

Investigate biodiversity

How do inherited traits impact survival? How can we use Simpson's Index of Diversity to quantify the change of diversity within an ecosystem?

Standards

- **B.H.3: Genetic mechanisms and inheritance**
- **B.E.1: Mechanisms:** Natural Selection
- **B.DI.1: Biodiversity:** Species Diversity

Introduction

What characteristics help organisms to survive and reproduce over time? The theory of natural selection demonstrates how genetic variation within a species provides different traits that help certain members of a population survive and reproduce, passing on these traits to the next generation. Simpson's Index of Diversity is a tool used to measure the level of biodiversity present in each ecosystem. It measures both the species richness and the species evenness in a community.

Student prior knowledge

Students should be familiar with the process of natural selection and the concept of “survival of the fittest”. It is important that they understand what heritable traits are (variation within species) and how they are passed down from one generation to the next. This knowledge will help them to understand how competition within an ecosystem can lead to evolutionary change within that ecosystem over time.

Students should also have a basic understanding of algebra in order to utilize Simpson's Index of Diversity to determine the level of diversity within an ecosystem.

Suggested Timeline

1–2 class periods (50–100 minutes)

Materials

- *Natural selection and change* student sheet
- 1 plastic cup per student (stomach)
- 1 large plastic cup per student (community cup)
- Beak options (1 set per group of 4–5 students)
 - 1 plastic spoon
 - 1 paper clip
 - 1 set of chopsticks
 - 1 forceps
 - 1 pipe cleaner
 - Alternative: any classroom item can be used for a beak
- Food items per student group. These items can either be counted or weighed. They should be dry beans:
 - 100 split peas or 150 g split peas
 - 100 lentils or 150 g lentils
 - 100 navy beans or 150 g navy beans
 - 100 pinto beans or 150 g pinto beans
 - 100 black-eyed beans or 150 g black-eyed beans
- *Suggested: 1 large pizza box per group*

Teacher preparation

Prepare student group materials: 4 empty cups, 1 spoon, 1 forceps, 1 paperclip, 2 chopsticks, 1 pipe cleaner, 1 cup containing the assortment of beans above in the materials section. The pizza box, if used, will help keep beans in one area.

Procedure

PART 1: SURVIVAL OF THE FITTEST SIMULATION

1. Introduce the topic of natural selection by survival of the fittest. Ask the students what they think “survival of the fittest” means.
 - How can one organism do better than (outcompete) another organism in its environment?
 - If an organism is able to perform better, what does that mean for that organism?
 - How will it pass this advantageous trait on to the next generation?
 - How does the survival of the fittest theory impact the biodiversity of an ecosystem?
2. Ask students what an organism’s basic needs are. Ask them to discuss this with a partner and fill in the Survival of the Fittest student sheet.
3. Pass out the food, beaks, and cups (and pizza box, if using) to each student group.
 - Let the students explore the beak types and food for a few minutes. Each student will use the same beak throughout the entire simulation.
 - Ask them to write a claim of their beak’s ability to consume food based on their observations. Will they survive (be able to consume enough food) in order to reproduce and pass on their heritable trait?
4. Play the Survival of the Fittest simulation. Each round is 60 seconds (1 minute) long.
 - **Round 1:** Have the students record the quantity or weight of different beans that they will try to consume in the following rounds on their data chart. Dump 1 cup of beans on the student group table (or dump into the empty pizza box to help keep beans on the table). Have each student practice using their beak to ‘eat’ the food for one minute. When they are finished, have them record the amount of beans on their chart and place their stomach contents into the community cup. *Note: Students must pick up each piece of food individually and place it in the cup without scooping it into the cup. One hand must hold the cup; the other hand must hold the beak.*
 - **Round 2:** Have each student group stand in a circle with their beaks and stomachs ready. Do not add any additional beans to this round. Have each student try to “eat” as much of the remaining beans as they can in 60 seconds. Record the group data on the student sheet. *Remember, their goal is to survive and make it to the next round.*
 - **Round 3:** The top 3 students from each group compete in this round. Do not add any additional beans to the table. Have the students stand in a circle with their beaks and stomachs ready. Have each student try to “eat” as much as they can in 60 seconds. Record data on the student sheet.
5. Have students submit class data to determine which beak type (trait) performs best. Which beak type is most successful? (Alternatively, students can also examine food data. Food sources are plants, which reproduce. Which food type is most successful and able to survive to reproduce into the next generation?)

