

Fantastic Fins: Diving into Diversity in Guppies

Unit: Evolution & Natural Selection	Utah SEEd Standard / NGSS Performance Expectation: 4.3 Analyze and interpret data to identify patterns that explain the claim that organisms with an advantageous heritable trait tend to increase in <u>proportion</u> to organisms lacking this trait. Emphasize analyzing shifts in the numerical distribution of traits and using these shifts as evidence to support explanations.	Time: 70-80 Minutes
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Link to all lesson resources and materials: <https://byu.box.com/s/lrhspcpluik8g5hrqdr2p3oovprfvlx>

Anchor Phenomenon	Male guppies exhibit a wide range of morphological features. Populations in aquariums develop more vibrant and conspicuous coloration and fin structure. Wild populations are less conspicuous, varying from river to river.
Driving Question(s)	Among the species <i>Poecilia reticulata</i> , what causes the differences in male morphology in particular environments?
Performance Task	Students will explore how environmental pressures and sexual selection determine which traits are advantageous in specific environments. They will analyze and interpret data gathered from an online simulation, identifying patterns in morphology based on changing variables.

Lesson Summary:

	Time	Guiding Question / Learning Objective	How are students answering the guiding question or meeting the learning objective?
	5 min	What patterns do you notice in the guppies?	After viewing images of several guppies, students will identify and write questions about the patterns that they observe.



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Engage			
 Explore	40 min	Can a guppy both stand out to attract a mate AND be camouflaged enough to survive?	Students will design a paper guppy to camouflage in the classroom to hide from the teacher-predator. Students will use the Enders Guppies Simulation to run a control experiment and then alter variables to gather data that they will analyze and interpret to understand how predators and morphology affect guppy survivability.
 Explain	10 min	What are the advantages and disadvantages of being brightly colored? What changes can be seen in male guppies when predators are present?	Students answer questions based on the patterns observed from the simulation and information from the article.
 Elaborate		(Optional) What other patterns can be observed when different variables are introduced?	Students will continue altering variables using the Enders Guppies Simulation to collect and analyze more data.
 Evaluate	15 min	What will male guppies look like in an environment with picky females and no predators? What will male guppies look like in an environment with plentiful predators? What will male guppies look like when there are sexual selection and predation pressures?	Students will complete a table explaining the male morphology based on two different habitats and design a new guppy to survive <i>and</i> reproduce.

Three Dimensions Focused on in This Lesson

Disciplinary Core Idea:

[NGSS Appendix E](#)

Standard BIO.4.3

Analyze and interpret data to identify patterns that explain the claim that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. Emphasize analyzing shifts in the numerical distribution of traits and using these shifts as evidence to support explanations. (LS4.B, LS4.C)

Students know and apply the Disciplinary Core Idea (DCI) of LS4.B Natural Selection in their thinking and reasoning to communicate that:

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.

(LS4.C): Adaptation

Students know and apply the Disciplinary Core Idea (DCI) of LS4.C Adaptation in their thinking and reasoning to communicate that:

- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

Science and Engineering Practices:

[NGSS Appendix F](#)

Science and Engineering Practice (SEP)

Analyzing and Interpreting Data: Students analyze and interpret data to support the claim that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

Students do and use the Science and Engineering Practice by:

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
- Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Crosscutting Concept:

[NGSS Appendix G](#)

Scale, Proportion, and Quantity:

Proportional relationships provide information about the significance of the distribution of traits in a population.

Students think and connect through the Crosscutting Concept to reason that:

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.



Learning Objectives

1. Students will be able to explain how environmental pressures may change the frequency of specific traits within a population. Specifically, students will be able to explain how predation and sexual selection impact male guppy morphology. Students show proficiency when they can explain male guppy morphology in an environment with little to no predators as well as male guppy morphology in an environment with no predators.

Related Knowledge and Skills from Prior Grades

Disciplinary Core Idea:

[NGSS Appendix E](#)

LS4.B

Natural selection

Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.

LS4.C Adaptation

Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.

Science and Engineering Practices:

[NGSS Appendix F](#)

Analyze and Interpret Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
- Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
- Distinguish between causal and correlational relationships in data.
- Analyze and interpret data to provide evidence for phenomena.
- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
- Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).
- Analyze and interpret data to determine similarities and differences in findings.
- Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.

Crosscutting Concept:

[NGSS Appendix G](#)

Scale, Proportion and Quantity

In grades 6-8, students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.



