

Investigate poultry genetics

How can we predict the expression of traits in poultry?

Standards

- **B.H.1:** Cellular genetics
- **B.H.3:** Genetic mechanisms and inheritance

Introduction

Why do turkeys and chickens look so different from one another? Why do different breeds of poultry have different plumage colors and feather patterns and produce different colored eggs? Humans have been selecting traits in poultry for hundreds of years through the process of artificial selection and hybridization. In this lesson students will learn about poultry genetics and predict why certain traits exist in selected poultry. They will investigate examples of multiple allele, incomplete dominance, and sex-linked traits as they compare poultry traits in order to explain why some traits are not used within commercial poultry farms.

Student prior knowledge

Students should be familiar with the following expressions of the inheritance of traits: dominant/recessive, incomplete dominance, multiple alleles, and sex-linked traits. Students should be comfortable with completing Punnett squares before attempting the investigation in this lab.

Suggested timeline

1–2 class periods (50–100 minutes)

Materials

- Student artificial selection worksheet
- Student incomplete dominance worksheet
- Student sex-linked worksheet

Teacher Preparation

Print off student worksheets

Procedure

1. Ask the students to brainstorm what chickens and turkeys look like, being as descriptive as possible. They can brainstorm alone or in a group using sticky notes or whiteboards. 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? Consider these ideas as a class.
3. Pass out the student worksheets and review the terminology at the top of each page (multiple alleles, incomplete dominance, and sex-linked traits).
4. Working in groups, have students investigate the multiple alleles in Investigation 1.
5. Review the multiple allele worksheet as a class and discuss how poultry combs have different purposes in various climates. Next, discuss how these combs are expressed and why possible producers make selection choices based on housing and production needs.

6. Working in groups, have students investigate incomplete dominance in Investigation 2.
7. Review part 2 as a class and discuss how smooth and curling feathers impact poultry populations.
8. Smooth feathers are a genetic trait, meaning that this trait was selected for at some point in chicken ancestry. What purpose could curled or smooth feathers serve in the natural and human environments?
9. Working in groups, have students investigate sex-linked traits in Investigation 3.
10. Review part 3 as a class and discuss why feather patterns can help a producer determine the gender of chicks and how this is important in commercial decision making.

Suggested wrap-up activity

Genetics are complicated! Many traits are controlled by more than one gene (comb type, feather patterns, etc.). Is it possible to breed for specific traits by observing phenotypic traits in parents? Why are commercial poultry so different from wild poultry? How has the commercial poultry industry changed chickens and turkeys through selective breeding and hybridization? Have students research the characteristics of wild and commercial birds and debate which characteristics they feel are most important to food production as we move into the future.

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.

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 chicken breeds 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.
- **Multiple alleles trait:** a genetic trait that is controlled by more than 2 alleles.
- **Codominance:** when both alleles for a gene are expressed equally.
- **Incomplete dominance:** when both alleles for a gene are incompletely expressed or blend their characteristics to make a new phenotypic expression.
- **Sex-linked traits:** when the genes are located on the sex chromosomes of an organism.
- Comb type in chickens is controlled by two or more 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.
- When the duplex comb gene is present, the comb will be divided and demonstrated as either the v-shape (D^v) or the buttercup (D^b) comb. If the duplex comb gene is absent the comb will be represented as the single (d) comb.
- The frazzle gene (FF) is lethal to poultry and not found in nature as the chicks die soon after birth. However, it is incompletely dominant to the smooth (ff) feather pattern and can result in a frizzle (Ff) feather pattern.
- Poultry do not display external genitalia, making it very difficult to accurately determine gender until later maturation. Sex-linked feathering traits such as barring can help producers to know what gender chicks are. Male poultry have 2 ZZ chromosomes, whereas female poultry only have one Z chromosome and one W chromosome and are the determining gender for sex determination.

Teaching suggestions

- 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.
- 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, each exhibiting specific characteristics that are important to consumers. What characteristics are important to your students?

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.
- **Breeders** observe the health of the flock and record data on laying efficiency and behavior to select the traits to be combined for future generations.