Name_____ Date _____

SC.7.L.16.1 Understand and explain that every organism requires a set of instructions that specifies its traits, that this hereditary information (DNA) contains genes located in the chromosomes of each cell, and that heredity is the passage of these instructions from one generation to another. SC.7.L.16.2 Determine the probabilities for genotype and phenotype combinations using Punnett squares and pedigrees. SC.7.L.16.3 Compare and contrast the general processes of sexual reproduction requiring meiosis and asexual reproduction requiring mitosis.

Reproduction and Heredity

From Genes to Organisms

Every organism, from single-celled bacteria to giant sequoia trees, is made out of cells. Every cell within an organism contains all of the instructions the organism needs to grow and survive! The information in cells is stored in a special molecule called DNA. DNA contains sections called genes that tell cells how to build proteins. In this way, cells can build all of the structures the organism needs to survive.

Cell Division

The life cycle of an organism includes birth, growth, reproduction, and death. The life cycle of a eukaryotic cell, called the cell cycle, can be divided into three stages: interphase, mitosis, and cytokinesis. During the cell cycle, a parent cell divides into two new cells, called daughter cells. The new cells are identical to the parent.

Cells need to reproduce to ensure that the instructions carried in their DNA can survive. Cells reproduce themselves through a process called cell division. Cell division happens in all organisms and takes place for different reasons. For example, single-celled organisms reproduce through cell division. In multicellular organisms, cell division is involved in growth, development, and repair, as well as reproduction.

During most of a cell's life cycle, DNA is wrapped around special proteins in a complex material called **chromatin**. Before cell division, DNA is duplicated, or copied. Then, in an early stage of cell division, the chromatin is compacted into visible structures called chromosomes. A duplicated chromosome consists of two identical structures called **chromatids**. The chromatids of eukaryotic cells are held together by a centromere.

After all the DNA has been duplicated, the cell can divide into two new cells. This process is called **mitosis** in eukaryotic cells. Prokaryotic cells undergo a similar process called binary fission.

Mitosis

Meiosis

Most eukaryotic organisms reproduce by sexual reproduction. Sexual reproduction requires organisms to make specialized cells called gametes. Male gametes are called sperm cells, and female gametes are called egg cells. Gametes are different from all other cells in the body because they contain only a single copy of each chromosome, while body cells contain pairs of each. For example, humans have 46 chromosomes in each body cell, or 23 pairs. Human gametes have only 23 total chromosomes each. Cells with two copies of each chromosome are called **diploid** cells. Those with just one copy are called **haploid** cells.

Because gametes are different from other body cells, they require a special process to make them. The process of cell division that forms gametes is called **meiosis**. Meiosis is similar to mitosis, but each daughter cell goes through an extra round of cell division. A single cell undergoing meiosis will result in four daughter cells with a single copy of each chromosome instead of two daughter cells with two copies each.

Meiosis

Heredity

When two gametes combine to form a new organism, all of the cells of the new organism will again have two copies of each chromosome. One copy of each chromosome will have come from either parent. The new organism will then have traits similar to each parent. The passing on of information from parents to offspring is called **heredity**.

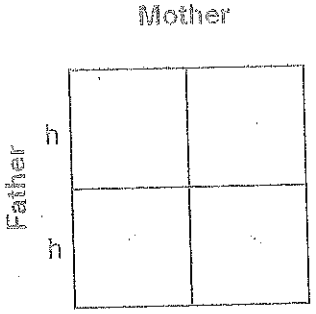
About 150 years ago, Gregor Mendel discovered the principles of heredity while studying pea plants. Mendel knew from his experiments with plants that there must be two sets of instructions for each trait an organism inherits. Scientists now call these instructions for inherited traits **genes**. Each parent gives one set of genes to the offspring. The offspring then has two forms of the same gene for every characteristic, or feature—one from each parent.

The different forms of a gene are called **alleles**. Many alleles are either dominant or recessive. If an allele is dominant, then the trait it encodes will be the one that shows up. For example, consider the gene responsible for producing dimples, or creases in the cheeks. This gene comes in two alleles: one for dimples and one for no dimples. If you have even one copy of the allele for dimples, you will have dimples. This happens because the allele for producing dimples is dominant. An organism needs to receive two copies of a recessive gene to have the recessive trait.

