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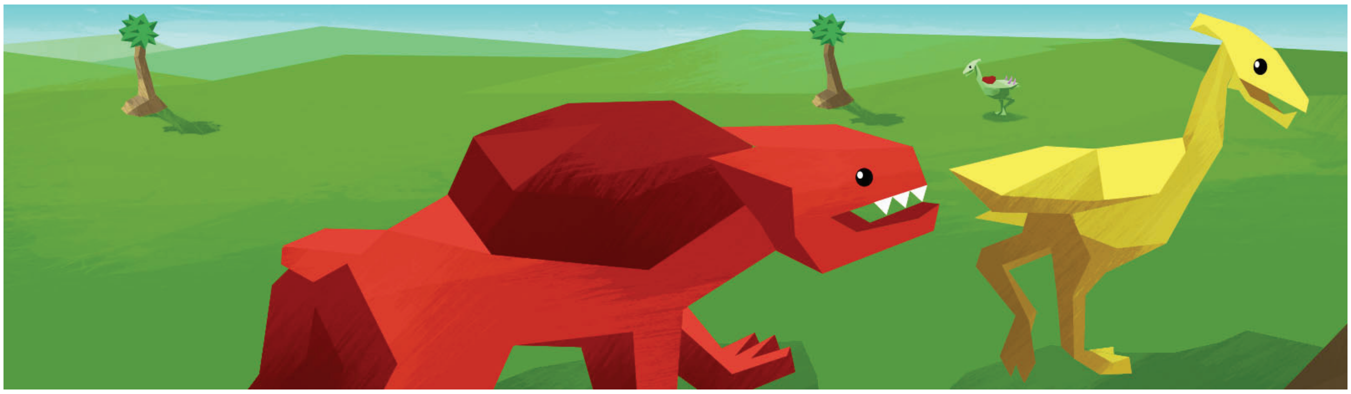

Natural Selection:

Poisonous Newts

Investigation Notebook with Article Compilation

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Developed by the Learning Design Group at the University of California, Berkeley's Lawrence Hall of Science.

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Natural Selection: Poisonous Newts
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Natural Selection:
Poisonous Newts

Investigation Notebook

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Safety Guidelines for Science Investigations

1. **Follow instructions.** Listen carefully to your teacher's instructions. Ask questions if you don't know what to do.
2. **Don't taste things.** No tasting anything or putting it near your mouth unless your teacher says it is safe to do so.
3. **Smell substances like a chemist.** When you smell a substance, don't put your nose near it. Instead, gently move the air from above the substance to your nose. This is how chemists smell substances.
4. **Protect your eyes.** Wear safety goggles if something wet could splash into your eyes, if powder or dust might get in your eyes, or if something sharp could fly into your eyes.
5. **Protect your hands.** Wear gloves if you are working with materials or chemicals that could irritate your skin.
6. **Keep your hands away from your face.** Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
7. **Tell your teacher if you have allergies.** This will keep you safe and comfortable during science class.
8. **Be calm and careful.** Move carefully and slowly around the classroom. Save your outdoor behavior for recess.
9. **Report all spills, accidents, and injuries to your teacher.** Tell your teacher if something spills, if there is an accident, or if someone gets injured.
10. **Avoid anything that could cause a burn.** Allow your teacher to work with hot water or hot equipment.
11. **Wash your hands after class.** Make sure to wash your hands thoroughly with soap and water after handling plants, animals, or science materials.

Name: ______________________________ Date: ____________________

Natural Selection: Poisonous Newts
Unit Overview

What caused the rough-skinned newts in Oregon State Park to become more poisonous? As you and your classmates take on the role of student biologists, you will investigate the interaction of the environment and populations of organisms in order to answer this question. Using the *Natural Selection* Simulation as well as data, physical models, and science articles, you will investigate what can cause populations to change over time.

Name: ______________________ Date: ______________

Chapter 1: Environmental Change and Trait Distribution
Chapter Overview

In Chapter 1, you will begin to investigate a population of highly poisonous newts. Are all the newts in this population extremely poisonous? What could have caused them to become so poisonous? Your first challenge in this unit is to answer these questions.

