A Study of Changes in Population Unit

Lesson 2: Loberg Lake Stickleback

Grade 9-10 General Biology

Length of lesson: 90 minutes

Placement of lesson: Lesson 2 of 6

Unit Overarching Goal

Populations of organisms change over generational time (evolve) as a consequence of natural selection and adaptation due to the interaction of four factors: (1) the potential for a population (species) to increase in number, (2) variations in traits inherited from organisms' parents, (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.

Unit Central Question

What is the process that leads to changes in populations of organisms over time?

Lesson 2 Main Learning Goal

Living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.

Lesson 2 Focus Question

What would happen to a population if there were a change in the environment where the population lived?

Ideal student response

Characteristics of a population can change to make the individuals better able to survive in the environment. When saltwater stickleback fish were introduced to the freshwater Loberg Lake, data show that over time they looked less and less like other saltwater stickleback and more and more like stickleback in other freshwater environments, i.e., they had a reduction in spines and reduction in armor.

Science Content Storyline

Lamarckian (Scientist 1) thinking would say that these changes might have occurred quickly when an organism "wanted" to change or needed to change and, therefore, changed as an individual. Darwinian (Scientist 2) thinking would predict that changes would occur more slowly and not occur in an individual but as a proportion of the overall population.

Materials

- Lesson 2 slide deck

Lesson 2 General Outline

Time (min)	Phase of Lesson	How the science content storyline develops
5	**Revisit the Unit Central Question and Link to Prior Learning** What process leads to changes in populations of organisms over time?	
15	**Lesson Focus Question:** What would happen to a population if there were a change in the environment where the population lived? Students write their initial ideas in their student workbook.	
60	**Loberg Lake: A Fish Story**	
	Activity Setup Students read a brief scenario introducing the Lake Loberg, AK, stickleback fish. They create a timeline to ensure understanding of what happened to the stickleback population.	Scientist 1 would say that these changes might have occurred quickly when an organism “wanted” to change or needed to change and, therefore, changed as an individual.
	Activity Students read about a study that was conducted on the stickleback population in Loberg Lake, AK. Students are then given new data about stickleback and determine if the data best support the ideas of Scientist 1 or Scientist 2.	Scientist 2 would predict that changes would occur more slowly and not occur in an individual but as a proportion of the overall population. Populations change over multiple generations rather than over a generation or two. This supports Scientist 2’s ideas.
	Activity Follow-up Students synthesize all the data they received from the activity and think about which scientist’s ideas the data best support.	Living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not. An individual’s characteristics cannot change due to want or need. This refutes Scientist 1’s explanation of acquired characteristics.
10	**Summarize and Link:** Students revise their answer to the focus question. The teacher summarizes the lesson and links to the next lesson.	

Lesson 2: Loberg Lake Stickleback

Phase of Lesson: *Revisit the Unit Central Question and Link to Prior Learning and Lesson Focus Question*

Main Learning Goal: Living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.

Focus Question: What would happen to a population if there were a change in the environment where the population lived?

Unit Overarching Goal

Populations of organisms change over generational time (evolve) as a consequence of natural selection and adaptation due to the interaction of four factors: (1) the potential for a population (species) to increase in number, (2) variations in traits inherited from organisms' parents, (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 thatare better able to survive and reproduce in that environment.

Notes:

Time: 20 Minutes

STeLLA Strategies

- ❖ Strategy 1: Ask questions to elicit student ideas andpredictions
- ❖ Strategy 2: Ask questions to probe student ideas andpredictions
- ❖ Strategy B: Set purpose with a focus question

Science Ideas

- The population of stickleback in Loberg Lake would eventually be composed of individuals with little or no armor and short or no spines due to differences found in a freshwater environment as opposed to a saltwater environment.

Common Student Ideas

- Populations change because individuals adapt deliberately or through non-heritable processes because they need a given trait.
- An individual's traits change throughout her or his lifetime based on use or disuse. These acquired changes are passed on to the offspring.
- Change occurs in inherited traits of a population because individuals observe the traits of other, successful individuals and model their appearance or habits**.**
- Changes in a population occur because there are gradual changes in all individuals.
- Some individuals will change their behavior in order to survive. For example, stickleback with long spines will lay them down to avoid predators.

