A Study of Changes in Population Unit

Lesson 1: Stickleback, Stickleback, Where Are Your Spines?

Grade 9-10 General Biology

Length of lesson: 90 minutes

Placement of lesson: Lesson 1 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 1 Main Learning Goal

Populations of organisms change over time (evolve), and there have been competing explanations of what causes populations to change.

Lesson 1 Focus Question

What are possible explanations for how a population of organisms gains or loses characteristics?

Ideal student response

According to Scientist 1, the freshwater stickleback have low body armor and short or no spines because their environment changed from saltwater to freshwater. The freshwater stickleback didn't need their armor and spines in order to protect them anymore; in fact, they were a liability because dragonfly nymphs can catch stickleback by their spines. As a result, stickleback armor diminished and spines became shorter and disappeared. The adult stickleback with low armor and shorter spines had offspring with low armor and shorter spines. Over a short period of time, most stickleback in freshwater lakes had low body armor and short or no spines.

According to Scientist 2, the freshwater stickleback have low body armor and short or no spines because individuals in the population that had full armor and long spines often did not live long enough to reproduce because of predation by dragonfly nymphs. Individuals with low armor and no spines lived longer and had more offspring than individuals with high armor and long spines. Over time, the number of individuals in the population with low or no body armor and short or no spines increased, while the number of individuals with full armor and long spines decreased. Over time, most stickleback in freshwater lakes had low body armor and short or no spines.

The Phenomenon

Over 13 generations of time, the stickleback population in Loberg Lake changed, due to natural selection, from being made up of mostly individuals with stickles (spines) and full armor to being made up of mostly individuals with short spines and low armor.

Background on Stickleback Fish

In the wild, there are three types of threespine stickleback populations:

- ocean—fish that live and breed strictly in the ocean;
- sea-run—anadromous fish, like salmon, that are born in freshwater, spend most of their lives in the ocean, and migrate back to freshwater to breed; and
- freshwater—fish that live and breed entirely in freshwater.

Freshwater stickleback populations were established when some sea-run populations became trapped in lakes that formed at the end of the last ice age. These lakes were initially connected to the ocean but were cut off as ice fields retreated and the land rose.

In most cases, freshwater stickleback populations are strikingly different from sea-run and ocean populations. Sea-run and ocean stickleback fish generally have full armor defenses, although some have low armor or no armor at all. The fullarmor defenses include bony plates along the sides of their bodies and long spines projecting from their backs and pelvises. Freshwater stickleback populations generally have low armor or none at all, although some have full armor. In addition, freshwater stickleback fish are slightly smaller and more streamlined than their sea-run ancestors. (Adapted from HHMI BioInteractive In-Depth Guide: *The Making of the Fittest: Evolving Bodies, Evolving Switches*.)

Science Content Storyline

Scientist 1 (Jean Baptiste de Lamarck) and Scientist 2 (Charles Darwin) offer different explanations of what causes populations of organisms to change over time. The populations of stickleback in the ocean and in freshwater look different from one another even though they are members of the same species and can interbreed. Scientist 2 would explain the change in the freshwater population as the result of natural selection, while Scientist 1 would explain the change based on inheritance of acquired traits.

Materials

- video clip excerpted from HHMI BioInteractive: The Making of the Fittest: Evolving Bodies, Evolving Switches
- computer access to watch video, either as a class or per student
- headphones (optional if students are watching the video individually)
- story cards (1 set printed in color and on card stock per group of 3–4 students)
- story cards (1 set for use by teacher printed in color and on 8 ½ X 11 paper)
- sticky notes
- Lesson 1 slide deck

Advance Preparation

- Determine how students will access the video (individually or as a whole class).
- Make sure you have all the materials prepared for use or distribution before class to be efficient with time. You may not be able to complete the lesson in one class period because students need more time to read, talk, think, or write.
- Identify where students can find a definition of populations so you can point them to it if they are unsure about the word during the introduction to the module. We expect that students will have learned the word in middle school or during a previous ecology unit, but they may need to be reminded of the definition.
- Dedicate space on the wall to leave the story cards to revisit as needed throughout the unit and take a photo of the arrangement.