Name: ______________________ Date: ______________

Lesson 1.2: The Mystery of the Poisonous Newts

Welcome to your new role as student biologists! In this unit, you will learn about how populations change over time and use this information to solve a mystery about a state park's population of newts that has changed over many years. Most of the newts in the population today are extremely poisonous, even though their ancestors many years ago were not. Park visitors want to know why this happened, and we are going to figure it out. Let's get started!

Unit Question

- Why do populations change over time?

Chapter 1 Question

- What caused this newt population to become more poisonous?

Vocabulary

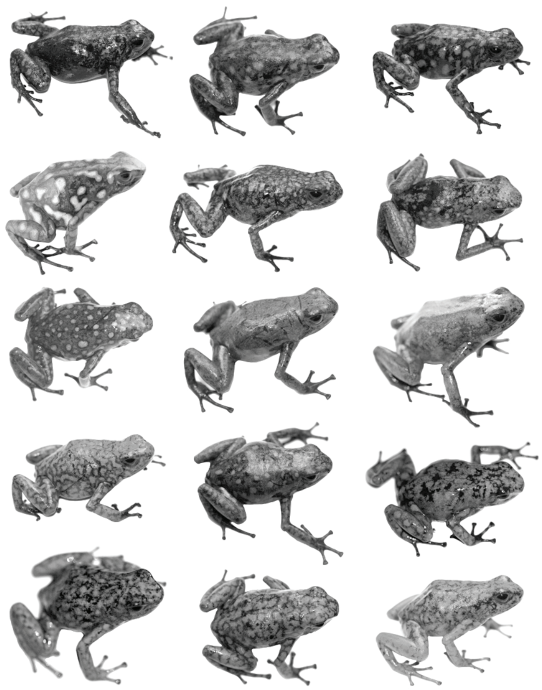
- environment
- generation
- population
- trait

Name: ______________________________ Date: ______________

Warm-Up

Observing a Population

Below is an image of a rain forest in Ecuador. The frogs (also pictured below) live there and are all the same species, a type of dart frog. Observe the frogs closely and describe them below. (Note: Your teacher will project a color version of these images.)



Describe the group of frogs in the image.

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Name: ______________________________ Date: ________________

Observing Traits

Observe the butterfly closely and describe it.

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Take turns describing your butterfly to the other members of your group. What is similar and different about the butterflies in your group?

Name: ______________________________ Date: __________________

Reflection

Based on today's lesson, how would you describe the traits of this population? (check one)

- ☐ All of the horses have the same traits because they are in the same population.
- ☐ This population has different traits for color: some are brown, some are black, some are gray, and some are white.
- ☐ None of the horses in this population have similar traits because they are all individuals.
- ☐ The horses in this population are all the same because they all have a coat, a mane, and a tail.
- ☐ These horses must not be a population because they have different traits.

Name: ________________________________ Date: ____________________

Homework: Reading "The Rough-Skinned Newt"

Read and annotate the article "The Rough-Skinned Newt." Answer the reflection questions below.

1. What are some of the traits present in the newt population described in the article?

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2. How might these traits change from individual to individual? *(Hint: Do you think the newts are all exactly the same color or size?)*

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Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ______________________________ Date: ____________________

Homework: Reading "Meet a Scientist Who Studies Natural Selection"

Read and annotate the article "Meet a Scientist Who Studies Natural Selection." Answer the reflection questions below.

1. Why are yeast good organisms for studying natural selection?

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2. What is one interesting thing you learned about Dr. Yuan?

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Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ______________________________ Date: ________________

Lesson 1.3: Exploring Variation and Distribution in Populations

In this lesson, you will focus on the traits of individuals in populations. You will be introduced to the *Natural Selection* Simulation and have a chance to explore three fictional populations: ostrilopes, thornpalms, and carnithons. Then, you will watch a short video that introduces a type of graph you will be using throughout this unit called a histogram. Histograms are helpful in describing the traits in a population. Lastly, you will get a chance to build your own histograms.

Unit Question

- Why do populations change over time?

Chapter 1 Question

- What caused this newt population to become more poisonous?