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Connections to Mathematics and ELA/Literacy Standards

ELA/Literacy Standards:

- **RST.11-12.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- **WHST.9-12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- **WHST.9-12.9:** Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics Standards:

- **MP.2:** Reason abstractly and quantitatively

Materials

Handouts

[Guppy template](#)

[Fantastic Fins - Guppies Student Worksheet](#)

[Fantastic Fins Assessment](#)

[Variation and Natural Selection Article](#)

[Simulation Key](#)

Other Resources

[Guppy Pictures](#)

Simulation:

https://virtualbiologylab.org/NetWebHTML_FilesJan2016/EndlersGuppiesModel.html

[Guppy Simulation Key](#)

PBS Endler's Guppies: https://www.pbs.org/wgbh/evolution/sex/guppy/low_bandwidth.html

Student Worksheet Key:

[Fantastic Fins - Guppies Key](#)

ENGAGE

What patterns do you notice in the guppies?

Teacher: (5 min) Have sets of laminated [guppy fish pictures](#) on the tables for students to observe. Give each student two sticky notes, one orange and one pink.

- Ask students to identify and write down any patterns they see from the pictures on the orange sticky note.

Teacher Tips:

Any two colors of sticky notes will work. Just be sure each student has one of each color. Different sized sticky notes



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- Ask students to write down questions they have about those patterns on their pink sticky notes. - Asks students to answer questions 1 and 2 on the student worksheet where they select which guppy they like best, describe it, and explain why they like it. Students: - Identify and write down on the orange sticky note any patterns they see from the pictures. - Write down questions they have about those patterns on their pink sticky note. - Answer #1 on the student worksheet where you select the guppy you like best and describe it. - Answer #2 on the student worksheet where you decide whether the guppy is male or female and back it up with evidence.	will also be effective if you don't have different colored sticky notes.
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EXPLORE

Can a guppy stand out to attract a mate AND be camouflaged enough to survive?

Teachers: (10 min)

- Hand out a copy of the [guppy template](#) to each student.
- Explain to students that the classroom is the river environment where these guppies live.
- Explain that they will use colored pencils, crayons, pencils, pens, highlighters or any other materials available to camouflage their guppy from predators to make it more suited for survival.
- The teacher leaves the room for two minutes so the students can hide their guppies.
- The teacher will be the predator and have 1 minute to find as many guppies as possible.
- After the teacher has preyed on the student's guppies, discuss student design methods as a class.
- Have students answer questions 3-6 on their student worksheets analyzing the activity.
- Have a class discussion to allow students to share why they designed their guppy the way they did and what they would alter or change.
- Refer back to the laminated guppy pictures and have the students quickly categorize the fish that would camouflage well in a river vs the fish that would stand out.

Students:

- Design and color their guppy.
- Hide it visibly in the classroom "river" environment using tape. Be sure it is not hidden behind anything. It should be out in the open.
- Answer #3 on the student worksheet by summarizing why they designed their guppy with the

Teacher Tip:

The following is the key for the student handout.

[Key Fantastic Fins - Guppies](#)

Assign points based on proficiency standards for your classroom.

If possible, provide Swedish fish or fish crackers for those whose fish survive.



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characteristics they chose.

- Answer #4 and #5 by tallying how many fish were preyed on and how many survived.
- Answer question 6 by explaining what they might change to their design to increase survival.
- Share design experiences with the group.

Teachers: (20 min)

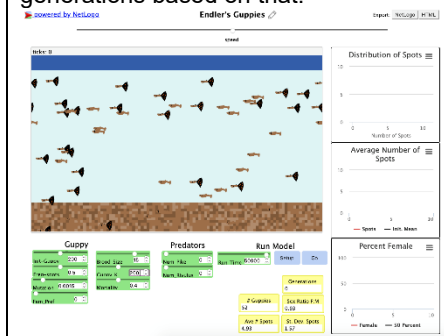
- Using the online simulation, students will run experiments by collecting and analyzing data using variables that alter the population of guppies in a water environment.
- https://virtualbiologylab.org/NetWebHTML_FilesJan2016/EndlersGuppiesModel.html
- Ask students what characteristics make up a great experiment. Discuss with students the importance of testing one variable at a time, what are independent and dependent variables, running the experiment multiple times, having a control, and recording the data.
- Organize students in groups of three. Allow students to spend 2-3 minutes manipulating the simulation to see how it works. Ask students to pay attention to patterns in the simulation.
- After students have explored the simulation, be sure to help them reset the variables to their default settings.
- Students will run four experiments: one control experiment and three experiments testing three different variables. Explain to students that the variables they will change first are female preference and pike predators. All other variables will be kept constant. Student groups should make a plan about how to test each variable and what value to change their independent variables.
- Ask students to change the speed of the simulation so it moves quicker. Students should run the simulation for 100 generations. Depending on your technology, running four tests for that long may take a significant amount of time. Each test should be run for at least 100 generations.
- Ask students to collect and add their data to their student data sheet.
- Students answer #7: “Analyze the data you collected and explain what patterns you see.”
- Students answer #8: “As the proportion of predators to guppies increases, what trends in the average number of spots do you observe?”
- Students answer #9: “In a simulation with female preference and pike predators, what do you predict will happen to the average number of spots after 100 generations?”
- Then students will run the simulation and collect the data.