Lesson 1 General Outline

<table>
<tr><th>Time (min)</th><th>Phase of Lesson</th><th>How the science content storyline develops</th></tr>
<tr><td>10</td><td>What Causes Populations of Organisms to Change Over Time? (Unit central question)
Introduce central question for the unit and link to previous unit(s). Teacher makes student thinking visible by recording student answers to the unit central question.</td><td></td></tr>
<tr><td>40</td><td>A Phenomenal Fish Story
<u>Activity Setup</u>
Students focus on what happens to stickleback in preparation for considering the lesson focus question: What are possible explanations for how a populationof organisms gains or loses characteristics?
<u>Activity</u>
• Students are introduced to stickleback fish.
• Students watch scenes drawn from the HHMI BioInteractive video The Making of the Fittest: Evolving Switches, Evolving Bodies as an introduction to saltwater and freshwater stickleback populations, including differences inmorphology and predators.
• Teams of 3–4 students use story cards to show the key ideas from the video.
<u>Activity Follow-up</u>
The teacher leads a discussion of the key ideas and develops a visual representation that summarizes key events that led to a single saltwater stickleback population becoming separated into different saltwater and freshwater populations. Introduce the focus question.</td><td>The populations of stickleback in the ocean and in freshwater look different from one another even though they are members of thesame species.</td></tr>
<tr><td>30</td><td>Two Views about Change in Populations
<u>Activity Setup</u>
Students focus on different ideas about how the change in the stickleback population occurred to answer the lesson focus question: What are possible explanations for how a population of organisms gains or loses characteristics? For example, some populations of stickleback fish no longer have body armorand spines.
<u>Activity</u>
Students examine a summary table of two scientists’ ideas. The class discusses the key elements of each perspective.
Students then use the key ideas and comparison to consider cause and effect relationships to determine how each scientist would explain the changes.
<u>Activity Follow-up</u>
Class discussion: Are these two sets of ideas exclusive of each other? Can both explanations be supported with evidence?</td><td>Scientist 1 and Scientist 2 offer different explanations for what causes changes in populations of organismsover time. Scientist 2 would explain the change in the freshwater population as the result of natural selection, and Scientist 1 would explain the change based on inheritance of acquired traits.</td></tr>
<tr><td>10</td><td>Summarize and Synthesize Ideas
Students consider the ideas of two scientists and how the scientists would explain an event that happened long ago. In the next several lessons we will look for evidence using a recent change to a stickleback population that might convince us that one explanation can better explain the changes in populations.</td><td></td></tr>
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Lesson 1: Stickleback, Stickleback, Where Are Your Spines

Phase of Lesson: *What Causes Populations of Organisms to Change Over Time?*

Main Learning Goal: Populations of organisms change over time (evolve), and there have been competing explanations of what causes populations to change

Focus Question: What are possible explanations for how a population of organisms gains or loses characteristics? For example, some populations of stickleback fish no longer have body armor and spines.

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.

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Time: 10 Minutes

STeLLA Strategies

- ❖ Strategy 1: Ask questions to elicit student ideas andpredictions
- ❖ Strategy 2: Ask questions to probe student ideas and predictions

Science Ideas

- populations of organisms change over time(evolve).
- Throughout history scientists have offered competing explanations of what causes populations to change.

Common Student Ideas

- Populations change because individuals adapt deliberately or through nonheritable processesbecause 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 appearanceor habits.
- Changes in a population occur because there aregradual changes in all individuals.

Lesson 1: Stickleback, Stickleback, Where Are Your Spines

Introduction

In this unit, you will have a chance to think about populations of organisms and how their characteristics change over time. You will ask questions that scientists have wondered about for a long time. Scientists have made observations and found that different populations have characteristics that have changed. Here are some examples of questions that scientists have asked:

- Why have some antibiotics that once killed many kinds of bacteria stopped being as effective at killing these bacteria?
- Deer mice populations living in Nebraska generally have dark-colored fur. When some populations migrated to the light-colored sand hills of Nebraska, why did their fur change from dark brown to light brown?
- The peppered moth, living in the forests outside of London, England, used to be a light color with black spots. When the air in London became filled with soot because of the Industrial Revolution, the white trees became darker, and the moths became darker. What caused this change?

To help you learn more about these questions, the unit will focus on the question below.

Unit Central Question

<u>What is the process that leads to changes in population of organisms over time?</u>

Process and Procedure

1. Write your best ideas about the unit central question in the space below. Leave space to revise your ideas as you learn more in later lessons.

Focus on Student Thinking

- Use STeLLA Strategy 1: Ask questions to elicit student initial ideas and predictions to get a variety of ideas out. Make it clear to students that you are not going to tell which ideas about what causes populations to change over time are right or wrong at this point; the activities of this series of lessons will help us supportor challenge the ideas shared now. The purpose is to reveal several student ideas, so you and the students get a sense of the different ideas in the class. The goal is *not* to surface every idea each student has.
- Question: What causes populations of organisms to change over time? Sample student responses follow:
    - God did it.
    - They needed to change—they had to get stronger/faster/more camouflaged, or they'd die.
    - They evolved, or they mutated.
    - An environmental disaster happened, or humans killed the biggest/best.
    - Something happened and the population moved to a new environment.
    - Natural selection caused the population to change.
    - Survival of the fittest
- Use STeLLA Strategy 2: Ask questions to probe student ideas and predictions. Examples of questions include the following:
    - Tell us more about … .
    - What do you mean when you say … ?

If many students use the phrases "natural selection," "survival of the fittest," or "adaptation/adapt," ask probe questions to determine students' understanding of these ideas. Often, students have a general understanding of these ideas.