Lesson 2: Loberg Lake Stickleback

Introduction

You have been learning about stickleback fish to help you understand how populations change over time. In this lesson, you will learn about the changes to one specific population of stickleback.

Process and Procedure

1. Write the focus question for the lesson in the box below. Underneath the box, write your best ideas about the question. Leave space to revise your ideas as you learn more.

What would happen to a population if there were a change in the environment where the population lived? Students write their initial ideas in their student workbook.

Focus on Student Thinking

- Ask students to share their ideas with the entire group. The purpose is for you and the students to get a sense of the class's thinking about the focus question. You may find it useful to ask two or three students to share their ideas. Be sure to probe ideas to ensure that a depth of student thinking is surfaced. Use STeLLA Strategy 1: Ask questions to elicit student ideas and predictions. Make it clear to students that just like at the beginning of Lesson 1, we are gathering a lot of ideas and that you are not going to tell which predictions are right or wrong at this point.
- Sample student responses follow:
    - Some saltwater stickleback fish would die as they will find it hard to live in freshwater.
    - Since dragonfly nymphs grab stickleback by the spine and eat them, it's best for stickleback to lose their spines.
    - Stickleback will try to lose their spines so they are not captured and eaten by predators. When a stickleback loses its spines, that fish can then pass "spinelessness" on to its offspring.
    - Only stickleback without spines will survive and then have offspring without spines as well.
- Use STeLLA Strategy 2: Ask questions to probe student ideas and predictions. Again, the purpose here is to get a quick, public snapshot of what students are thinking. The goal is not to interrogate one student for five minutes. If interesting misconceptions emerge, note them on the board and come back to them at the end of the lesson. Examples of probe questions include the following:
    - Tell us more about ….
    - What do you mean when you say … ?

Implementation	Notes
Revisit the Unit Central Question and Link to Prior Learning ● Remind students that the overarching goal of this series of lessons is to answer the unit central question: What process leads to changes in populations of organisms over time? Let them know that as the lessons progress, they will be able to better answer this question. ● Remind students that during the last lesson they learned about stickleback fish and thought how a fully armored population of saltwater stickleback could have lost their armor when in a freshwater environment. Furthermore, they were introduced to two different ideas of how a population of organisms can change over time. Today, they will learn more about a particular population of stickleback fish in Alaska and continue to think about the two scientists' perspectives. *Teacher note:* Keep in mind that the main learning goal for this lesson is for students to figure out that living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not. *Lesson Focus Question* ● **STEP 1:** Introduce the Lesson 2 focus question: "What would happen to a population if there were a change in the environment where the population lived?" Write this question on the board so you and the students can refer to the question throughout the lesson. Ask students to write the Lesson 2 focus question in the box in their notebooks and, keeping what they learned during the previous lesson in mind, write their best ideas in the space below the box, leaving room so that they can modify their response as needed. Use the information in "Focus on Student Thinking" in the SE Key to see examples of ways to elicit and probe student ideas.	

Lesson 2: Loberg Lake Stickleback

Phase of Lesson: *Loberg Lake: Fish Story*

Main Learning Goal: Living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.

Focus Question: What would happen to a population if there were a change in the environment where the population lived?

Unit Overarching Goal

Populations of organisms change over generational time (evolve) as a consequence of natural selection and adaptation due to the interaction of four factors: (1) the potential for a population (species) to increase in number, (2) variations in traits inherited from organisms' parents, (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 thatare better able to survive and reproduce in that environment.

Notes:

Time: 60 Minutes

STeLLA Strategies

- ❖ Strategy 2: Ask questions to probe student ideas and predictions
- ❖ Strategy 3: Ask questions to challenge student thinking
- ❖ Strategy 9: Engage students in making connections by synthesizing and summarizing key science ideas

Science Ideas

- An individual's characteristics cannot change due to want or need.
- Populations change over multiple generations rather than over a generation or two.
- Changes to the stickleback population occur over multiple generations and do not occur in an individual but as a proportion of the overall population.
- Living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.

Common Student Ideas

- Populations change because individuals adapt deliberately or through non-heritable processes because they need a given trait.
- An individual's traits change throughout her or his lifetime based on use or disuse. These acquired changes are passed on to the offspring.
- Change occurs in inherited traits of a population because individuals observe the traits of other, successful individuals and model their appearance or habits**.**
- Changes in a population occur because there are gradual changes in all individuals.

