

Lesson 1: Non-Mendelian Inheritance Patterns

Introduction

The purpose of this lesson is for students to explore different inheritance patterns beyond Mendelian genetics. The lesson will expand a high school students' knowledge of Punnett squares and human genetic traits. It is possible to extend this lesson into an ethics discussion, as students will be creating a "Martian baby" with their knowledge of inheritance. This lesson is designed for a ninety minute class period, but may be divided to fit into two shorter periods.

Student Background Knowledge

Students should know that genes code for traits and be familiar with simple dominance inheritance and Punnett squares. They should understand the terms genotype and phenotype. A working knowledge of how to calculate probability is also helpful in this lesson.

Teacher Background Knowledge

Complete dominance is an inheritance pattern where the dominant allele (noted as a capital letter) always trumps the recessive allele when present. For example, if T, the dominant allele, codes for a tall plant and t, the recessive allele codes for a short plant, than plants with the genotypes TT or Tt will be tall. The only time the recessive phenotype is expressed is in the homozygous recessive genotype (ex: the genotype tt codes for a short plant). In humans, polydactyly (having extra fingers or toes) follows a simple dominance inheritance pattern. Polydactyly is actually the dominant trait, but there is a low frequency of the dominant allele in the population. Students may ask why polydactyly is rare if it is dominant. This is a great opportunity to tie in population genetics and allele frequency.

Incomplete dominance inheritance occurs when the heterozygote (Tt) phenotype is a blending of the dominant and recessive phenotypes. In the case of the homozygous dominant (TT=tall) and homozygous recessive (tt=short) plant, the heterozygous (Tt) plant would be of medium height. In humans, the trait for sickle cell anemia is incompletely dominant. A person who is heterozygous for the sickle cell trait has less severe anemic symptoms than the homozygous recessive person. Sickle cell heterozygotes are also resistant to malaria. You may extend the lesson to discuss heterozygote advantage here.

Co-dominant inheritance is when the heterozygote exhibits both the dominant and the recessive phenotype. A black chicken (BB) mated with a white chicken (bb) will produce a heterozygous (Bb) chicken, checkered with black and white feathers. Human blood type is inherited co-dominantly. A mother with A type blood has blood cells with the A protein. A father with B type blood has blood cells with the B protein. Their child with AB type blood has blood cells that have both the A and the B protein.

Finally, sex-linked inheritance refers to the genes that are carried on the sex chromosomes. Females are XX and males are XY. The X chromosome is much larger than the Y chromosome, and contains more genes. For this reason, most sex-linked traits in humans affect males more often than females. Some genes, like the recessive gene for colorblindness, are found only on the X chromosome and not the Y. Girls who inherit

the gene for colorblindness from their mothers still have a chance to inherit the dominant, normal gene from their father. Boys who inherit the gene for colorblindness from their mothers don't get that second chance because the Y chromosome they inherit from their fathers does not contain any gene for color vision, normal or not.

TEKS Objectives:

BIOL.1.05 Organize, analyze, evaluate, make inferences, and predict trends from data.

BIOL.2.35 Describe the components and structure of DNA and illustrate how it carries the information for traits

BIOL.2.38 Compare genetic variations observed in plants and animals

BIOL.2.45 Illustrate the results of natural selection in speciation, diversity, phylogeny, adaptation, behavior, and extinction

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Materials

24 Plastic Easter Eggs (assorted colors)

48 Small Objects in colors that match the eggs (I use little erasers, but Skittles or jelly beans would work too)

Popsicle Sticks (10 per group)

6 different colors of paper

Lesson Plan

OPENING: Show students three Easter eggs, two of the “dominant” color and one of the “recessive” color. Have them predict the “genotype”, or color of the two erasers, inside each egg. (ex: Blue is the dominant color or phenotype, yellow is the recessive color or phenotype. Present two blue eggs and one yellow one. The homozygous dominant blue egg contains two blue erasers. The heterozygous egg is blue and contains one blue and one yellow eraser. The homozygous recessive egg is yellow with two yellow erasers inside)

CONCEPT DEVELOPMENT: Allow students to share their answers. Use the discussion to review vocabulary: homozygous, heterozygous, dominant, recessive, phenotype, and genotype. Tell students that so far, they have been observing complete dominance. Today they will learn about other patterns for inheritance.

Use the eggs to demonstrate as you explain each pattern of inheritance:

Complete Dominance:

Eggs same as in warm up.

EX: TT=tall, tt=short, Tt=tall

Human EX: Polydactyly

Incomplete Dominance:

Homozygous Dominant: One blue egg with two blue erasers inside

Heterozygous: One green egg with one blue and one yellow eraser inside

Homozygous Recessive: One yellow egg with two yellow erasers inside

EX: TT=tall, tt=short, Tt=medium

Human EX: Sickle Cell Anemia

Co-dominance:

Homozygous Dominant: One blue egg with two blue erasers inside

Heterozygous: Egg with a blue top and a yellow bottom with one blue and one yellow eraser inside

Homozygous Recessive: One yellow egg with two yellow erasers inside

EX: BB=black chicken, bb=white chicken, Bb=checkered chicken

Human EX: Blood Type

Sex-linked:

Homozygous Dominant: One blue egg with two blue erasers inside

Heterozygous Female: One blue egg with one blue and one yellow eraser inside

Heterozygous Male (Unaffected): One blue egg with one blue eraser inside

Heterozygous Male (Affected): One yellow egg with one yellow eraser inside

Homozygous Recessive: One yellow egg with two yellow erasers inside

Human EX: Colorblindness

GUIDED PRACTICE: Give students their own eggs and erasers to demonstrate the homozygous dominant, heterozygous, and homozygous recessive genotypes and phenotypes of each situation. Students may work in small groups if supplies are limited. Have students create an example of an inheritance pattern and trade with another student/group. Students must then determine the inheritance pattern they were given.

STUDENT PRACTICE: “Martian Baby” activity.

LAB PREP: Create “chromosomes” by gluing the gene sequences onto popsicle sticks. Each chromosome should be in a different color. Sex Chromosomes special instructions: Maternal sex chromosomes should be the same color on both sides (I recommend pink); each side representing an X chromosome. Paternal sex chromosomes should be two colors (ex: pink and blue) to represent the X and Y chromosomes that the father can contribute.

Model the lab for students before they begin.

1. Record the genotype of each parent, writing in the letters on both the front and the back of their popsicle stick.
2. Flip the popsicle stick like flipping a coin to simulate independent assortment of the genes.
3. Record the genes (letters) that landed facing up in the “egg” column if you have the female chromosomes and in the “sperm” column if you have the male chromosomes.
4. Refer to “Gene Decoding Chart” to determine the trait your Martian baby will have based on the genes contributed from the sperm and egg.
5. Repeat for each autosome and the sex chromosomes.

6. Draw your Martian baby using the “Phenotype Reference” page.
7. Answer the analysis questions.

CLOSURE: Exit Ticket: Students will complete Punnett squares to determine the ratio of phenotypes for each new inheritance pattern.