Implementation	Notes
Introduce Unit Central Question and Link to Previous Unit ● Let students know that in this unit, they will learn more about populations of organisms—specifically, how populations of organisms change over time. Ask students to individually think of what they know about the word populations. If they defined it in their notebooks earlier in the year, ask students to turn back in their science notebooks and find that definition. Then invite them to turn to a partner and say what a population is and provide an example. ○ A population is a group of organisms of the same kind (the same species; they can reproduce with each other) that live in the same environment. The example should include the type of organism and the"place" or environment where the population can be found, for example, a population of Northern Cardinals living in a Kentucky forest. ○ After eliciting student thinking, ensure that students are aware that variations in traits exist in all populations. ● It is important to note that the purpose of this lesson is *not* to have students arrive at a right answer, but to make their thinking about changesin populations visible by getting as many of their ideas out as possible and probing for specificity in what they say. Remind students to use Strategy 4: Engage students in communicating in scientific ways by using their CSW charts and sentence stems. ● Ask students to read the introduction to the lesson quietly or have one readit aloud. To introduce the question, note the examples in the student notebook and share additional examples with students. For example, students may have heard that at one time whales lived on land. What caused whales to change so that they now live in water? What caused the change to occur? *Unit Central Question* ● **STEP 1:** Introduce the unit central question, "What causes populations of organisms to change over time?" Note that this question is printed in the box to help them find it more easily later. Ask students to write their best ideas about the unit central question in the space under the box. ○ Remind them that they will write their ideas about *how* they think these changes occurred, not offer more examples of changes. ● Lead a whole class discussion to allow students to share their ideas. ○ It is important to note that the purpose of this lesson is NOT to have students arrive at a right answer, but to make their thinking about changes in populations visible by getting as many of their ideas out aspossible and probing their ideas. Use the information in "Focus on Student Thinking" in the SE Key to see examples of ways to elicit and probe student ideas.	

Lesson 1: Stickleback, Stickleback, Where Are Your Spines

Phase of Lesson: *A Phenomenal Fish Story*

Main Learning Goal: Populations of organisms change over time (evolve), and there have been competing explanations of what causes populations to change

Focus Question: What are possible explanations for how a population of organisms gains or loses characteristics?

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.

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Time: 40 Minutes

STeLLA Strategies

- ❖ Strategy 1: Ask questions to elicit student ideas andpredictions
- ❖ Strategy 2: Ask questions to probe student ideas andpredictions
- ❖ Strategy 3: Ask questions to challenge student thinking

Science Ideas

- The populations of stickleback in the ocean and infreshwater look different from one another even though they are members of the same species.
- Some stickleback have low armor and short spinesand some have high armor and long spines.

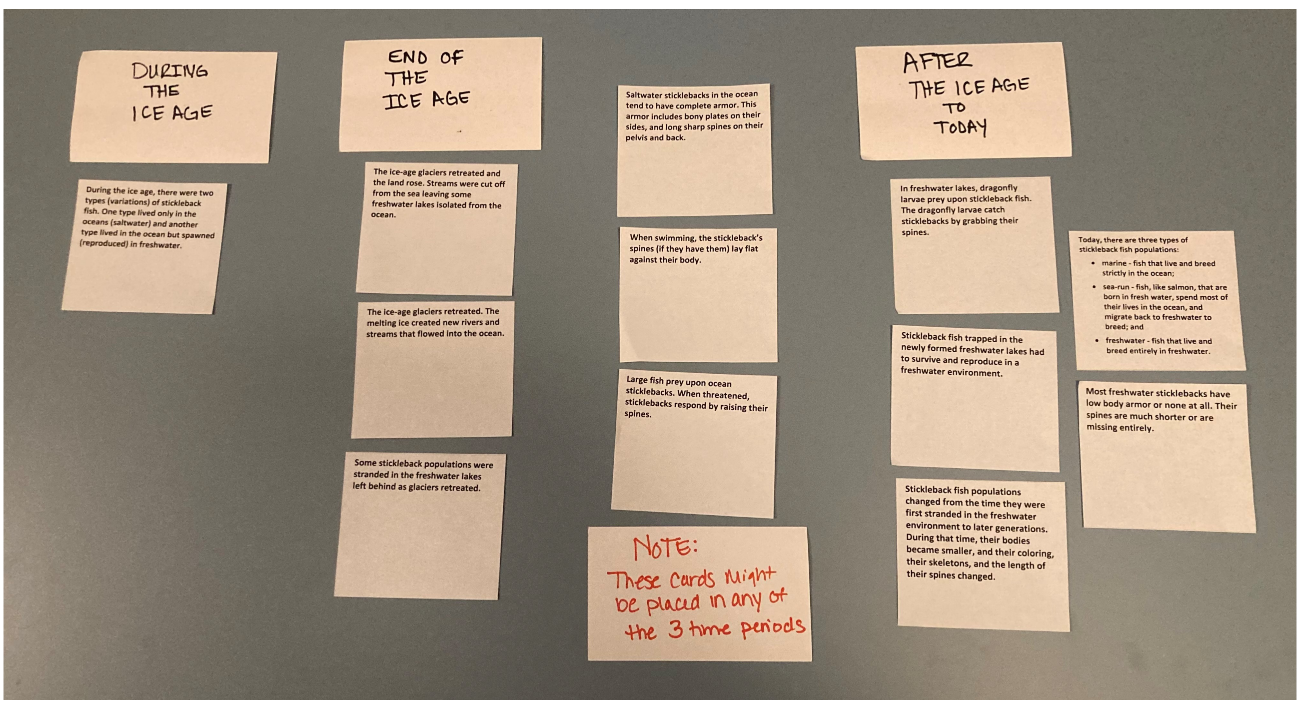
Common Student Ideas

- Populations change because individuals adapt deliberately or through nonheritable processesbecause they need a given trait.
- An individual's traits change throughout her or hislifetime 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 appearanceor habits.
- Changes in a population occur because there aregradual changes in all individuals.

