Investigate poultry genetics

Focus question
How can we predict the expression of traits in poultry?

Standards
- **8.LS.1 Diversity of species**, a result of variation of traits, occurs through the process of evolution and extinction over many generations. The fossil records provide evidence that changes have occurred in number and types of species.
- **8.LS.3** The characteristics of an organism are a result of **inherited traits** received from parent(s). Expression of all traits is determined by genes and environmental factors to varying degrees. Many genes influence more than one trait, and many traits are influenced by more than one gene.

Introduction
Why do chickens look so different from one another? Why do different breeds of chickens have different plumage colors and feather patterns and produce different colored eggs? Humans have been selecting specific traits in poultry for hundreds of years through the process of artificial selection. In this lesson students will learn about poultry genetics and predict why certain traits exist in selected chickens. They will research and select specific traits to cross and predict what phenotypic traits will be expressed.

Student prior knowledge
Students will need to understand how to complete punnett squares before attempting the investigation in this lab. Students will be asked to complete both monohybrid and dihybrid punnett crosses as they determine the phenotypic expression of traits.

Suggested timeline
1 class period (50 minutes)

Materials
- Student artificial selection sheet
- Sticky notes or computer and Jamboard (`jamboard.google.com`)
- Chicken breed resource: `meyerhatchery.com`
- 2 long balloons
- Permanent markers (2 colors)

Teacher preparation
- Print off Artificial Selection student sheet (1 per student)
- Blow up 2 long balloons and have 2 different colored permanent markers ready for classroom demonstration

DIFFERENTIATION
Create differentiated groups for laboratory time. Ensure each group contains students of varying ability levels as a support in answering lab questions. Parts 1-3 sequentially increase in complexity.

Procedure

1. Ask the students to brainstorm what chickens look like as a class. Remind them to be as descriptive as possible. They can brainstorm alone or in a group using sticky notes or Google Jamboard. Put these descriptions in a place for the class to see.
2. Reflect on the student descriptions of chickens. For example, if a student wrote that chickens come in many plumage color patterns, discuss how this happens as a result of genetic inheritance. If a chicken is black, what could its parents look like? Brainstorm these ideas as a class.
3. Pass out the Artificial Selection student sheet to the class and review the terminology at the top of the page.
    a. Demo this terminology with 2 long, air-filled balloons and 2 permanent markers of different colors as you read through the descriptive paragraph with the students.
    b. Hold up a balloon in each hand and explain that each balloon is a chromosome (wound up DNA). One balloon represents a chromosome from a rooster and the other a chromosome from a hen.
    c. Each chromosome contains hundreds of different genes (at this point draw a gene on one chromosome by creating a circle around the outside). Each gene will have two alleles (draw another gene on the opposite chromosome at the same location in a different color). Explain that typically there are dominant and recessive alleles that determine the expression of the inherited trait.
    d. When fertilization occurs, a sperm cell (hold up one chromosome higher than the other and explain that it is from the rooster) and an egg cell (hold up the other chromosome and explain that it comes from the hen) join together to make a complete chromosome pair (line up the two chromosomes and twist them together to form a complete pair).
    e. Review the terms in the text again by pointing out each piece on the balloon modeling demonstration. Draw 2 more genes in a different location and ask students to determine if the combination of alleles is homozygous or heterozygous based upon the color of the genes. How can we determine what is expressed by the allele combination? Have the students offer suggestions on how to model dominant and recessive traits.
4. Working in groups, have students investigate Part 1, plumage color.
5. Review part 1 as a class and discuss how genotype determines phenotype, allowing breeders to make predictions of possible selection choices.
6. Working in groups, have students investigate Part 2, shank feathers.
7. Review part 2 as a class and discuss how feathered and unfeathered shanks impact chickens. Feathered shanks are a genetic trait, meaning that nature selected for this trait at some point in chicken ancestry. What purpose could feathered shanks serve in the natural environment?
8. Working in groups, have students investigate Part 3, chicken combs.
9. Review part 3 as a class and discuss comb variations among chickens. What are the genotypic and phenotypic ratios that result from this cross?

SUGGESTED WRAP-UP ACTIVITY

Genetics are complicated! Many traits are controlled by more than one gene (egg color, skin color, feather pattern, etc.) Is it possible to breed for specific traits by observing phenotypic traits in parents? For example, if I breed a rose comb chicken to a pea comb chicken, will I only see walnut comb chicks as offspring of this cross? Have the students work together on this problem in groups and discuss the possible outcomes.