PART 2: SIMPSON’S INDEX OF DIVERSITY

6. Next, have the students use their data as a class to calculate the difference in biodiversity between the beginning populations of beans and beaks (before round 1) compared to the final biodiversity of the same species (after round 3).

Suggested wrap-up activity

Have students discuss the importance of competition within species. Ultimately, if competition drives how traits are selected for within a species, and there is high competition for food resources, how might this impact evolution? What happens to the ecosystem's biodiversity over time? Or conversely, what happens to a species when competition ceases to exist?

Differentiation

- Differentiate according to students' fine motor skills. It might be necessary to use only large feed items and/or spoons as beaks if this differentiation piece is necessary for the students.
- Provide only 1 food type and 1 beak type to a group of students to determine alternative heritable traits such as agility, eyesight, behavior, etc.
- Provide students with predetermined data for analysis instead of participating in the modeling lab.

More challenges

- Have the students watch the following video and describe how natural selection has led to new finch species on the Galápagos Islands. youtu.be/s64Y8sVYfFY How has the biodiversity of this island changed with natural selection?
- Explain how the black pepper moth coloration changes from year to year depending upon predation. Peppered moth simulation: echalk.co.uk/Science/Biology/PepperedMoth/PepperedMoth.htm
- **Home connection:** How are modern poultry farms changing the necessity for variation among poultry for production needs? How are consumer choices (white meat preferences, food costs, etc.) related to trait selection in poultry for commercial production?

Support information

- **Biodiversity:** the number of different species within an ecosystem.
- **Species richness:** the number of species within an area.
- **Species evenness:** the measure of relative abundance of each species within an area.

THE THEORY OF EVOLUTION BY NATURAL SELECTION

- **Variation:** Members of any given species are seldom exactly the same, either inside or outside. Organisms can vary in size, coloration, ability to fight off diseases, and countless other traits.
- **Inheritance:** When organisms reproduce, they pass on their DNA—the set of instructions encoded in living cells for building bodies—to their offspring. Since many traits are encoded in DNA, offspring often inherit the variations of their parents.
- **Selection:** Environments cannot support unlimited populations. Because resources are limited, more organisms are born than can survive. Some individuals will be more successful at finding food, mating, or avoiding predators and will have a better chance to thrive, reproduce, and pass on their DNA. Small variations can influence whether or not an individual lives and reproduces.
- **Time:** In generation after generation, advantageous traits help some individuals survive and reproduce. These traits are passed on to greater and greater numbers of offspring. After just a few generations or after thousands, such traits become common in the population.
- **Adaptation:** The result is a population that is better suited—better adapted—to some aspect of the environment than it was before. The Survival of the Fittest simulation is one way to explain biological fitness, the ability of an organism to reproduce and pass on its DNA to the next generation. Therefore, “survival of the fittest” means that the fittest organism in a population is the organism that is able to breed and reproduce most successfully.

SIMPSON'S INDEX OF DIVERSITY

A tool used to measure the level of diversity within an ecosystem or community. It measures both the species richness and the species evenness in a community. A community dominated by one or two species is considered to be less diverse than one in which several species have a similar abundance. The Simpson's Index of Diversity value (D) ranges between 0 and 1. In Simpson's Index of Diversity, "1" represents infinite diversity and "0", no diversity.

Bozeman science: Ecosystem diversity: youtu.be/QKIMS0hVJdc

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Simpson's Index of Diversity

n = the total number of organisms of a particular species

N = the total number of organisms of all species

Teaching suggestions

This can be a messy lesson to do with students! It may be a good idea to create an area for your students to feed in such as a new pizza box or something similar that is the same size for all student groups. This will provide a measurable area for the ecosystem as well as provide camouflage for food items to hide in.

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!

- **Poultry caretakers** help with monitoring flocks for their health and well-being, ensuring they have constant access to fresh food and water as well as a safe living environment. Caretakers walk their barns every day to check their flock and the equipment that helps to keep them safe and fed.
- **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.
- **Hatchery workers** manage hen care and equipment to achieve high hatchability while performing tasks such as egg setting, transfer, and care of day-old chicks.