Loberg Lake: A Fish Story

2. Read and annotate *Loberg Lake: A Fish Story* to learn more about a case where saltwater stickleback were put into a freshwater lake. As you read, stop and discuss the questions in the scenario with your group.

Loberg Lake: A Fish Story

Scenario: Loberg Lake, Alaska

Loberg Lake is a small freshwater lake in Alaska, just north of Anchorage. It covers about 11

acres and contains approximately 62 million gallons of water. For comparison, an Olympic size pool contains about 650,000 gallons of water making it about 100 times smaller than this lake. Loberg is a popular lake for fishing. A population of stickleback fish lived in the lake. Like many freshwater stickleback, the fish had little body armor and short spines. In 1982, the Alaska Department of Fish and Game decided to exterminate all the stickleback fish in the lake using chemicals. They made this decision because they thought removing the stickleback would improve the lake for recreational fishing because there would be more room for trout and salmon.

Stop and Think

Why would removing stickleback fish affect the numbers of trout and salmon and therefore improve the recreational fishing in Loberg Lake?

As scientists surveyed the fish in the lake in the following years, they did not see any sign of stickleback. In 1990, however, scientists did find stickleback in Loberg Lake. Scientists do not know exactly how the fish were reintroduced because Loberg Lake is not connected to the sea. There may have been a temporary connection to ocean waters at some point. The scientists do know from studies that the stickleback found in 1990 were very similar to the ocean, or marine, stickleback in nearby Cook Inlet. These fish had a full set of armor—up to 30 body plates—and long spines. They were very different from the original population of stickleback that were in the lake in 1982. Every year since 1990, the scientists have returned to Loberg Lake to examine the stickleback. They take a sample of the fish in the lake by setting traps and counting the number of fish that are caught overnight. Then they examine each fish. By 2008, most of the fish had little armor and short spines, like the original freshwater population of stickleback.

Stop and Think

Why do you think the scientists have continued to study the fish in the lake each year?

Loberg Lake is a typical freshwater lake in Alaska. The stickleback eat a diet of insects and small shrimp-like organisms. There are no large predator fish of stickleback in the lake. The stickleback predators in the lake environment include small fish, birds, otters, and dragonfly nymphs. Stickleback typically live about two years so the fish that were found in 1990 must have been born around 1988. The stickleback are able to reproduce after the first year. Each female stickleback can lay several hundred eggs at a time.

Implementation

Notes

Activity Setup

- **STEP 2:** Let students know the scenario they will read about is a real case where saltwater stickleback fish were introduced into a freshwater environment. Remind them that during the last lesson they thought about how freshwater stickleback are different from marine stickleback and how the differences might be explained. However, they did not have the benefit of using real data. For this lesson they will continue to study the stickleback but use real data from a recent research study to provide evidence for their ideas. During the debrief, the accompanying slide deck may help support students as they make sense of the stickleback scenario.

- Let students know that the scenario they are about to read is divided into three separate sections with questions after two of the passages. Remind students to annotate on their text as they read, then answer the questions before they begin reading the next section. This can be completed individually, with a partner, or as a large group to support reading abilities of all students in the class. However, students should have an individual copy on which to annotate and take notes.

- Remind students that after reading the scenario and answering the questions, they should have a solid understanding of *what* happened at Loberg Lake and to the stickleback population and have enough information to begin thinking about *how* this might have happened.

As students are reading and answering the questions, circulate among them and ask elicit (STeLLA Strategy 1) and probe questions (STeLLA Strategy 2) to clarify their thinking and timeline of events.

Loberg Lake: A Fish Story Timeline

3. Draw a timeline below to approximate scale and fill it in to show what happened in Loberg Lake.

Example timeline

1982	1990	2008
Stickleback fish exterminated from Loberg Lake	Stickleback fish found in Loberg Lake	Stickleback have short spines and low body armor.
Original stickleback population had little body armor and short spines.	New stickleback population had long spines and full body armor like saltwater stickleback.	Stickleback population looks much more like the 1982 stickleback population and less like saltwater versions found in the lake in 1990.

Focus on Student Thinking

- Example teacher and student dialogue is shown below:

  T: Tell me, what was the series of events that occurred at Loberg Lake? (ELICIT)

  S: Loberg Lake is a favorite fishing spot and all the stickleback were removed from Loberg Lake to improve the fishing. After a few years, scientists found the stickleback population reestablished itself in the lake.