Active questions

1. What is a phenotype? Can you give an example in either chickens or humans?
2. How are phenotypes determined in an organism?
3. What is a genotype?
4. What does a genotype determine in an organism?
5. How can we determine genotypes without using genetic testing to confirm these traits?
6. How have farmers used artificial selection to provide eggs to consumers over time?
7. What traits do most eggs that you purchase in the store have?
8. What breed differences do you see in the chickens sold on the Meyerhatchery.com website?

More challenges

- Explore egg color in chickens. Egg color is a multiple allele trait like skin color is in humans. Darker eggs have more dominant alleles on each gene location than lighter colored eggs. Have students research chickens like Marans that have very dark brown eggs and determine the genotypes that make this phenotype possible.
- Explore plumage colors and patterns. Single color feathers are known as primary color patterns in chickens whereas multiple colors on a single feather are known as secondary color patterns. Pick a breed of chicken and explain which color pattern it contains by exploring its feather colors. Is it possible for a chicken to display both primary and secondary color patterns at the same time?
- **Home connection:** What types of chickens or turkeys interest you most? Why? Share the differences in poultry heritable traits at home. What traits would you choose? Colored or white eggs? How many eggs per week? Feather pattern colors?

Support information

- **DNA:** deoxyribonucleic acid: The material containing the genetic instructions used in the development and function of an organism. DNA is arranged in the double helix–shaped strands.
- **Gene:** A segment of DNA that carries a blueprint for the function of a cell and, ultimately, a particular characteristic of an organism.
- **Chromosome**: A structure containing a complete strand of DNA. Chromosomes function in the transmission of hereditary material from one generation to the next. Chromosomes typically come in pairs, with one set donated from the mother and one from the father. Chickens have 39 pairs.
- **Genotype**: The genetic makeup of an organism, represented by 2 alleles.
- **Heterozygous:** Having two different alleles of a particular gene or genes.
- **Homozygous:** Having two identical alleles of a particular gene or genes.
- **Phenotype:** The observable physical or biochemical characteristics of an organism resulting from its genotype. Examples of aspects of a chicken's phenotype include body shape, feather color, eye color, comb type, and so on.
- **Punnett Square**: A square diagram that is used to predict the genotypes and phenotypes of a selectively bred cross.
- Comb type in chickens is controlled by two different genes on two different chromosomes. One is the rose comb gene (R), and the other is the pea comb gene (P). A presence of the gene is represented by the dominant allele (R); an absence of the gene is represented by the recessive allele (r). Both the rose comb gene and the pea comb gene can express themselves in the heterozygous state (Rr). That is, only one copy of the rose comb gene or the pea comb gene is sufficient for that type of comb to occur. Therefore, both genes can be thought of as dominant genes.
    - When at least one copy of the rose comb gene is present and the pea comb gene is absent, the result is a rose comb. In other words, a chicken with a rose comb has one of two possible gene combinations: RRpp or Rrpp.

- When at least one copy of the pea comb gene is present and the rose comb gene is absent, the result is a pea comb. A chicken with a pea comb has one of two possible gene combinations: rrPP or rrPp.
- When at least one copy of each gene is present, the result is a walnut comb. A chicken with a walnut comb has one of four possible gene combinations: RRPP, RrPP, RRPp, or RrPp.
- When both genes are absent, the result is a single comb. A chicken with a single comb has the only possible gene combination: rrpp.

Career connections

Have you ever wondered what type of poultry careers help to make a healthy, safe environment for commercial birds? Let's take a look!

- **Animal Scientists** apply principles of the biological, physical, and social sciences to the problems associated with poultry production and management. In other words, they study animal health and behavior in order to help design the perfect environment for commercial birds to live in and produce meat and eggs.
- **Geneticists** are biologists who study genetics, the science of genes, heredity, and variation of organisms.

Teacher suggestions

1. Prior knowledge of basic genetic information is important for this lesson. Students should have prior knowledge of the information in this lesson and general working knowledge of Punnett squares. See support information above.
2. Have students work in groups of 3 or 4 as they work through parts 1, 2 and 3. It is important that they see that chickens have many breed varieties that each exhibit specific characteristics that are important to consumers. What characteristics are important to your students?