A Phenomenal Fish Story

2. To begin to explore ideas about how populations change over time, you will consider populations of small fishcalled stickleback. They represent a *natural phenomenon* that will help you understand what might happen to any population. A natural phenomenon is an observable event or process in nature that makes you ask questions like, *what happened?* Or *why did that happen?* Preview the provided card set with your group. You will be sequencing the cards using information in the video. Watch the video about stickleback populations. You can watch the video clip more than once, if needed. As you are watching, ask yourself the question, "What is happening to the stickleback fish?" and "What might be causing it to happen?"
3. To help you understand what happened to the stickleback fish, group the story cards provided by your teachers into three-time segments:
   a. during the ice age
   b. at the end of the ice age
   c. after the ice age to today
4. Now, using the sticky notes provided, make a label for each of the three-time segments. Then under each heading label, arrange the cards in a way that tells the story of what happened to the stickleback of Loberg Lake.

   Be prepared to share your visual representation of your sequence story cards with the class.
   A sample storyboard might look like this:



Implementation	Notes

Activity Setup
• Tell students that in this lesson they will learn about populations of small fish called stickleback. To find out more, they will have a chance to watch a video, and then arrange story cards to show what happened to the stickleback. Much like scientists, they will add to their knowledge as they do each part of the activity. Emphasize that once we know *what* happened to the stickleback, we'll consider ideas about *how* it happened.
Activity part 1: Video clip
• **STEP 2:** Give one story card set to each student group. Tell students they will be arranging the cards based on information provided in a video they will watch. Provide time for groups to preview the cards before showing the video. https://www.biointeractive.org/classroom-resources/making-fittest-evolving-switches-evolving-bodies. **Pause at 01:17 and ask students the "Would it make a difference that fish who lived in the ocean were now isolated in freshwater lakes?" Stop video at 03:29.**
• Show students the videoclip to introduce them to the phenomenon that will be a focus of this unit.
  ○ It may be helpful to show the videoclip more than once.
  ○ If students are going to watch the video multiple times, consider showing students images of the stickleback and dragonfly nymphs after the first time they watch so they can more easily identify what is happening in the video.
• The purpose of the video is to give them some background on the stickleback fish and dragonfly nymph. Before moving to the next step, be sure they understand (1) the relative size of a stickleback, (2) stickleback spines and armor help prevent them from being swallowed by larger fish, (3) the relative size of the dragonfly nymph, and (4) dragonfly nymphs are juvenile forms of adult dragonflies.
Activity part 2: Story cards
• **STEP 3:** Ask student groups to revisit the cards and arrange them in three-time segments (during, at the end of, and after the ice age) to show what happened to the stickleback and their environment over time.
• **STEP 4:** Once groups have completed their preliminary sort, ask them to develop a final visual representation of what happened.
  ○ Provide groups with three sticky notes as labels for the time periods.
  ○ Within each time segment, students should group cards so that the arrangement tells the story of what happened to the stickleback populations.
  ○ **Note:** The cards describing the morphology and predators of the ocean stickleback could be placed in any of the three time periods. The cards are not intended to be a timeline of events. It is important that students understand the origin of the isolated freshwater populations and the differences between saltwater and freshwater stickleback. Help students avoid spending unproductive time debating over the correct placement of these cards.	

Focus on Student Thinking

As students work to arrange their cards, circulate among the teams asking elicit, probe, and challenge questions. Example teacher and student responses follow:

T: Can you talk a little bit about the placement of your cards? (ELICIT)

S1: We can't decide which card should go first, the one about freshwater stickleback having no armor or the one about freshwater stickleback getting eaten by dragonfly nymphs.

T: What do you think about how this affects the placement of the cards? (PROBE)

S1: Well, I think the stickleback getting eaten by dragonflies has to come first. That's why they didn't want spines.

T: What do others think? (ELICIT)

S2: I think they had spines when they first got stuck in the lake. I don't know when the dragonflies showed up. I guess they were always there since they can fly.

T: What do others think? (ELICIT)

S3: I don't think it matters which one goes first.

T: Say more about why you don't think it matters. (PROBE)

S3: Well, both cards were probably happening at the same time.

S1: Oh, I guess it really doesn't matter which one comes first then.

S2: Because they both happened after the Ice Age ended until now.

T: How can you show that with the way you arrange your cards? (CHALLENGE)

S1: We could put one above the other.

T: What would that look like with your cards? (PROBE) OR Remember, it's more about grouping the cards by time frame (before, during, after) than sequencing within a given time frame.