  T: Were these stickleback the same or different from the original population of stickleback? (PROBE)

  S: They were different from the first one as they were more like the saltwater stickleback—long spines and more armor.

  T: Over the years, what changes happened to this new stickleback population in Loberg Lake? (PROBE)

  S: The new stickleback population began to lose armor and its spines got shorter.

  T: So, the new population of stickleback started with longer spines and more armor, but over successive generations of time, scientists found that the stickleback were losing their armor and spines.

Implementation

- **STEP 3:** Once all students have completed the reading and answered the questions, ask them to develop a timeline. Have them draw a timeline in their work books to approximate scale and fill it in to show what happened in Loberg Lake. Ask them about what happened at Loberg Lake (the effect) and what might have happened to cause the stickleback population change. Based on your class needs this can be done individually, in pairs, groups, or as a whole class.

- Be sure to build consensus around the timeline of important events that occurred at Loberg Lake. Have students refer to the reading as a whole group to ensure that there is consensus on the order of events; and that they accurately *understand* the flow of events and the changes in stickleback morphology from 1982 to 2008. Additionally, ask students to begin thinking about how these changes might have occured.

> Refer to "Focus on Student Thinking" in the SE key to see examples of questioning strategies.

- Make sure that students understand the timeline of events, specifically how stickleback morphology changed from the original population in 1982 to the new population in 2008.
    - The 1982 stickleback population had low body armor and short spines.
    - The 1990 stickleback population had full body armor and long spines.
    - The 2008 stickleback population had low body armor and short spines.

- At this point ask students to revisit their own timeline and in a different color, make additions or revisions as needed.

- Once the timeline is created, make sure to emphasize that the 1990 stickleback population looks like saltwater populations, whereas the 2008 stickleback population looks much more like the original 1982 stickleback population.

Transition

- Let students know that the next set of activities will help them think about *how* the stickleback population in Loberg Lake could have changed to now have short spines and low body armor.

Notes

4. Between 1990 and 2015, the stickleback fish population in Loberg Lake changed a lot. Use the following table to help you consider how the two scientists you learned about in Lesson 1 would explain the changes. You may need to refer to *Two Views about change in Populations* from lesson 1.

Question	How **Scientist 1** would answer	How **Scientist 2** would answer
1. Did the population of stickleback fish change between 1990 and 2008?	Answer the question by circling: **[✓ YES]** **NO**	Answer the question by circling: **[✓ YES]** **NO**
2. Did any individual fish change during its lifetime?	Answer the question by circling: **[✓ YES]** **NO**	Answer the question by circling: **YES** **[✓ NO]**
3. Which variation of stickleback would decrease in the presence of dragonfly nymphs?	Answer the question by circling: **[✓ LONG SPINE]** **SHORT SPINE**	Answer the question by circling: **[✓ LONG SPINE]** **SHORT SPINE**
4. Which variation of stickleback is favored when there are NO large fish, like trout?	Answer the question by circling: **LONG SPINE** **SHORT SPINE** **[✓ NEITHER]**	Answer the question by circling: **LONG SPINE** **SHORT SPINE** **[✓ NEITHER]**
5. How many generations of fish would it likely take for the population to change from mostly full armor, long spine fish to low armor, short spine fish?	**Number of generations 1-2**	**Number of generations 8-10**

Focus on Student Thinking

- Ask appropriate probe (STeLLA Strategy 2) and challenge questions (STeLLA Strategy 3) as students are filling out the chart. Be prepared to ask questions such as these:
    - Can you talk more about why you thought that Scientist 1 (or Scientist 2) would respond to that question in that way? (PROBE)
    - Say more about your thinking. (PROBE)
    - What evidence do you have from Lesson 1 that makes what you think Scientist 1 (or Scientist 2) would answer the question in this way? (PROBE/CHALLENGE) *
    - Can you find evidence that supports each scientist? What evidence supports that scientist's explanation? (CHALLENGE)
    - How does (or doesn't) that piece of evidence fit with Scientist 2's ideas? (CHALLENGE)

**Some of these questions can be probe or challenge depending on whether students have identified evidence from their summary chart prior to the teacher asking the question.*

Implementation

Notes

Activity

- **STEP 4:** Let students know they are to use the guiding questions found in the table to help them consider how the two scientists would explain the changes. Remind students to refer to *Two Views about Change in Populations* from Lesson 1 to help them answer the questions.
- Emphasize that responses to some of the questions may be quite similar or the same between the two scientists.

