

Mom! Dad! Why Can't You Leave Me Alone?



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Host Organization: Stanford

ETP Type: New Lesson

Subject/Grade: Life Sciences/9th

Abstract

In this lesson, "Why Can't You Leave Me Alone?" students explore the selective pressures that led to the evolution of parenting behavior in Dendrobatidae, or Poison Dart Frogs. This lesson engages students in creative thinking to arrive at a plausible explanation for the evolution of a seemingly taxing behavior. Traditionally adaptations are presented as examples in lessons and their evolutionary advantage is described to students without much thought of the process. This lesson utilizes a student-led modeling activity in which they are presented with various facts, data, and environmental variables through which they craft a story to answer the question of why Poison Dart Frogs just cannot leave their offspring alone. Students will take part in a whole class brainstorm activity of variations. They will then write a storybook taking that variation from a mutation in the population to an adaptation fixed in the species.

Focal Content & Supporting Practices

LS 4-2: 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 number, (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.

Science and Engineering Practices:

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS4-2),(HS-LS4-4)

Disciplinary Core Ideas

LS4.C: Adaptation

Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)

Cross Cutting Concepts

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2),(HS-LS4-4),(HS-LS4-5)

21st Century Skills and Applications

This lesson develops the essential 21st Century Skill of Creativity and Innovation. Students are not only able to generate original ideas but collaborate in a group framework in which they expound upon, refine and evaluate their ideas at regular intervals.

Measurable Objective(s)

1. Students will show mastery-level understanding of the relationship between natural selection and adaptation through posing an explanation of how a variation could become a fixed adaptation in a species due to the process of natural selection.
2. Students will be able to distinguish natural selection as a selective force without a predetermined outcome. Students can provide examples of the diversity of solutions to a single environmental pressure.

Formative Assessment(s)

Throughout the modeling process, students present draft natural selection model plans to the teacher for feedback. Particular attention will be paid to

- Have students identified specific selective pressures? Are these connected to the adaptations observed?
- Do the students identify the source of the variation that results in the adaptation?
- Are students avoiding Lamarckian-like explanations (organisms do not intend their adaptations)?
- Have students explained how those behaviors result in the survival of the species?

Summative Assessment(s)

The final natural selection model involves a class presentation. Students will formulate a natural selection story, which will be told across slides mimicking the pages of a storybook explaining the original pressures these species likely underwent and explaining how behaviors helped the species survive the stressors.

Fellowship Description

The O'Connell laboratory at Stanford University studies evolution, physiology and behavior through the model organism: Dendrobatidae, or Poison Dart Frogs. They are of interest to the O'Connell laboratory for exploring the molecular mechanisms behind their toxicity, which come from alkaloid compounds in their diet. Dart frogs serve as an interesting example of evolutionary biology due to their radiations on different continents including South America and Madagascar. Additionally, the coloring and poisonousness of these species serves as an important example of convergent evolution. Beyond being illustrative of many important concepts of evolution, dart frogs are a model for probing the evolutionary origins of particular behaviors. Many species of Dendrobatidae parent and some are monogamous. Parenting can be uniparental or biparental and may consist of frog parents transporting tadpoles after hatching so that they are not in competition with one another, feeding tadpoles unfertilized eggs and providing tadpoles with protection. The evolution of this behavior is fascinating in a species whose life cycle does not obviously necessitate the parenting, such as the mammalian life cycle.

I completed my fellowship at the O'Connell Laboratory. I studied the effect of the hormone on tadpole aggression. AVT was hypothesized to be partially responsible for aggressive, cannibalistic behavior in *D. tinctorious* tadpoles, which exhibit intraspecies competition due to the parenting exhibited by the adults of this species of Poison Dart Frog. Siblings compete for the parent, which due to the parental care

behavior, is the limited resource. Using Manning Compound to inhibit the production of AVT, I observed fighting behavior in tadpoles injected with and without the blocker. Tadpoles were videotaped fighting, the winner determined and then their brains sectioned and imaged for neuronal activity. The project required creativity and innovation in the design as well as communication and collaboration of scientific information. While the project question had been envisioned by my mentor, I designed the method of video capture and data collection and performed the data analysis. The skills I gained working in this lab are important not only for scientists and researchers but any career in which video data is useful. Devising a method for recording and analyzing video could be applied in teaching, anthropology, engineering and many other fields. The ability to communicate data also extends beyond the field of science into careers in statistics, marketing, and journalism, to name a few.