Implementation	Notes
○ Emphasize that there is no single correct answer to the placement of the cards, but that groupings of cards represent key features of saltwater and freshwater stickleback populations. Stress that the purpose of this activity is to learn what happened to the stickleback during this time. Refer to “Focus on Student Thinking” in the SE key for possible questions and student responses. The example highlights Student Thinking Lens Strategies1, 2, and 3. • Strategy 1: Asking questions that elicit student ideas and predictions. • Strategy 2: Asking questions that probe student ideas and predictions. • Strategy 3: Asking questions that challenge student thinking.	

Lesson Focus Question

5. Write the focus question for the lesson in the box below. Then, write your best ideas about the question under the box. Be sure to leave space to revise your answer as you learn more.

What are possible explanations for how a population of organisms gains or loses characteristics?

Focus on Student Thinking

- Use STeLLA Strategy 1: Ask questions to elicit student initial ideas and predictions to get a variety of ideas out. Make it clear to students that at this point in the lesson, we are gathering a lot of ideas and that you are not going to tell which ideas about how the freshwater stickleback lost their spines are right or wrong.
- It is important to note that the purpose of this lesson is *not* to have students arrive at a right answer, but to make their thinking about changes in populations visible by getting as many of their ideas out aspossible and probing for specificity in what they say.
- These are some sample student responses:
    - Stickleback lost their spines so the dragonfly nymphs couldn't catch them.
    - A mutation caused them to be born without spines.
    - When a dragonfly nymph grabbed a stickleback by the spines, it broke off and that stickleback got away, so it lived the rest of its life without spines.
    - Only stickleback without spines survived. All the stickleback that had spines got eaten by dragonflies.
- Use STeLLA Strategy 2: Ask probe questions to get more information about student thinking and understanding. Examples of questions include the following:
    - Tell us more about ....
    - What do you mean when you say …?

Implementation	Notes
Activity Follow-up • Once teams have arranged their story cards, conduct an uncurated gallery walk for students to observe other groups' card placement: ○ Divide groups of four into two pairs, having each pair visit different other groups' tables, noting similarities and differences between card sorts. ○ After pairs have visited their assigned tables, they should return to their own table and discuss their findings with the other pair. The group may or may not decide to revise their card placement using their discussion. • As groups finish their revisions, draw the class back together and ask students to share key events and ideas about what happened to the stickleback populations over time. • As a class, develop a common visual representation of what happened to the stickleback in this scenario: ○ Summarize that the population of stickleback in the freshwater lakes in Alaska now look different than they did when they were first isolated there after the ice sheets receded—that most of them have low armor and short spines or no armor and spines. Ask students to display thumbs up or thumbs down to show their confidence in WHAT happened to the stickleback populations over time. The purpose of this section is to ensure that students have a good understanding of what happened with the stickleback populations before moving to the next part of the lesson. • Have students leave their cards on their tables to help them answer the focus question. *Focus Question* • **STEP 5:** Introduce the Lesson 1 focus question, "What are possible explanations for how a population of organisms gains or losses characteristics?" ○ For students who might not understand the focus question, you might add: For example, some populations of stickleback fish no longer have body armor and spines." • Ask students to write the focus question in the box in their notebooks. Ask them to write their best ideas about the focus question. • Have students refer back to the Unit Central Question and decide how similar it is to their response to this focus question. Ask them to write and mark any new ideas in their Lesson 1 focus question response. • Tell students that now we know *what* happened to the stickleback populations, it is time to think about our ideas of *how* those changes occurred. Share that scientists who study populations of organisms also had different ideas about how populations change over time. In the next activity,we'll learn more about the ideas of two scientists.	Refer to "Focus on Student Thinking" in the SE Key for possible questions and student responses

Lesson 1: Stickleback, Stickleback, Where Are Your Spines

Phase of Lesson: *Two Views about Change in Populations*

Main Learning Goal: Populations of organisms change over time (evolve), and there have been competing explanations of what causes populations to change

Focus Question: What are possible explanations for how a population of organisms gains or loses characteristics?

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.

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Time: 30 Minutes

STeLLA Strategies

- Strategy 2: Ask questions to probe student ideas andpredictions
- Strategy 3: Ask questions to challenge student thinking

Science Ideas

- An adaptation is a change in a population that canhelp individuals in the population survive and reproduce in particular environmental conditions.
- Scientist 1's explanation focuses on the idea that a trait can change during the lifetime of an individual and that change can be passed from parent to offspring. Counter to Scientist 1's ideas, this cannot happen.
- Scientist 2's explanation describes a process by which organisms better adapted to their environment tend to survive and reproduce more than those less adapted to their 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 aregradual changes in all individuals.

Two Views about Change in Populations

6. You just explored what happened to the stickleback fish populations in freshwater lakes and saw that they look different from the ocean stickleback populations. For many years, scientists have wondered about what causes populations to change over time. Two scientists offered explanations to answer this question. To learn more about their ideas, read the information in *Two Views about Change in Populations*, found on the next page. Be sure to annotate using the literacy strategy explained by your teacher.

   Review your annotations and re-read, if necessary, to compare the two scientists' thinking about the sticklebacks. Use the literacy strategy explained by your teacher to identify what similarities the two scientists share Next identify what the differences were in their thinking. Record these in the space below.