Punnett Squares and Pedigrees

When Gregor Mendel studied pea plants, he noticed that traits are inherited in patterns. One tool for understanding the patterns of heredity is a diagram called a **Punnett square**. A Punnett square is a graphic used to predict the possible genotypes of offspring in a given cross. Each parent has two alleles for a particular gene. An offspring receives one allele from each parent. A Punnett square shows all of the possible allele combinations in the offspring.

In the Punnett square below, the letter *h* represents a gene with two alleles. The capital *H* represents the dominant allele, and the lowercase *h* represents the recessive allele. Because each parent has two alleles, but only contributes one to their offspring, different combinations are possible. The Punnett square shows all possible combinations.



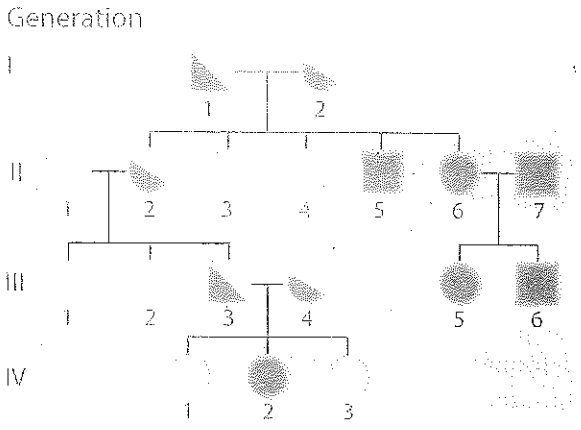
A Punnett square does not tell you what the exact results of a certain cross will be. A Punnett square only helps you find the probability that a certain genotype will occur. **Probability** is the mathematical chance of a specific outcome in relation to the total number of possible outcomes. Probability can be expressed in the form of a **ratio**, which is an expression that compares two

quantities. A ratio written as 1:4 is read as "one to four." The ratios obtained from a Punnett square tell you the probability that any one offspring will get certain alleles.

Another way of expressing probability is as a percentage. A percentage is like a ratio that compares a number to 100. A percentage states the number of times a certain outcome might happen out of a hundred chances.

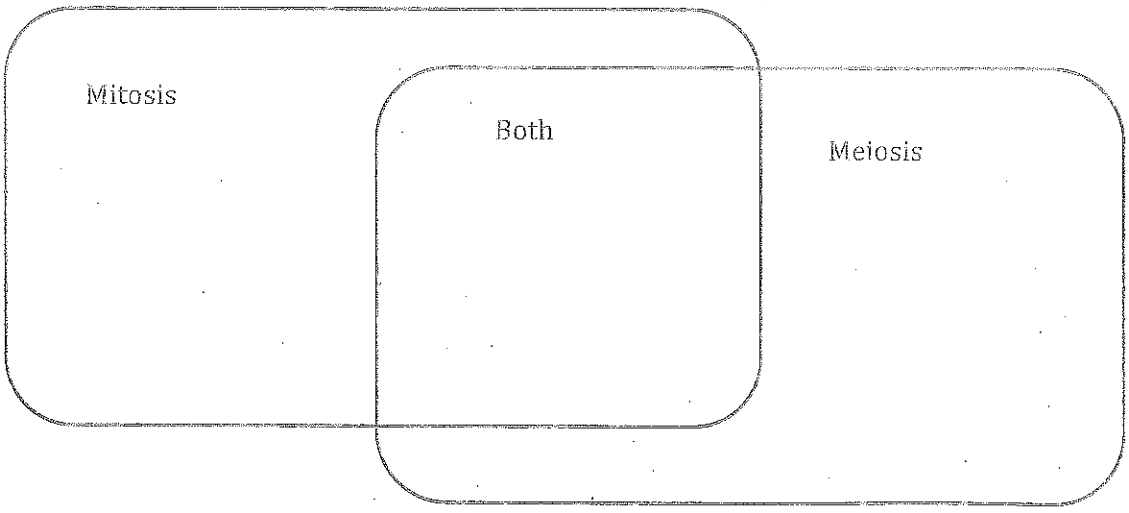
A pedigree is another tool used to study patterns of inheritance. A pedigree traces the occurrence of a trait through generations of a family. Pedigrees can trace any inherited trait—such as hair color. Squares in a pedigree represent males, and circles represent females. A horizontal line between a square and a circle represents a pair of parents. Vertical lines down connect parents to offspring.