Fellowship Connection to School/Classroom

This instructional plan is a part of a series of lessons meant to engage students more deeply by anchoring lessons within a high stakes phenomenon: *D. tinctorius*. Upon completion of my fellowship, the O'Connell lab helped me establish a colony of *D. tinctorius* in my classroom. Using their charismatic and interesting nature as an opening hook, this instructional plan will mark the first in a series of lessons that circled back to this semester-long anchoring phenomenon.

We will begin the year examining the process of evolution. From here, we will use this natural selection modeling activity to explore the complexity, variety and unknowns of how nature shapes the formation of a species. Through this activity students will show mastery of LS 4-2 because they will be able to explain the process of evolution using novel information presented to them. They use data and observations to construct an explanation of how natural selection could have resulted in the Poison Dart Frogs' parenting tendency. Throughout the development of their model, "nature" will add more unknowns and complexity to the problem, through which students will need to design an adaptive solution for. This activity allows for discussions around cause and effect and clarifies that natural selection is not the cause of adaptations but the effect of natural selection is to make random genetic variances more common if they result in a favorable phenotype.

Maintaining evolution as our frame for future lessons, we will explore behavior through the tadpoles, the nervous system using their toxicity as a case study and last, genetics and cell division through the process of metamorphosis.

Instructional Plan

Unit Title: From Variation to Adaptation

~3 Days With Block Scheduling

HOOK for lesson: Complete the following true or false discussion stating the TRUE/FALSE claim and have students stand and move to the side of the room that represents True or False. After sharing with a partner from their same side, a sample of students will be called upon to share their reasoning with the class. After representatives from each side have shared their reasoning, students are invited to switch sides if they have been convinced to do so. Finally, the teacher will summarize the main points made by the students and supplement with the points of emphasis included below, which will help direct their thinking of the challenges of offspring needing aquatic environments to develop. While misconceptions should be clarified, this discussion is not meant to reinforce right/wrong facts. One could argue humans are semiaquatic depending on the interpretation of the term.

TRUE OR FALSE: It is harder for animals to live in the ocean than on land.

Points of emphasis:

- Animals first evolved in aquatic environments.
- Can students identify some challenges in moving from one environment to the other?

- Animals did not consciously perceive terrestrial-based existence as easier-there were resources on land and less competition.

TRUE OR FALSE: Humans have adaptations meant for aquatic environments.

Points of emphasis:

- The common ancestor of all terrestrial animals was aquatic.
- Transitional species such as lobe-finned fish can be found today and are evidence of this.
- Human fetuses have gill slit for a portion of their development.

TRUE OR FALSE: Humans are semiaquatic organisms.

Points of emphasis:

- Humans develop in amniotic fluid. Aquatic environments remain essential for embryonic development.

TRUE OR FALSE: Organisms that reproduce in water have an easier reproductive strategy than those that reproduce on land.

Points of emphasis:

- Some aquatic species can simply release gametes into the water and the embryos form and hatch independently of the parents.
- Terrestrial lifestyle necessitates internal fertilization. Internal fertilization necessitates some level of parenting.

TRUE OR FALSE: It is evolutionarily wise to be a parent.

Points of emphasis:

- Evolutionary fitness is one's ability to survive AND REPRODUCE.
- Parenting has a cost to the organism performing the parenting.
- R versus K strategists.

CHUNKS for lesson: *How will you divide and teach the lesson to engage students' brains?*

<p>Day 1 Lesson Segment 1</p> <p>Activities: Hook and Framing Prezi</p> <p>Printed Prezi Version</p>	<p>The hook is described above. The framing Prezi ties in all of the discussion points from the hook activity and presents enough background information on amphibians that students can move into their independent learning about poison dart frogs' unique lifestyles.</p>
<p>Process / Movement</p>	<p>Students transition from individual seating to groups of three.</p>
<p>Day 1 Lesson Lesson Segment 2</p> <p>Activities: Group Background and Questions</p> <p>Class Brainstorm</p>	<p>Students will read, discuss and record information on the unique lifestyle of the poison dart frogs in small groups.</p> <p>After learning about the challenges posed by the small aqueous environments and the cannibalistic nature of poison dart frog tadpoles, the whole class will do a design* style brainstorm of variations that may be helpful in such environments. See design sources for more information on this methodology.</p>

