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# K-12 Partnership Lesson Plan

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# *Cannibalism: is it ever a good idea?*

*Exploring Kin Selection and Competition*

## Overview

## Students explore how different competitive strategies will affect how well organisms survive in a population. Students will play a game simulating several strategies in different environmental conditions, collect data from the game, and use these data to draw conclusions about the success of their strategies. This can be used to discuss how kin selection may influence evolution.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Graph their data and draw conclusions based on their results
* Explain how environmental conditions impact the success of different evolutionary strategies
* Explain how kin selection might affect evolution in a population

**Length of Lesson**

Introduction to background science and broader questions (15 minutes)

Game rules, playing game, collecting data (20 minutes)

Compiling data, drawing conclusions (10 minutes)

Follow-up discussion (10 minutes)

**Grade Levels**

This lesson is most appropriate for high school students, although it could potentially work with middle school students as well.

**Standards covered (NGSS)**

Disciplinary Core Ideas:

*Middle School*

* **MS-LS1-4**: use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
* **MS-LS4-4**: construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals’ probability of surviving and reproducing in a specific environment

*High School*

* **HS-LS2-8:** evaluate the evidence for the role of group behavior on individual and species’ chances to survive and reproduce
* **HS-LS4-2**: construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in numbers, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
* **HS-LS4-4**: construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Cross Cutting Concepts:

* Patterns
* Structure and function

Science and Engineering Practices

* Planning and carrying out investigations
* Analyzing and interpreting data
* Engaging in argument from evidence

***Previous Michigan Standards Met:***

* **B3.5B**: Explain the influences that affect population growth.
* **B5.1E**: Explain how natural selection leads to organisms that are well suited for the environment (differential survival and reproduction of chance inherited variants, depending upon environmental conditions).
* **B1.1C**: Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity – length, volume, weight, time interval, temperature – with the appropriate level of precision).
* **B1.1E**: Describe a reason for a given conclusion using evidence from an investigation.
* **L.EC.E.1**: Interactions – Organisms interact in various ways including providing food and shelter to one another. Some interactions are helpful; others are harmful to the organism and other organisms.
* **L.EC.06.21**: Describe common patterns of relationships between and among populations (competition, parasitism, symbiosis, predator/prey)

**Materials**

* Plastic or Styrofoam cups (one per student)
* Coffee stirrers or similar items (two per student)
* Food resources cut out of colored paper or foam (300 yellow general food resources, 150 red tadpoles, 150 blue tadpoles, 150 green tadpoles)
* Space to play game (something like a volleyball court is ideal, but any space where you can mark the boundary and then cut the space in half will work)
* Family Strategy Cards (found on the second page of the “Cannibalism Rule Sheet” on the “Cannibalism” lesson page on the KBS GK-12 website)
* Game Rules Sheet (found on website)
* Data Collection Sheets (found on website; print enough for 3-6 groups, depending on class size, ahead of time)
* Follow-up questions (found on website)

**Background**

### Competition is a central component of evolution by natural selection. Individual organisms need food, mates, and habitat, and will try to gather these resources directly (by fighting with one another) or indirectly (by trying to locate and use resources quicker or better than another individual). An overly simplified understanding of evolution suggests that each individual should focus only on its own success and always compete as intensely as possible, but this is not always the pattern we see in nature.

### Many species show examples of altruistic behavior, where individuals will help out other members of their species at what seems to be great personal cost. One classic example is alarm calling in the Belding’s ground squirrel, *Urocitellus beldingi*; sounding an alarm indicating that a predator is nearby benefits other squirrels in the group, but it attracts attention to the caller and makes that individual more likely to be attacked by the predator. This didn’t seem to make sense until researchers realized that individuals are more likely to give an alarm call when their relatives are nearby. An individual is likely to share genes with its relatives due to common descent, and so helping relatives to survive and reproduce can help pass genes on even if that individual puts itself at some risk. This idea, that an individual should help relatives at some cost to itself as long as the benefit to its relatives adjusted by how related they are is greater, is part of a concept known as kin selection.

### A variety of behaviors can be studied to investigate kin selection, but one that serves as a good starting point is cannibalism. While seen in human culture as an act of desperation or savagery, individuals consuming other members of their own species can be seen in many different types of animals. Compared to other behaviors, the costs and benefits of employing cannibalism as a strategy are fairly straightforward. An individual who consumes a member of its own species gets a meal (one that may be a higher quality resource than other items it might eat) and eliminates a potential future competitor. On the other hand, the risk of injury might be greater if members of its own species are larger than other prey items, the risk of disease may be greater (as in some cases of human cannibalism), and there may be additional indirect costs if a relative is consumed and eliminated from the gene pool.