The pedigree to the right traces eye shape in a family across four generations. Eyes can be either round or almond-shaped. The allele for almond-shaped eyes is dominant to the allele for round eyes. People who have two different alleles are shown in the pedigree by a square or circle that is half shaded. Individuals with two different alleles of a gene are heterozygous for that gene. If a child is heterozygous for the recessive allele, then the child will have almond-shaped eyes. Individuals with two identical copies of a single gene are homozygous for that gene. People with two copies of the recessive allele are shown by a fully shaded square or circle. These offspring will have round eyes. Many other traits follow a similar pattern.

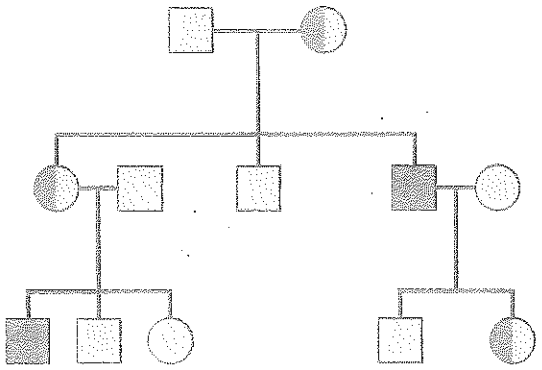


Student-Response Activity

1 Complete the Venn diagram to compare and contrast the processes of mitosis and meiosis.



2. How many individuals in this pedigree are homozygous, and how many are heterozygous?



3. The Punnett square shows a cross between two fruit flies. The allele "R" gives red eyes, and the allele "r" gives white eyes. The "R" allele is dominant to the "r" allele. Which trait will each combination of alleles give? Fill in your answers on the Punnett square.

	R	r
R		
r		

4. What is the probability that an offspring from the cross above will have the allele combinations shown below? Write your answer as a percentage.

RR _____

Rr _____

rr _____

5. One thing that all cells have in common is they all contain the molecule DNA. Why do all cells have DNA?

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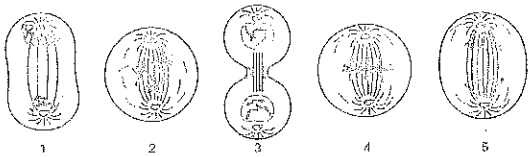
Fill in the letter of the best choice.

1. Cassie draws flashcards for each phase of mitosis and cytokinesis. Before she can label the backs of the flashcards, Cassie drops them onto the floor. The flashcards get mixed up as shown below.



In what order should Cassie place the cards to show mitosis from start to finish?

(A) 1 → 2 → 3 → 4 → 5
(B) 2 → 4 → 5 → 1 → 3
(C) 3 → 1 → 5 → 2 → 4
(D) 4 → 2 → 1 → 5 → 3

2. All cells contain the molecule DNA. Which best explains why DNA is important to all cells?

(F) All cells need DNA to process sugars.
(G) All cells need DNA to carry information.
(H) All cells need DNA to reproduce asexually.
(I) All cells need DNA to perform photosynthesis.

3. A bacterial cell divides to produce a new cell. Which best describes this?

(A) asexual reproduction
(B) meiosis
(C) mitosis
(D) sexual reproduction

4. In pea plants, the allele which produces yellow peas, Y, is dominant to the allele which produces green peas, y. Two pea plants with yellow peas are crossed and produce some offspring that produce green peas. Which best explains why?

(F) The parent plants were homozygous for the Y allele.
(G) The parent plants were heterozygous for the Y allele.
(H) The parent plants were homozygous for the y allele.
(I) The parent plants were homozygous for both alleles.

5. Heredity is the passage of information from one generation to the next. Which best describes heredity in sexual reproduction?

(A) Parents pass on DNA through mitosis.
(B) Genes are reproduced and recombined in meiosis.
(C) Gametes formed in meiosis fuse to make a new organism.
(D) Offspring acquire chromosomes from parents through binary fission.

6. The Punnett square shows the possible outcomes for a cross between two parents.

S	SS	Ss
s	Ss	ss

The genotype of one parent is shown. What is the genotype of the other parent?

(F) S
(G) s
(H) Ss
(I) ss