS:

1. Name one genetic trait (enzyme) that is found on Chromosome 21 by accessing the following website: <http://www.ncbi.nlm.nih.gov/science96/>
2. What is the function of this enzyme?
3. What disease does it cause if it is missing or abnormal?



Figure 1-2. Human karyotype.

INVESTIGATION 3: INTRODUCTION TO PUNNETT SQUARES

OBJECTIVE:

To replicate Mendel's experiment in a virtual environment and illustrate the law of independent assortment.

MATERIALS:

http://www.biology.arizona.edu/mendelian_genetics/problem_sets/monohybrid_cross/01t.html

<http://biology.clc.uc.edu/courses/bio105/geneprob.htm>

PREDICT:

A husband and wife with brown eyes, who each had a blue-eyed parent, are hoping to have blue-eyed children. What are the chances that their first child will have blue eyes?

PROTOCOL:

1. Go to the first website listed under Materials and read the Tutorial to learn how to set up a Punnett square.
2. Go to the second website listed under Materials and work through the first problem (Test Cross).
3. Record your results in Figure 1-3 on the response sheet.

QUESTION:

In sheep, white coat color is due to a dominant gene (W); black coat color to its recessive allele (w).

If you wished to establish a flock of pure breeding sheep, black or white, which could most easily be accomplished? Explain why.

MAKE CONNECTIONS:

How are the traits that are inherited from each parent related to the process of meiosis?

REVIEW:

For an introduction to Mendel's theory that genetic information is inherited as discrete bits see <http://www.dnafb.org/dnafb/3/concept/fs.html> and press the "Animation" button.

Also see <http://www.dnafb.org/dnafb/4/concept/fs.html> for a review of Mendelian genetics.

DISCUSSION:

1. In sheep, white coat color is due to a dominant allele (W); black coat color to its recessive allele (w).
 - a. A black sheep crossed to a black sheep can produce what offspring?
 - b. A white sheep, the product of a black x white cross, is crossed with a black sheep.
 - i. What kind of offspring can result?
 - ii. Give the genotypes and phenotypes of all the offspring.
 - c. A white sheep crossed to a white sheep produces offspring that are both white and black. What are the genotypes of the parents? The probable genotypes of all the offspring?
2. Review the scenario. At what stage of meiosis did the mistake that led to trisomy 21 most likely occur?
 - a. How many of chromosome 21 were in the other gametes that resulted from that meiotic division?
 - b. Do you think that, if fertilized, these gametes would result in term births? Why or why not?

Student Name _____

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Laboratory 1 - Meiosis and Mendelian Genetics

Response/Data Sheet

SCENARIO DISCUSSION QUESTIONS—MOTHER'S CONCERN:

- 1.
- 2.
- 3.

INVESTIGATION 1: MODELING MEIOSIS

PREDICT:

Table 1-1.

Cell Cycle	Main Characteristics
Interphase	
Meiosis I	
Meiosis II	

QUESTIONS:

- 1.
- 2.
- 3.
- 4.

HYPOTHESES:

- 1.
- 2.

MAKE CONNECTIONS:

- 1.
- 2.

Table 1-2. Differences Between Mitosis and Meiosis.

	Mitosis	Meiosis
Occurs in all cells that divide (yes or no?)		
Number of Divisions		
Number of Daughter Cells		
Chromosome number of Parent Cells (diploid or haploid?)		
Chromosome number of Daughter Cells (diploid or haploid?)		
Results in gametes (yes or no?)		
Involves separation of homologous chromosomes (yes or no?)		
Involves separation of sister chromatids (yes or no?)		

INVESTIGATION 2: HUMAN KARYOTYPING**PREDICT:*****Patient A***

A 1. What notation would you use to characterize Patient A's karyotype?

A 2. What diagnosis would you give patient A?

Patient B

B 1. What notation would you use to characterize Patient B's karyotype?

B 2. What diagnosis would you give patient B?

Patient C

C 1. What notation would you use to characterize Patient C's karyotype?

C 2. What diagnosis would you give patient C?

QUESTIONS:

- 1.
- 2.
- 3.

HYPOTHESIS:**MAKE CONNECTIONS:**

- 1.
- 2.
- 3.

INVESTIGATION 3: INTRODUCTION TO PUNNETT SQUARES

PREDICT:

Fill in the Punnett squares below from the computer exercise concerning deafness in dogs.

Homozygous Male

Heterozygous Male

Both Heterozygous

Figure 1-3. Punnett Squares for one trait.

QUESTION:

MAKE CONNECTIONS:

DISCUSSION:

1a.

1b.

1c.

2a.

2b.