Focus on Student Thinking

- Use STeLLA Strategies 2 and 3 to probe and challenge students' ideas about the ideas that Scientist 1 (Lamarck) and Scientist 2 (Darwin) had. The purpose is to reveal student thinking about Lamarckian ideas and support their application of Lamarckian and Darwinian ideas to the stickleback fish scenario. The goal is to ensure that each small group is effectively applying Lamarck's and Darwin's ideas. Be prepared to ask probe questions, such as these:
    - What do you mean by … ?
    - Say more about what you've written here.
- Be prepared to ask challenge questions, such as these:
    - How can you link that idea or phrase to what is written in the chart?
    - Where did you find that idea in the text?
    - Can you go back to the text to see if it can help you?
    - Did you make note of anything when you read the Two Views about Change in Populations essay that could help you here?
- It is important to note that the purpose of this lesson is not to have students arrive at a right answer, but to make their thinking about changes in populations visible by getting as many of their ideas out as possible and probing for specificity in what they say.

Implementation	Notes

Activity part 1: Two Views *reading*
 	
• **STEP 6:** Have students read the information on the handout using an appropriate literacy strategy to identify key ideas and any points of confusion they might have. Two strategies are described in the bullet below. For your own information, Scientist 1 represents Jean Baptiste de Lamarck and Scientist 2 represents Charles Darwin. Do not share this information with students at this point.
 	
• Literacy Strategy Options for reading/annotating:
  ○ As a class, read Scientist 1 together and annotate key ideas and points ofconfusion on the reading. Next, have students read Scientist 2 individually or in pairs and annotate.
  ○ Assign students pairs, have one partner read and annotate Scientist 1and the other read and annotate Scientist 2. Partners will then share annotations and the key ideas about their Scientist with their partner.
 	
• Both strategies may require more than one reading.
 	
Refer to “Focus on Student Thinking” in the SE Key for possible questions and student responses
 	
Activity part 2: Comparing Scientists’ Ideas
 	
• After using one of the Literacy Strategies above to read and annotate keyideas for both scientists, continue to deepen student thinking and understanding by asking them to compare Scientist 1’s and Scientist 2’s ideas.
 	
• Literacy Strategy Options for comparison:
  ○ Determine a common class symbol for marking similarities and another symbol for differences between the scientists’ ideas. Then have student pairs revisit the key idea annotations to identify and use the appropriate symbol to mark similarities and differences between the two scientists’ ideas.
  ○ Have students individually, in pairs, or as a class complete a Box-n-T to identify and record similarities and differences between the two scientists’ ideas. Instruct students to use their key idea annotations to determine ideas the two scientists share and record in the box and then decide and record parallel statements in the T column for differences.	

Box-n-T

Similarities	
Both scientists think… individual organisms in the same population have similar traits. Both scientists agree that parents pass traits on to offspring. An adaptation is a trait variation that helps individuals within a population survive and reproduce under particular environmental conditions better than those individuals without the trait variation.	
Differences	
Scientist 1 thinks… that organisms can change their traits in one generation based on the needs of the individual and then pass on that trait to their offspring. An adaptation can be acquired during the individual's lifetime and passed on to its offspring. [Adaptations can be acquired and passed on.]	Scientist 2 thinks… that organisms can't change the traits they have, but individual organisms with more favorable traits are more likely to survive to reproduce and pass on the favored trait. An adaptation is a variation of a trait that an organism inherited from its parent and the trait can be passed on to its offspring. [Adaptations are inherited.] The environment may favor one variation over another.

Focus on Student Thinking

Use STeLLA Strategies 1, 2, and 3 (elicit, probe, and challenge questions) to make student thinking visible. The following is an example of student and teacher dialogue.

T: You've used the word adaptation. What do you think is an adaptation? (Probe)

S1: It's a change.

T: What do others think? (Elicit)

S2: It's something that helps an organism.

S3: Not Sure

T: The two ideas so far are an adaptation is a change and it's something that helps an organism. Let's dig into these two ideas. (Probe)

T: S1, what do you mean by change?

S1: It's a change that helps an organism.

T: A change in what? Umm. What is changed and how does the change help the organism (Challenge; Note: because this question asks the student to link these two ideas.)

S1: I'm not sure.

S2: It's a change in a trait and it helps it survive.

T: S3, what do you think?

S3: that makes sense to me.

T: OK. Keep working on your chart and consider what you think Scientist 1 says about adaptations and Scientist 2.

Implementation	Notes
Box-n-T	

Similarities	
Both Scientist think …	
Differences	
Scientist 1 thinks…	Scientist 2 thinks…

- Circulate around the room to listen to students' conversations or read what they are writing and to determine how well students are representing the scientists' ideas.

Refer to "Focus on Student Thinking" in the SE Key for possible questions and student responses

7. Draw a "cause and effect organizer" in the space below as your teacher demonstrates. Both Scientist 1 and 2 would agree on the effect on **stickleback.** Discuss, decide, and record in your organizer the common effect on stickleback.

   Now focus on the boxes describing proposed causes for the changes in the s**tickleback** population. In the Scientist 1 box, you'll record Scientist 1's ideas about the cause and in the Scientist 2 box, you'll record Scientist 2's ideas about the cause. In later lessons, you'll analyze additional data and information to determine which scientist's ideas are better supported by evidence.