### The game students will play to explore these concepts further is based on the spadefoot toads (New Mexico spadefoot toad, *Spea multiplicata*, and Plains spadefoot toad, *Spea bombifrons*), which live in deserts in the southwestern United States. Both species get their name from their “spade,” a projection on their feet that allows them to burrow beneath the sand. Adult spadefoot toads spend most of their time underground until sudden desert rainstorms create temporary ponds for them. They then mate and lay their eggs in these ponds. Because these ponds dry relatively quickly, there is significant pressure on the tadpoles to grow and develop quickly so they can metamorphose before the pond dries up.

### Spadefoot toad tadpoles have evolved several potential strategies that allow them to take advantage of available resources. All tadpoles start out as omnivore morphs, feeding on organic detritus and plant matter at the bottom of these ponds. Some tadpoles consume fairy shrimp that live in these ponds – or other tadpoles – and proceed to develop into carnivore morphs, with shorter guts, larger jaw muscles, and more developed mouthparts. Some families are more likely to develop carnivores that others, but each tadpole can develop as either morph – it isn’t genetically predetermined.

### Scientific researchers have found evidence of kinship influencing cannibalistic behavior in these tadpoles. While omnivore morphs prefer to spend time around their siblings (similar to fish schools), carnivore morphs (who have greater potential to harm kin) prefer to be around unrelated individuals. When given a choice between a relative and a non-relative of approximately equal size, carnivore morphs prefer to consume non-relatives. This preference is no longer significant when carnivores have not eaten in a long time and are starving. This makes sense given ideas about kin selection – when your own survival is on the line, your own need for a meal trumps everything, but when the situation is less serious it makes sense to help your relatives if you can.

### Activities of the session

### Begin by introducing students to some of the relevant background concepts. Discuss how competition is relevant to the process of evolution by natural selection but there are examples of organisms behaving in ways that seem counterintuitive (or showing restraint). Discuss how helping relatives to survive may explain some of these behaviors.

### Introduce cannibalism as one useful behavior for exploring these ideas. Discuss how it may be useful as a strategy (as opposed to how it is seen in humans) because of clear costs and benefits. See if students can come up with some of these costs and benefits and explain any that they may have missed.

### Give students background on the spadefoot toad system and introduce them to the game they will be playing (see included Rules Sheet).

### Have students play a round as individuals to get them used to how the game works. Prior to the second round, give each student a slip of paper assigning them to Family 1, 2, or 3, giving them a family strategy (see included Family Strategy Cards). Have students collect data on which items they “ate” in these families after the second round (see included Data Sheet). Have students move remaining food items in the “pond” to the smaller area for the third round, where they will use the same family strategy. Have students collect data on the items they “ate.”

### Have students work in their groups to graph the food data they collected for each round. Students should then share their graphs with the class and observe any differences between groups. Students can also observe data on the number of tadpoles from each family remaining, either by counting the colors left in the “pond” or subtracting each group’s total from the original number, and see how different strategies may have impacted survival.

### Once students have had a chance to look at the graphs depicting their results, have them discuss the follow-up questions (see included Follow-up Questions). These can be done as a class or in small groups, followed by wrap-up discussion. You may also want to share some actual spadefoot toad cannibalism study results with them, to see how their results compare.

**Resources**

Some actual scientific studies on kinship and cannibalism in these tadpoles:

* Pfennig, D. W., Reeve, H. K., & Sherman, P. W. 1993. Kin recognition and cannibalism in spadefoot toad tadpoles. Animal Behaviour 46: 87-94.
* <http://labs.bio.unc.edu/pfennig/LabSite/Publications_files/1993_Anim_Behav.pdf>
* Pfennig, D. W. 1997. Kinship and cannibalism. BioScience 47: 667-675.
* <http://labs.bio.unc.edu/pfennig/LabSite/Publications_files/1997_BioScience.pdf>
* Pfennig, D. W. 1999. Cannibalistic tadpoles that pose the greatest threat to kin are most likely to discriminate kin. Proceedings of the Royal Society of London, Series B 266: 57-61.
* <http://labs.bio.unc.edu/pfennig/LabSite/Publications_files/1999_PRSL.pdf>

**Extensions and Modifications**

This game could also be modified to focus on resource quality rather than kin selection, making some resources worth more than others and varying how difficult they are to find.

The amount of resources needed for survival can be adjusted up or down depending on the specific students.

**Assessment**

Student understanding can be assessed based on how well they draw conclusions based on their data and the answers to the follow-up questions.