Students:

- Open the simulation on their Chromebook or other devices.
- Manipulate the simulation and pay attention to patterns you see that causes the proportion of guppies to change.
- With your group, make a plan of how to run the experiments. Remember, your first experiment will be your control experiment, leaving all variables at the default when you open the

[Guppy Simulation Key](#) – Use this key to help interpret the simulation controls.

Run the simulation a couple of times yourself so you can see how long it takes to complete and adjust the number of generations based on that.



‘Percent female’ can be somewhat difficult for students to find without explicit instructions. The simulation readily gives the ratio, however, to find the percent female, students should hover over the red line in the percent female graph. If they follow the red line in the graph to the point furthest to the right, it should give them the percent female.

Remind the students to compare their results back to the control.

The 3rd simulation could be used as an extension for students who finish



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simulation. Then, using the simulation, test the two independent variables: female preference and pike predators. • Run the simulation with both variables to test your predictions. • Observe the changes in the simulation to the proportion of the average number of spots as the simulation progresses. When the simulation has been completed to the designated number of generations, collect the data from your tests and from the others in your group on the proportion of guppies and add it to your student data table on your student worksheet. • Answer questions 7, 8, & 9 on your student worksheet. Teachers: (10 min) • Hand each student a copy of the variation and natural selection reading. • Ask students to take 5 minutes to read the article individually and annotate by underlining the characteristics of the guppy habitat. Also, highlight the characteristics that feature male guppy morphology. • Have students organize their annotations in the guppy habitat/male morphology table on their student worksheets. • Have students share what they learn with a partner. • Have students share what they have discussed with their partner with the class. Students: • Read and annotate the article. • Summarize what you have learned about guppy habitat and male morphology in the table on the student worksheet.	early/quickly if time doesn't permit all students to run the 3rd simulation. If you have struggling readers, you can read and annotate the article together in class.
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EXPLAIN

*What are the advantages and disadvantages of being brightly colored?
What changes can be seen in male guppies when predators are present?*

Teacher: (10 min) • Students answer #10 on their student worksheet: "What are the advantages of being brightly colored?" • Students answer #11: What are the disadvantages of being brightly colored?" • Students answer #12: "Why would the proportion of females to males ever be significantly different than 50%?" • Students answer #13: "Predict what male guppies would look like in an environment with no	Teacher Tips Be sure to emphasize the following: DCI: Advantageous traits are passed on. CCC: Scale, proportion and quantity SEP: Analyze and interpret data
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- predators. Explain your reasoning.”
- Students answer #14: “How would you change your design if you were to color a guppy to attract a mate rather than remain hidden from predators?”.
 - Hold a class discussion related to their answers to be sure students are learning the DCI, CCC, and SEP.

Students:

- Answer questions 10-14 on the student worksheet.

ELABORATE

What other patterns can be observed when different variables are introduced?

If time permits, students can alter the other variables in the simulation. Some examples could include mutation rate, adding both predators, etc., to see how it affects the proportions of guppies in the population.

EVALUATE

*What will male guppies look like in an environment with picky females and no predators?
What will male guppies look like in an environment with plentiful predators?
What will male guppies look like when there are sexual selection and predation pressures?*

(15 min) [Fantastic Fins Assessment](#): Students will fill out a table explaining the male morphology based on two different habitats and design a new guppy to survive AND reproduce.

POSSIBLE EXTENSION / ALTERNATIVE ADAPTATIONS

- If time allows, have students return to their post-it note questions they wrote at the beginning of the lesson. Ask them to write down any answers they have since learned. Questions that have gone unanswered could be discussed as a class, answered in small groups, or researched individually.



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- Students could research the effect of the aquarium industry on male guppy morphology. This aspect of human selection without the presence of predators has impacted domestic guppy morphology.
- Students could use the simulation to explore other variables such as mutation rate, rivulus predators, or mortality.