Cause and Effect Organizer

Cause

Scientist 1

The stickleback needed to change from high armor and long- spines to low armor and long-spines to low armor and short-spines to survive the dragonfly nymphs. They passed that trait on to their offspring. Adaptations can be acquired and passed on.

Scientist 2

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.

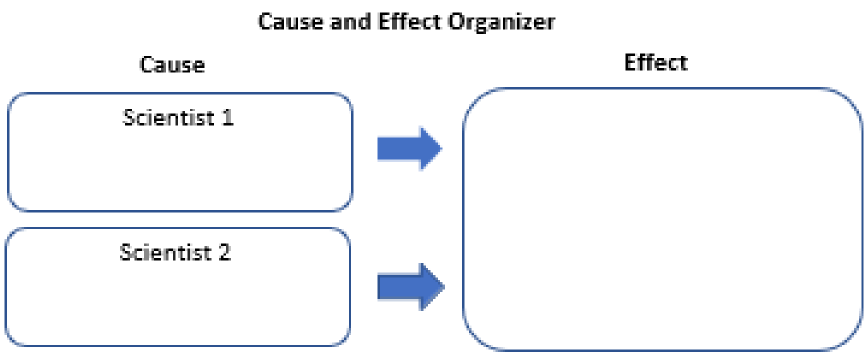
Effect

Stickleback fish populations changed from the time they were first stranded in the freshwater environment of Loberg Lake to later generations. During that time, they changed from high armor and long spines to low armor and short spines in about 18 generations (1990 to 2008).

Implementation	Notes

Activity Follow-up

- **STEP 7:** When all students have finished comparing the two scientists' ideas, ask them to now consider cause and effect relationships.
- Have students draw a cause and effect graphic organizer in their notebooks. Make sure they draw it big enough to add ideas later in the unit. Ask them to fill in the "effect" section of the cause and effect graphic organizer. Effect: Stickleback fish populations changed from the time they were first stranded in the freshwater environment of Loberg Lake to later generations. During that time, they changed from high armor and long spines to low armor and short spines in about 18 generations (1990 to 2008).
- Encourage students to use their story cards to help fill in the effect box.
- Note that we emphasize traits—not generic changes such as, populations increase or decrease in overall number.



- Allow time for student pairs or groups to discuss and identify possible causes based on the perspectives of Scientist 1 and 2. Have students fill in each perspective in the appropriate "cause" section of the organizer: Scientist 1's perspective (i.e., stickleback broke off their long spines so they could avoid predators) and Scientist 2's perspective (i.e., stickleback with short spines and little armor were able to escape predation better than fish with long spines and full armor).
- As students finish both perspectives, encourage them to begin a discussion around the following questions:
  - Are these two sets of ideas completely different from each other?
  - Can both explanations be supported with evidence? Explain.
- Ask students to share their thinking about the differences how each scientist explained the cause of the stickleback change, as well as their thinking about the two discussion questions above.

Transition

- Close the discussion and transition to the next activity by telling students that we will continue to compare their own ideas to those of the two scientists.

Two Views about Change in Population

Scientist 1	Scientist 2
Ideas about Populations and Individuals In a population, all the individuals have similar traits. There are differences in how a trait appears in different individuals. An example of this idea might be that all bears have claws, but they have different sized claws. Individuals can change the way a trait appears if they need it to be different. Once their needs are different or the environment changes, it leads to changes in behavior and traits. Those changes mean that the individual uses traits more or less, which then leads to the trait changing in that individual. The new version of the trait is then passed down to their offspring in the next generation. An example would be that bears use their claws to help them catch and eat prey. The bears with the longer claws are better able to catch prey and have more to eat. The bears with the shorter claws may not be able to catch prey as effectively and do not eat as often or as much. Bears with shorter claws would need to have longer claws to catch prey. As the bear uses the claws more, the claws will grow longer and stronger. Then, if the bear reproduced, the longer, stronger claws are passed down to its offspring. Because individuals can change their traits as they need to, in this case the bears change their claws and pass the longer claw trait to their offspring. The population will have mostly bears with long claws in the next generation.	*Ideas about Populations and Individuals* In a population, all the individuals have similar traits. There are differences in how a trait appears in different individuals. An example of this idea might be that all bears have claws, but they have different sized claws. Individuals do not change the version of traits that they have. However,the different versions mean that some individuals are better suited for the environment where they live. Those individuals are better able to survive. They are also more likely to reproduce. Because they reproduce, the version of the traits that the individuals had are passed down to their offspring in the next generation. An example of this idea would be that in a population of bears, some bears have longer, stronger claws and others have shorter, weaker claws. The bears with the longer claws are better able to catch prey and have more to eat. The bears with the shorter claws may not be able to catch prey as effectively and do not eat as often or as much. This makes them less likely to survive long enough to reproduce. The well-fed bears with longer claws can survive long enough to possibly reproduce. This means the longer, stronger claw version of the trait is passed down to the bears’ offspring. Some of the bears with the shorter claws do survive, however. This means that in the next generation, there are more bears with longer claws and fewer with shorter claws. This trend continues in each generation of new bears. After many generations, most of the bears in the population have stronger, longer claws.