	*Though this brainstorm will occur via the design model, I will not refer to it as such on student handouts to ensure there is no confusion between intelligent design or Lamarckian style evolution and natural selection.
Process / Movement	After the brainstorm students will work as individuals within their group of three.
Day 1 Lesson Segment 3 Activities: Variation to Adaptation Storyboard Formative Assessment	<p>Students will work on developing their adaptation storyboard. Drawings may be sketches because these will not be used as the final illustrations for the Storybook. Students will then pick their favorite storyboard of the three and submit it to the teacher for critique and feedback on the following:</p> <ul style="list-style-type: none"> • Have students identified specific selective pressures? Are these connected to the adaptations observed? • Do the students identify the source of the variation that results in the adaptation? • Are students avoiding Lamarckian-like explanations (organisms do not intend their adaptations)? • Have students explained how those behaviors result in the survival of the species? <p>Standards-based rubric to guide feedback.</p>
Process / Movement	The next class period, students will receive their storyboard with feedback. They will immediately return to their groups to discuss and implement feedback.
Day 2 Lesson Segment 4 Activities: Storybook Example and Storybook Creation	Students will use the storybook template presentation attached to design their final story of natural selection. Students will illustrate their story either by hand or software and upload this into the template. Details of the story will be written in the speaker's notes, rather than crowding the slides with text.
Day 3 Closure: Storybook Presentations	Students will present their storybooks to the class in a series of readings. After all ideas are presented, students will learn about the parent care strategies different species of poison dart frogs are known to exhibit . Teachers can choose to follow up with articles, lecture or a video. Life in Cold Blood illustrates many interesting examples.

Supply List

One large TRUE sign and one large FALSE sign
 Poison Dart Frog Information Handout (one per student)
 Evolution of Parenting Group Handout (one per group of three)
 One large PHYSICAL TRAITS sign, one large BEHAVIORS sign, and one large DEVELOPMENTAL CHANGES sign
 Post-Its (many (~30 per student))
 Markers (one per student)
 Variation to Adaptation Storyboard Worksheet (one per student)
 Art supplies (if hand-illustrating)
 Computers

References

"Effective Brainstorming Techniques." IDEO U. 17 July 2019
<<https://www.ideo.com/pages/brainstorming>>.

"Poison frogs." Smithsonian's National Zoo. 12 July 2018. 16 July 2019
<<https://nationalzoo.si.edu/animals/poison-frogs>>.

Keywords

natural selection, adaptation, variation, evolution

Links to Files in this ETP

Hook and Class Framing Prezi

https://prezi.com/bcgjhp-ilvy3/?token=c1794a7e9672f628d4eb7f599b1666ad12beadc3caf0fa6bbdb8663cfd2a1e8c&utm_campaign=share&utm_medium=copy

PrintVersion:

<https://drive.google.com/file/d/1DjIfQmdu-OUPyscxbOXqRLRONEZaBCcc/view?usp=sharing>

Poison Dart Frog Information Sheet

https://docs.google.com/document/d/1y9Mtv0ud5Te28bIEgv6of6YrRuoelKZyI8_0qFOY490/edit?usp=sharing

Group Directions Handout

https://docs.google.com/document/d/1pmxwxcgYKullY3GTLq_U-0ySjvDGLvDdXs58PgQhfaE/edit?usp=sharing

Adaptation Storyboard Template (Formative)

https://docs.google.com/document/d/1hwdZsRcoBz1AMX2NN5y8-rVqkdPxQbE2r1LuwCL_38/edit?usp=sharing

Adaption Storybook Template (Summative)

https://docs.google.com/presentation/d/1KkEO2bi_CA2kxb6OrPwK63WG_Rli9n6u4VZAXS9IMzM/edit?usp=sharing

Adaption Storybook Example

https://docs.google.com/presentation/d/1Mu3gzbGhmsVB9_hC_ianhl2dw13ElrriTzVNWf06joE/edit?usp=sharing

Standards-Based Rubric (can be used for both formative and Summative Assessment)

https://docs.google.com/document/d/1JoOHZ_C44xzFkIahGgrYJoRFt81QorqTNRZP4hE28X8/edit?usp=sharing