Mendelian Genetics

Strand Life at the Molecular and Cellular Level

Topic Examining Mendelian genetics and genetic variation

Primary SOL BIO.5 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include
- d) prediction of inheritance of traits based on the Mendelian laws of heredity;
- f) genetic variation.

Related SOL BIO.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
- b) hypotheses are formulated based on direct observations and information from scientific literature.

Background Information

Selective breeding is a tool that has been used for many years to create favorable characteristics in living organisms. Humans have domesticated animals for thousands of years for different purposes, using selective breeding. By crossing different breeds of the same species, they have been able to create animals that are optimized for working, protection, and consumption. One species in particular is the domesticated dog, or *Canis domesticus,* which is the product of selective breeding of wolves. (As a warm-up, you may want to include the question, "What is the origin of domesticated dogs?")

Using basic Mendelian genetics can help one determine the probability of offspring expressing specific traits. Although nothing is guaranteed, using this probability can determine the *chances* of favorable characteristics being expressed. Genotypes can be used to calculate the probability of a specific trait being expressed through the use of a monohybrid cross. Each genotype can then be calculated to determine a traits phenotype—what it looks like or what trait is expressed. If a trait has a dominant allele in its genotype, that trait will be expressed. If a trait has a recessive allele in its genotype, that trait may possibly not be expressed. In order for a recessive trait to be expressed, both alleles in the genotype must be present. This genotype is called "homozygous recessive."

Materials

- Internet access
- Scoring Guide for Experimental Design (attached)
- Coloring utensils

Vocabulary

allele, co-dominance, dihybrid cross, dominant, F2, genetics, genotype, Gregor Mendel, heterozygous, F1, homozygous, hybrid, incomplete dominance, Law of Independent Assortment, Law of Segregation, monohybrid cross, offspring, P1, pedigree, phenotype, probability, Punnett square, purebred, recessive, selective breeding, sex-linked, trait

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)
In this during-learning activity, students will design an experiment to determine the genotypes and phenotypes resulting from selectively breeding two breeds of purebred dogs. Before doing the activity, students should already have had some exposure to Mendelian genetics, monohybrid crosses, dihybrid crosses, and pedigrees. When grouping students for this lesson, you may choose groups based on readiness level or student choice.

Prior to engaging in this lesson, students should complete the lesson entitled "The Parts of an Experiment: Introduction to Inquiry and the Scientific Process" in order to gain more experience in designing experiments and writing lab reports. That lesson also includes generic differentiation strategies for general inquiry lessons.

1. Put students in groups of two to four, and have each group choose a different breed of dog.
2. Have groups research their chosen breeds, using the Internet. Instruct them to focus on specific traits of their breeds, such as size, ear shape, hair length/type, fur color, muzzle shape, tail length/shape, eye color, temperament, breeding purpose (how dog is used), genetic disorders.
3. As students are researching, have them determine which traits are dominant and which are recessive in their breeds. Instruct them to create a chart of the genotypes and phenotypes of their breeds. Have them include a photograph of their breeds in their data sheets.
4. After research is finished, have each student pair up with a student from another group. Inform partners that they will design an experiment, using the attached Scoring Guide for Experimental Design, to answer the question, "What will the puppies look like if we were to selectively breed our two breeds of dogs?" Tell students that in this experiment, because they will be breeding two different breeds of dogs with each other, they should choose 10 prominent traits of all dogs to focus on when determining what the offspring will look like.
5. Instruct students in how to determine the possible traits of their puppies. They must use Punnett squares to determine the first eight traits by monohybrid crosses and the last two traits by dihybrid crosses. Also, they must include all the genotypic and phenotypic ratios next to each cross. This first crossing will be called the F1 generation. They should omit co-dominance or incomplete dominance from consideration when doing their crosses.
6. After students have done their crosses, using Punnett squares, have them create two theoretical puppies from the possible genotypes for each trait. Direct them to create a chart with each puppy's trait, genotype, and phenotype. Also, have them draw pictures of the two puppies, based on information from the chart.
7. Next, have each student pair choose one of their puppies and use it to repeat steps 5 and 6 together with another pair's F1 generation puppy. This second crossing will be the F2 generation.
8. After the F2 generation puppies have been created, have each student individually design a pedigree, based on one of the traits used in the cross. Remind students to use the scoring guide to help them with their work. Have each student choose a different trait to make his or her pedigree so each pedigree looks different. While students work, circulate in the classroom to help students with questions and problems.

Assessment

- **Other**
  - Students' work in pairs to create the F1 generation puppies and answer the question, "What will the puppies look like if we were to selectively breed our two types of dogs?"
  - Students' work individually to create pedigrees.

Extensions and Connections (for all students)

- Have students write a research paper or create a computer-generated presentation on a genetic disorder, allowing them to choose disorders that interest them. Make sure they follow the criteria below:
  - Name of genetic disorder/disease
  - Symptoms
  - Genetic cause or pattern of inheritance
  - Dominant or recessive
  - Gender-linked
  - Possible genotypes, phenotypes, pedigree, karyotypes (may include photos)
  - Cures
  - Research
  - Life expectancy
  - Incidence
  - Long-term health considerations
  - Argument for investment of more money for research about this disease

Strategies for Differentiation

- Employ flexible groupings of students by grouping them according to common readiness levels, shared interests, or diverse strengths.
- Create a sample pedigree for students, using something other than breeds of dogs.
- Assign or have students choose only five instead of 10 prominent traits of all dogs to focus on when determining what the offspring will look like.
- In place of having students research dog breeds, provide them with "pooch profiles" for various breeds, including in each profile a photograph of the breed as well as a list of dominant and recessive traits.
- Provide students with blank charts instead of having them create charts themselves.

Scoring Guide for Experimental Design

Item	Possible Points (200 Total)	Points Earned
Title: A descriptive title identifies the basic concept.	**10**	
Problem: The problem is stated clearly and succinctly.	**10**	
Hypothesis: "If…, then…." statement is included.	**15**	
Independent variables: Units and measuring tools are identified.	**10**	
Dependent variables: Units and measuring tools are identified.	**10**	
Controls and constants: All controls and constants are identified.	**10**	
Materials: All materials needed for experiment are listed.	**15**	
Safety: Harmful chemicals or organisms are listed; dangers are identified and explained; needed safety equipment is identified.	**10**	
Procedure: Very detailed steps are included.	**40**	
Data and observations: Data tables are used; observations are made and recorded.	**40**	
Conclusions and analysis of data: Graphs are used; conclusions are drawn and recorded; hypothesis are evaluated.	**30**	
TOTAL POINTS EARNED		