Refer to “Focus on Student Thinking” in the SE key to see examples of questions for Strategies 2 and 3.

- Note that students might have trouble with the question: “How many generations of fish would it likely take for the population to change from mostly full armor, long spine fish to low armor, short spine fish?” Help them think through the question by discussing how long it might take for a fish to make a decision and change as opposed to some fish being more able to survive and pass on traits. Emphasize that from the perspective of Scientist 1 it would be very short—1 or 2 generations—where as it would be longer from Scientist 2’s perspective—multiple generations.
- Ask students to quietly review their ideas and determine which rows show differences between the two scientists’ ideas. They should respond that (2) “Did any individual fish change during its lifetime?’ and (5) “How many generations of fish would it likely take for the population to change from mostly full armor, long spine fish to low armor, short spine fish?” show differences.
- Have students share their responses in the large group prior to moving on to STEP 5. Be sure to appropriately challenge the evidence behind each response. Do not blindly accept the responses students are sharing. This is a good opportunity to move students forward with the appropriate use of probe and challenge questions.
- By the end of the discussion, make sure that students understand that many of the ideas were the same between the two scientists. However, if they can find evidence for the places the scientists had different ideas, it will help them to decide which scientist might have ideas more aligned with the way populations change in nature.

5. Which statement below best represents your thinking about the traits that an organism can pass on to its offspring?

- ❖ All organisms with or without favorable traits will pass on only the favorable traits.
- ❖ Any organism that survives long enough to reproduce will pass on its traits, both favorable and unfavorable.
- ❖ Organisms with favorable traits can reproduce and pass on favorable traits to offspring; however, organisms with unfavorable traits cannot reproduce and pass on their unfavorable traits.
- ❖ Organisms that reproduce will pass on favorable traits they have acquired during their lifetime in order to adapt to their environment.

Implementation	Notes
- **STEP 5:** Have students individually respond to the probe about passing on traits to offspring. - Once students have selected their responses, guide a class discussion so students can share their ideas and reasoning.	

6. In the next steps, you will learn more about stickleback fish. You will use the information to decide whether scientist 1's ideas or Scientist 2's ideas better explain how populations change. The graph shows the *percent of fish in the sample the scientists took* with complete armor and low armor each year. Taking a sample allows scientists to represent the percentages in the total fish population without catching all the fish.

Use Identify and Interpret (I^2) by following the steps below to analyze the graph.

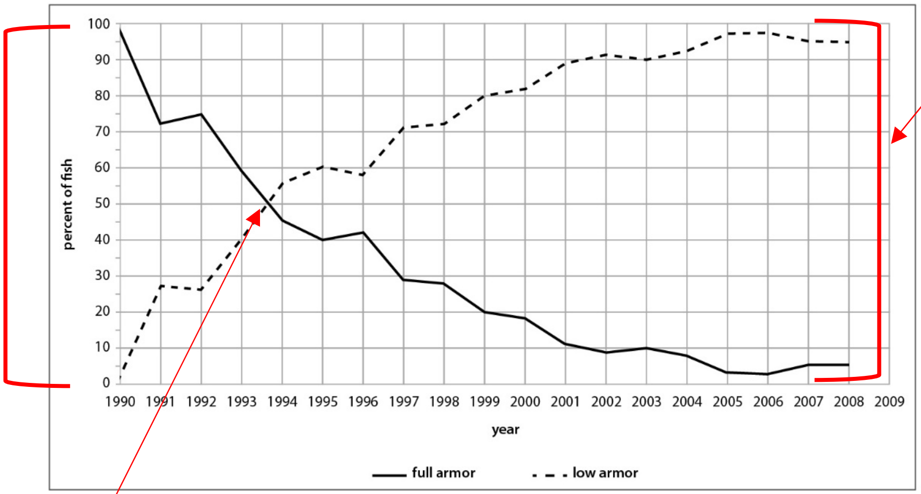
a. Draw arrows to places on the graph that show changes, trends, or differences.

b. For each arrow, write the words "What I see" or "WIS". Then write a short statement to describe the change, trend, or difference that you noticed.

c. Under each "What I see" statement, write the words "What it means" or "WIM". Write a comment for each statement to explain what the change, trend, or difference means for the fish population.