Implementation	Notes

Lesson 1: Stickleback, Stickleback, Where Are Your Spines

Phase of Lesson: *Summarize and Synthesize Ideas*

Main Learning Goal: Populations of organisms change over time (evolve), and there have been competing explanations of what causes populations to change

Focus Question: What are possible explanations for how a population of organisms gains or loses characteristics?

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.

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Time: 10 - 20 Minutes

STeLLA Strategies

- Strategy I: Summarize key science ideas

Science Ideas

- An adaptation is a change in a population that canhelp individuals in the population survive and reproduce in particular environmental conditions.
- Scientists 1's explanation focuses on the idea that atrait can change during the lifetime of an individual.Counter to their ideas, acquired traits cannot be passed from parent to offspring.
- Scientist 2's explanation describes a process by which organisms better adapted to their environment tend to survive and reproduce more than those less adapted to their environment.
- Throughout history scientists have offered competing explanations of what causes populations to change

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

8. You have just considered two scientists' ideas about how populations change. Now take a few minutes to compare their ideas to yours. To do this, reread your initial response to the lesson focus question. Determine if your initial ideas were more like those of Scientist 1 or Scientist 2. Use a colored pen or pencil to put a "1" near your phrases or sentences that are more like Scientist 1's ideas and use a different color to put a "2" near your phrases or sentences that are more like Scientist 2's ideas.

   Now, compare your initial thinking to the ideas that you saw in the activities you completed. If your thinking has changed, add to or revise your initial response in a different color.

Implementation	Notes
• To close this lesson, you will need to make a decision based on your formative assessment of students' thinking about the ideas of the two scientists. Notice that the Student Edition is designed based on Option 1 below. If you don't think students are ready, let them know that they will revisit their ideas during the next lesson. • **STEP 8** ***Decision Point:*** If the majority of students have represented the scientists' ideas well, then you are ready to have them compare their ideas to those ofthe scientists. Go to Option 1: Summarize. The decision point is not about right answers about how natural selection works, but rather about students understanding of the ideas of Scientists 1 and 2. • *Option 1: Summarize* ○ Share with students that as they've seen in this lesson, two scientists had different ideas about how populations change over time. ○ Ask students to think about their response to the lesson focus question in light of the activity they just completed. Ask them to think about whether their ideas are more like Scientist 1's ideas or more like Scientist 2's ideas. Ask students to use a colored pen to put a "1" near sentences that are more like Scientist 1's ideas and a different-colored pen to put a "2" near their sentences that are more like Scientist 2's ideas. ○ Once they have coded their initial response, invite them to revisit their initial response and add to or revise it using a different color. ○ If this activity occurs at the end of a class period, you may wish to ask students to leave their notebooks open to this page and stack them up so you can review their ideas overnight. ***Decision Point:*** If the majority of students have *not* represented the scientists' ideas about what caused the change in stickleback well, then go to Option 2: Developing and Using a Model. • *Option 2: Developing and Using a Model* ○ For this activity, you will need two types of goldfish crackers (e.g., pretzel and cheese) or anything else that can represent two types of fish in Loberg Lake; something to represent dragonfly nymphs (e.g., gummy bear or something slightly larger than the fish); and an area representing Loberg Lake ○ After distributing the materials above to each group, have students complete an analogy map to show that they understand what each part of the model represents. ○ Ask students to begin their model with 10 total fish creating a population of Loberg Lake in the beginning ○ Models should have more full armored, long spine stickleback at this point.	

Implementation	Notes

◦ Next, have student groups add a dragonfly nymph and alter their model to show what would happen between this first generation of stickleback and the next generation according to Scientist 1.
    ◦ Models should show all first generation full armor, long spine fish changing to low armor, short spine fish.
    ◦ Models should show all second-generation offspring to be lowarmor, short spine.
◦ Now have students reset their models to the beginning and, again, add the dragonfly nymph. However, this time ask students to show what would happen between this first generation of fish and the next generation according to Scientist 2.
    ◦ Models should show <u>*some*</u> full armor, long spine fish removed to indicate getting "eaten" by the nymph.
    ◦ Models should show first generation fish reproducing second-generation offspring with the same traits as parent.
    ◦ Models should continue to show some full armor, long spine fish eaten by the nymph and all next generation offspring with the same traits as their parent.
    ◦ Have students continue until they have a generation of more low armor, short spine offspring than full armor, long spine. Ask students to keep track of how many generations it takes to reach this point in the population.
◦ Have students return to their Box and T charts from Step 6 and add to or clarify their statements.
◦ Once you are confident that most students have a good sense of the differences between the two scientists, invite them to compare their answers to the focus question with the ideas of the scientists as described in Option 1 above, then add to or revise their initial response.
 	
Link to Next Lesson
• Link to the next lesson by sharing that in the next lesson they will learn more about a specific population of stickleback fish in Alaska as well as more about the two scientists' ideas about what causes populations to change over time.The next lesson also highlights the role of traits and adaptations in the change in population over time.	