

Investigate Hardy–Weinberg and the evolution of turkeys

How can natural selection change allele frequencies and drive color evolution in turkeys?

Standards

- **B.H.3: Genetic mechanisms and inheritance**
- **B.E.1: Mechanisms:** Natural selection
- **B.E.2: Speciation:** Variation of organisms within species due to population genetics and gene frequency

Introduction

Evolution in a population is defined as a change in the frequency of its alleles. The Hardy–Weinberg principle is a tool that can be used to estimate the allele frequencies among a population from generation to generation. The population is considered to be in equilibrium as long as the following five conditions are met:

1. The population is large.
2. Members of the population show no preference in mating.
3. There are no mutations.
4. Members are not moving into or out of the population.
5. There is no natural selection.

If these conditions are met, the population's allele frequencies will stay the same from generation to generation and we will know no evolution took place within the population.

In this lab we will look at a population of turkeys that has met the five Hardy–Weinberg principle conditions and is currently in equilibrium. We will then look at a population of turkeys where the changing habitat conditions have produced turkeys with lighter coat patterns. How will natural selection affect the gene frequency and evolution within the population?

In turkeys, black feather patterns are dominant over bronze feather patterns. In the Hardy–Weinberg principle the following variables represent alleles.

Phenotype	Genotype	HW variable
Homozygous black	BB	p^2
Heterozygous black	Bb	$2pq$
Homozygous bronze	bb	q^2

Student prior knowledge

In order to successfully complete this activity, students should know the basic concepts of genetics: Mendel's laws, patterns of dominance, and recessive allele inheritance. Students should be able to describe how traits are passed from generation to generation. A general understanding of the concept of evolution and how evolution occurs among a population is fundamental to understanding this activity.

Suggested timeline

1–2 class periods (50–100 minutes)

Materials

- *Feathers of change* student sheet
- Turkey allele cards
- Scratch paper for calculations
- Calculator

Teacher preparation

This activity is a teacher-guided activity involving the whole class. Prior to class the teacher will need to print the turkey allele cards and *Feathers of change* student document.

- For part 1, each student will need:
 - One capital “B” card
 - One lowercase “b” card
- For part 2:
 - 50% of the students will need two lowercase “b” cards
 - 50% of the students will need one capital “B” card and one lowercase “b” card

At the beginning of each part of the activity, pass out cards to each student.

Procedure

1. Divide the students into groups and prepare to run the first Hardy–Weinberg simulation.
 - In this simulation each class member will represent a heterozygous black turkey.
 - Ask the students to make a prediction for the allele frequency of the turkey population.
 - Each student trades one allele card at a time with other students continuously for two minutes.
 - Record students’ data in data table 1.
 - Use this data to determine the allele frequency as a percentage in data table 2.
 - Use the data in table 1 and the Hardy–Weinberg equation to determine the frequency as a decimal in Data table 3.
2. Pose the following questions to the class:
 - In the first simulation, did your predictions agree with the allele frequencies calculated in data table 2?
 - If your class results in data table 2 did not agree, what are some of the possible reasons why?
3. Prepare to run the second Hardy–Weinberg simulation.
 - In this simulation each class member will have either a heterozygous (Bb) black genotype or a homozygous bronze genotype (bb).
 - Ask the students to make a prediction for the allele frequency of the turkey population.
 - Each student should trade one allele card at a time with other students continuously for 2 minutes.
 - Record their data in data table 4.
 - Use this data to determine the allele frequency as a percentage in Data table 5.
 - Use the data in table 4 and the Hardy–Weinberg equation to determine the frequency as a decimal in Data table 6.
4. Pose the following questions to the class:
 - In the second simulation, did your predictions agree with the allele frequencies calculated in Data table 5?
 - If your class results in data table 5 did not agree, what are some of the possible reasons why?
 - Which condition of the Hardy–Weinberg principle influenced the greatest difference between your data table 2 and data table 5?
 - If changing habitats continue to select for bronze turkeys, which variable in the Hardy–Weinberg principle would decrease the most? Which one would increase the most? Why?
 - How does natural selection drive evolution?

Suggested wrap-up activity

1. The class will revisit Hardy–Weinberg’s 5 conditions for a population to remain in equilibrium and discuss the results from the first and second simulations.
 - Did natural selection occur? What scientific proof do you have to support this?
 - What are some factors that could cause the population’s allele frequencies to shift? Be specific! What are plausible reasons that the color patterns of turkey feathers change?
2. Is this an evolutionary shift that could lead to a new species? Why or why not?
 - Define the term **species**. How would we know that a new species has evolved from another species?

Differentiation

- Students can count populations of other types (i.e. insects, birds or trees) and see if they can apply these principles to other populations. (They will need to use various sampling techniques then generalize to a larger scale.)
- This activity can be led by the teacher for those students struggling with the concept or done individually at the student’s own pace for those students that are comfortable with the concepts after the simulation portion.
- Students may need extra support with the Hardy–Weinberg calculations. They could watch remedial videos and use practice questions for more practice.

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More challenges

- Research mechanisms of evolution. Have student groups present their findings to the class or create a project that can be shared with other groups in a gallery walk. Discuss examples of each mechanism in taxonomy and predict future extinctions and/or speciation events due to current environmental challenges.
- **Home connection:** Start a conversation about the changing habitats in your local area. How have they changed over time? Why did these changes take place? Have you noticed any changes in wild flora or fauna populations?

Support information

- **Genotype:** the combination of alleles for a particular gene for an organism.
- **Allele:** variants of a gene.
- **Dominant allele:** one or two alleles may be present for this phenotype to be expressed; masks the recessive allele.
- **Recessive allele:** two alleles must be present for this phenotype to be expressed in an organism.
- **Allele frequencies:** the percentage of each available allele of a gene in a gene pool for a population.
- **Phenotype:** the observable traits of an organism’s genotype.
- **Evolution:** the change in allele frequencies in a population over time.
- **Hardy–Weinberg principle:** tool that can be used to estimate the allele frequencies among a population from generation to generation.
- The expression of inherited traits of an organism are influenced by the environment in which the organism lives. Environmental factors such as diet, temperature, humidity, oxygen levels, light cycles, and the presence of mutagens all impact gene expression.
- Solving Hardy–Weinberg problems by Bozeman Science: youtu.be/xPk0AnK29kw

Teaching suggestions

- Turkey Allele cards: Print these cards on cardstock and laminate them to hold up for multiple classes. Numbering the cards makes it easier to sort them after each activity.
- Continue to add to your class gene pool from period to period to simulate the natural world. Keep class data sets from year to year to provide your students with annual data that they can track to determine if the changing environment is impacting the turkey population.

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!

- **Geneticists** are biologists who study genetics, the science of genes, heredity and variations of organisms.
- **Veterinarians** care for the health of the poultry flocks and work to protect public health. They diagnose, treat, and research medical conditions and diseases of pets, livestock, and other animals.
- **Breeders** select and breed poultry for the desired characteristics such as meat and/or egg production in commercial poultry settings.
- **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.