WIS
Most Stickleback have full armor
A few have low armor

WIM
Variation of this trait exists in the population



WIS
Few stickleback have full armor
Most have low armor

WIM
Variation of this trait still exists in the population

WIS
In 1993 about half the population had full armor and then other half low armor.
WIM
Th proportion of the population with full armor was decreasing and the proportion with full armor was increasing.

The graph shows the change in the percent of fish in the sample of a population of stickleback with full body armor and low body armor. In 1993 about half the population had full armor and the other half low armor which means the proportion of the population with full armor was decreasing and the proportion with low armor was increasing. In 2008, Few stickleback have full armor and most have low armor which means variation of this trait still exists in the population. In 1990, few stickleback have low armor and most have high armor which means variation of this trait existed when scientists began studying the population.

Implementation

- **STEP 6:** Let students know that in the next steps, they will learn more about the stickleback and use this information to determine which scientist's ideas better explain how populations change. For this step, students will be examining a graph that shows the percent of fish in the population with full armor and low armor each year. They will be using a method called Identify and Interpret (I^2) to analyze the data.
    - Ask students to follow the steps to complete their analysis. If your students have never used this method before, you may want to model each step.
    - To begin, students should only draw arrows to the places that they notice changes, trends, or differences. Consider giving them a particular number of arrows to draw so they can write several statements about the graph but not so many that they are drawing arrows to inconsequential things, such as the colors of the lines.
    - Emphasize that as students do STEP 4b, they should write "What I see" or "WIS" and then an observation about what they saw that led them to draw an arrow. These statements should simply be observations, not trying to attribute a cause to them.
    - Stress that for each WIM comment, students are to write what the trend, change, or difference means *to the fish population*, not speculate on a bigger idea of what might have caused the change.

- Support the analysis process by asking appropriate probe (STeLLA Strategy 2) and challenge (STeLLA Strategy 3) questions to students.
    - Although there are a number of observations students could make, there are three specific points on the graph that are important to the developing storyline.
        1. 1990—almost 100 percent of the fish had full armor
        2. 1990 to 1994—dramatic decrease in fish with full armor and a dramatic increase in fish with low armor
        3. 2004 (after a 14-year time span)— over 90 percent of the fish had low armor.
    - Use the attached questions template at the end of this lesson's implementation guide to make sets of question cards to use with student groups. Provide the appropriate question card to student groups who are struggling with the WIS/WIM data analysis and/or are missing the three important points described above. Notice the questions are written to get students to think about what data they see first (WIS) before asking them to consider the meaning (WIM).

Notes

Implementation

- As each student group has completed STEP 6, refer the group to the final question on the chart from STEP 3: How many generations of fish would it likely take for the population to change from mostly full-armor, long-spined fish to low-armor, short-spined fish? Tell them to think about how their observations and interpretations of the stickleback data fit with how fast or slow change occurs according to each of the two scientists' perspectives.
    - From Scientist 1's perspective, change would occur in a very small amount of time—one or two generations.
    - From Scientist 2's perspective, change occurs over longer periods of time—many generations.
- After all groups have had time to consider the question above, lead a class discussion about the idea that stickleback generations are approximately two years and have them think about how many generations it took for the population to change to a mostly low armor population. You may need to discuss how there were changes occurring and after a couple of generations there had been a significant change but that the majority of the population was not low armor for about seven generations.

Teacher note: Keep in mind that the goal for this lesson is for students to figure out that living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.

Notes

Stickleback Fish at Three Time Points during Adult Life

7. Examine the following sets of pictures. Each picture represents the same fish at several points in its adult life. These fish are form Loberg Lake where there were larger fish predators present.

12 Months

18 Months

photos by Kasie Barnes

24 Months

   a. Look closely at the dorsal (back) side of each fish to locate its dorsal spines. The arrow on the top picture of each fish points to the location of dorsal spines. Based on the four sets of pictures, what do you observe about the dorsal fin of each fish (did each fish gain spines, lose spines, or stay the same)? Why did you choose the answer you did?

   b. Based on your answer to 5a, do you think fish can make the conscious decision to lose, gain, or keep spines and armor and then do so based on the decision? Why or why not?

   c. If a fish loses its spines because of a fight with another stickleback, can it pass on “spinelessness” to its offspring?

   d. What additional data would help support your ideas better?

Implementation

- **STEP 7:** Students will observe a set of fish pictures; this is the same fish at three points in its life—12, 18, and 24 months.
- The purpose of this step is to have students think about whether there is evidence from the pictures that a single fish could *willfully* lose or gain spines and armor as needed.
- If students have difficulty in answering the questions in STEP 5b, remind them that they should not consider that fish might lose spines because of a fight with another fish or a predator preying on them. Only consider whether fish can lose or gain the trait without an outside influence (i.e., willing a trait to be lost or gained and then having that loss or gain occur).
- Lead a class discussion about the process of science and discuss the ideas that more fish would likely help them make a more informed decision about the evidence. However, these types of data are not necessarily collected regularly. Have them consider whether this supports one of the scientist's perspectives as opposed to "proving" one was correct. Emphasize that because this fish was from a laboratory, they were able to control the interactions it had, so it is likely a better source of data than simply catching a fish from a lake without knowing what had occurred in the time between photographs.
- Student thinking that the fish will change their behavior to survive, such as hiding from predators or flattening their spines, may persist. If so, some instruction about "learned vs. innate behavior" is advised.
- Once students have completed STEP 5, ask the class whether what they observed and wrote about regarding the fish pictures aligns better with Scientist 1's perspective or Scientist 2's. Refer students to *Two Views about Change in Populations* for additional information if they struggle to answer this question.
- A possible challenge (STeLLA Strategy 3) question if students assert that the evidence from the fish pictures better aligns with Scientist 1's ideas could be, "If Scientist 1's ideas hold true, how might the pictures of the adult fish differ during each time period in its adult life?" Consider asking a similar question about the information in STEP 4 with the graph.

Notes

8. Refer back to the table you completed for the two scientists' ideas in step 4. Based on the new data you have about stickleback from steps 6 and 7, determine if you can add any information to your answers. Add new ideas to your table in a different color.

9. Also in your table, circle any questions where the two scientists' ideas are different from each other. For each question you circle, list the question number and evidence you have related to the question in the space below. Then write whether the evidence supports the ideas of Scientist 1 or Scientist 2.

10. Now, refer back to your cause and effect organizer in Lesson 1, step 9 and decide which cause is supported by evidence. Record your response below.

Focus on Student Thinking

- The use of probe questions is especially important to this part of the follow-up to reveal any naïve conceptions related to Lamarck's (Scientist 1) and Darwin's (Scientist 2) ideas.
  - Examples of probe questions (STeLLA Strategy 2) include the following:
    - Can you say a bit more about … ?
    - Can you clarify what you just said about … ?
  - Refer students to the summary chart of the scientists' ideas and appropriately use challenge questions (STeLLA Strategy 3) to move student thinking forward.
  - Following are examples of challenge questions:
    - How does what you just said relate to Scientist 1's ideas as described on the summary chart?
    - What evidence can you find on the summary chart that supports what you just said?

Implementation

Notes

Activity Follow-up

- The purpose of STEPs 6 and 7 is for students to synthesize (STeLLA Strategy 9) the information that they gleaned from reading the scenario and the data they just observed and analyzed in STEPs 6 and 7 (on their notebook pages).

- **STEP 8:** Tell students to individually look at the table they completed in STEP 4 about the way the scientists would answer different questions. Based on the new information they have about stickleback from STEPs 6 and 7, they should add any new ideas in a different color.

- **STEP 9:** Next, ask them to circle the questions where the scientists' ideas are different from each other. Students should then write down any evidence that supports one scientist or the other. Remind them of the discussion about the pictures of the four fish from Loberg Lake where they would be exposed to a variety of different situations. Ask students to consider which scientist the results support, even if they would like additional information.

- Based on information from STEPS 6 and 7, students should be able to find evidence for their ideas.
    - There is strong evidence for Scientist 2's response to these questions:
        - Question 2: Did any individual fish change during its lifetime?
        - Question 5: How many generations of fish would it likely take for the population to change from mostly full armor, long spine fish to low armor, short spine fish?
- Ask students to determine, based on the evidence from the activities, which scientist's ideas are best supported. They may work with a partner or in small groups as it gives students a chance to vet their ideas prior to sharing them with the whole class.

- **STEP 10:** Have students refer back to their cause and effect graphic organizer from Lesson 1 and decide which cause is supported by evidence and record their response.

- Have students participate in a popcorn-share strategy (randomly volunteer) about which scientist's ideas are better supported by the evidence. Be prepared to probe and challenge students' thinking.

> Refer to "Focus on Student Thinking" in the SE Key for possible questions

Lesson 2: Loberg Lake Stickleback

Phase of Lesson: *Summarize and Synthesize Ideas*

Main Learning Goal: Living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce. This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.

Focus Question: What would happen to a population if there were a change in the environment where the population lived?

Unit Overarching Goal

Populations of organisms change over generational time (evolve) as a consequence of natural selection and adaptation due to the interaction of four factors: (1) the potential for a population (species) to increase in number, (2) variations in traits inherited from organisms' parents, (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 thatare better able to survive and reproduce in that environment.

Notes:

Time: 10 Minutes

STeLLA Strategies

- ❖ Strategy 2: Ask questions to probe student ideas and predictions
- ❖ Strategy 3: Ask questions to challenge student thinking
- ❖ Strategy I: Summarize key science ideas

Science Ideas

- The population of stickleback in Loberg Lake would eventually be composed of individuals with low or no armor and short or no spines due to differences found in a freshwater environment as opposed to a saltwater environment. This represents a change in the proportion of organism in a population that display the "favored" variation. In this case, low armor and short spines.

Common Student Ideas

- Populations change because individuals adapt deliberately or through non-heritable processes because they need a given trait.
- An individual's traits change throughout her or his lifetime based on use or disuse. These acquired changes are passed on to the offspring.
- Change occurs in inherited traits of a population because individuals observe the traits of other, successful individuals and model their appearance or habits.
- Changes in a population occur because there are gradual changes in all individuals.

Summarize and Synthesize Ideas

11. Based on what you know now, answer the focus question that you wrote on the first page of Lesson 2. Revise your ideas in a different-colored pen or pencil. If your ideas have changed a lot, you may also draw a line under your initial answer and write a new answer in a different color.

12. Scientist 1 is Jean Baptiste de Lamarck. His ideas of how populations change are called acquired characteristics. Scientist 2 is Charles Darwin. His ideas are called natural selection. Which scientist's ideas seem to be more like how the stickleback fish population changed over time? How did data help you determine whether Lamarck's ideas or Darwin's ideas are more likely to be true? Go back to your *Two Views about Change in Populations* reading and label each column with the appropriate Scientist's name.

Scientist 2 (Darwin) said that the stickleback with low armor and short spines survived, reproduced and passed on that trait to their offspring. Organisms inherit traits (i.e., variations of traits) from their parents. Some variations of traits may become favorable when particular environmental conditions change and help those with the trait survive and reproduce.

Low armor/short spines are the favored traits. The proportion of the population with low armor/short spines increased over time in the population according to the graph in STEP 6.

Scientist 1 (Lamarck) said that acquired traits could be passed on and they cannot like we said in STEP 7.

Implementation

Summarize

- **STEP 11:** Ask students to think about their response to the lesson focus question considering what they learned during today's lesson. Ask students to use a different-color pen and modify, if needed, their response to the focus question.

- Ask students to share their responses to the focus question and which scientist's idea they believe their revised response most closely aligns with.

- **STEP 12:** Have a student read their response aloud. Ask all students to refer to number 12 on their notebook sheet and ask a student to read it aloud. Now have them return to *Two Views about Change in Populations* in Lesson 1 and write each scientist's name at the top of the appropriate column. Hold a class discussion to make sure that students are aware that they have more evidence for Darwin's idea of natural selection.

- As possible, highlight (STeLLA Strategy H) the main learning goal, "Living populations change over time as organisms with traits that are well suited to the environment are better able to survive and reproduce." This leads to an increase in the proportion of individuals in future generations that have the traits and to a decrease in the proportion of individuals that do not.

Link to Next Lesson

- Tell students that in the next lessons, they will study natural selection in more detail. At this point, they have some evidence that Darwin's ideas represent how populations change, but they will use the stickleback fish to determine if the changing population really does fit with natural selection. They will look for more evidence related to the details of natural selection.

Notes