Vocabulary

- distribution
- histogram
- population
- trait
- variation

Digital Tool

- *Natural Selection* Simulation

Name: ____________________ Date: ____________

Warm-Up

Describing the Rough-Skinned Newt Population

Consider the poison-level traits in the rough-skinned newt population. Then, reread the first paragraph from the "The Rough-Skinned Newt" article and answer the question below.

Think about what you have learned so far about populations in general and the rough-skinned newt population in the park. What prediction would you make about the poison-level traits in this population? (check one)

- ☐ All of the newts have the same poison-level trait because they are from the same population.
- ☐ This population has different poison-level traits: some have low poison level, some have medium poison level, and some have high poison level.
- ☐ None of the newts in the population have the same poison-level trait because they are all individuals.

Name: ______________________________ Date: ________________

Exploring Variation and Distribution in the Sim

Part 1: Exploring the *Natural Selection* Simulation

Open the *Natural Selection* Simulation and explore the Sim with your partner. Share what you both notice.

Part 2: Changing Populations in the *Natural Selection* Simulation

Goal: Set up and observe different populations in the Sim.

Do:

- Open the *Natural Selection* Simulation and open the mode: Explore Variation.
- Complete the missions below.

Tips:

- It is not necessary to enter Run or Analyze to complete these missions.
- Turn off organisms that you are not investigating by pressing the INCLUDE THORNPALMS / OSTRILOPES / CARNITHONS toggles.

Complete each mission below by adjusting the trait-level and variation sliders. Zoom in to the environment to observe the individual organisms. Write a check mark next to each mission after you complete it.

_____ **Mission 1:** Set up a thornpalm population where all the thornpalms have medium thorns.

_____ **Mission 2:** Set up a thornpalm population where the thornpalms have many different thorn sizes.

_____ **Mission 3:** Set up a thornpalm population with many short thornpalms, a few medium-height thornpalms, and no tall thornpalms.

_____ **Mission 4:** Set up an ostrilope population that has blue, green, and yellow ostrilopes.

_____ **Mission 5:** Set up an ostrilope population where one feature has high variation and another feature has no variation.

_____ **Mission 6:** Set up a carnithon population where most of the carnithons have high levels of fur, but some have medium levels of fur.

_____ **Mission 7:** Choose one of the carnithon features. Set up a carnithon population with the highest level of variation possible.

Name: ______________________ Date: ______________

Building Histograms

Building Histograms

1. Follow the instructions on the Building Histograms sheet to create four different histograms showing different variation and distributions of traits.
2. Each histogram will represent a population of 12 individuals. Each cube represents one individual in the population.
3. After the activity, answer the question below.

Word Bank

variation	distribution	number of bars	bar height

How can histograms help you describe a population? Use the word bank above to help you explain your answer.

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Name: ______________________________ Date: ________________

Building Histograms (continued)

Create the following histograms for a population of 12 individuals, using 12 cubes.

Tips:

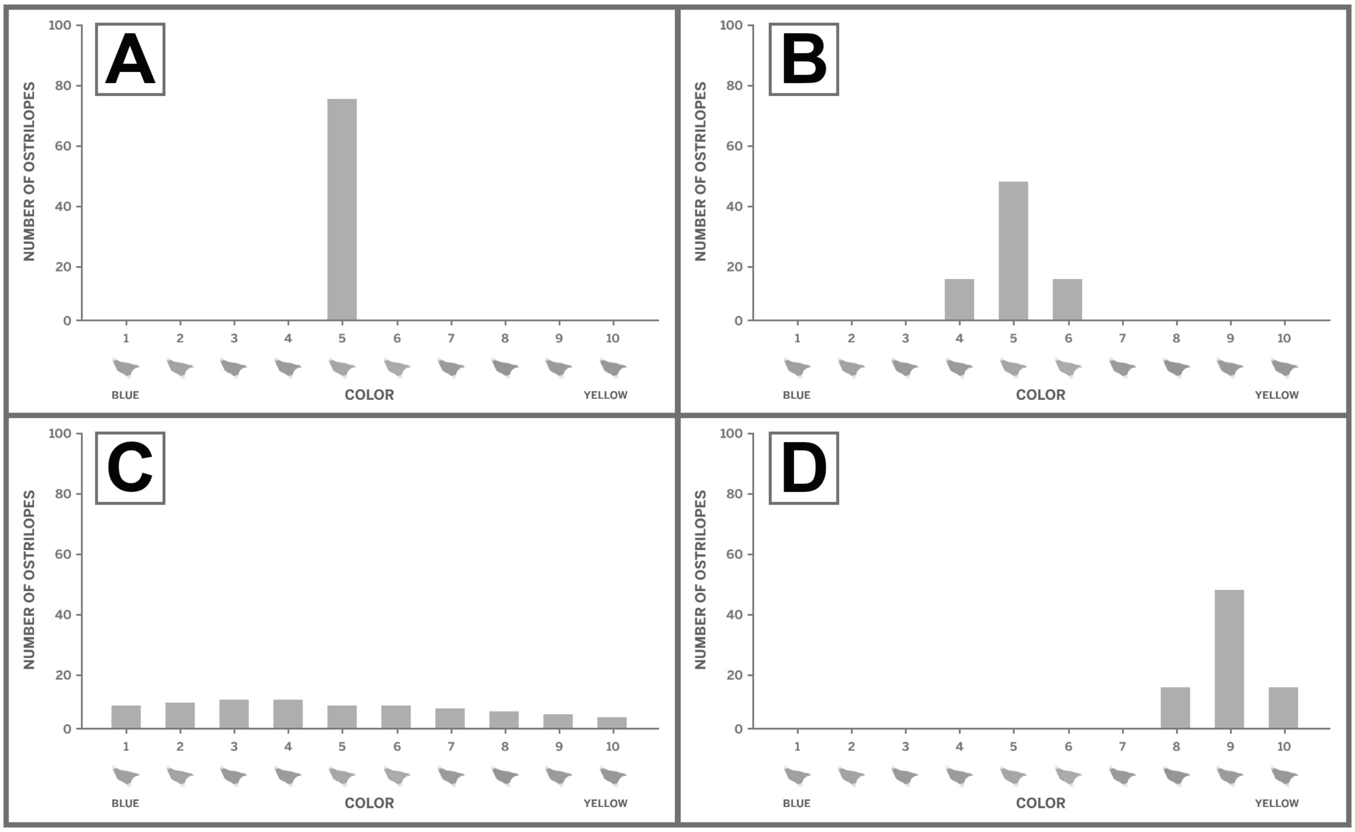
- Don't spend too much time making the cubes perfectly straight; this is a quick activity.
- There will be multiple correct answers for each prompt, so your histogram might be right even though it does not look exactly like someone else's histogram.

Instructions:

1. Make a histogram with no variation.
2. Make a histogram with low variation.
3. Make a histogram with high variation.
4. Make a histogram with high variation, but a different distribution of traits from Histogram #3.

Name: ________________________________ Date: ________________

Homework: Reading Histograms



1. Which histogram shows a population that's all one color? (circle one)

   Histogram A **Histogram B** **Histogram C** **Histogram D**

2. Which histogram shows a population with a lot of variation? (circle one)

   Histogram A **Histogram B** **Histogram C** **Histogram D**

3. Which histogram shows a population with mostly yellow ostrilopes and some variation? (circle one)

   Histogram A **Histogram B** **Histogram C** **Histogram D**

4. Which histogram shows the same variation as Histogram B but a different distribution of traits? (circle one)

   Histogram A **Histogram B** **Histogram C** **Histogram D**

Name: ______________________ Date: ______________

Lesson 1.4: Investigating Changes in Trait Distribution

You know the newt population used to have fewer poisonous newts than it does today. That means the distribution of high-poison levels has changed! Let's consider how the distribution of traits changes in a population over time. In this lesson, you will set up and run tests in the *Natural Selection* Simulation to find out how organisms' traits can affect their survival in specific environments. You will see what happens to ostrilopes when their environment changes from warm to cold. What you discover about ostrilopes might help you better understand the rough-skinned newts!

Unit Question

- Why do populations change over time?

Chapter 1 Question

- What caused this newt population to become more poisonous?

Key Concept

- A population can be described by the traits present and by the number of individuals who have each trait.

Vocabulary

- adaptive trait
- distribution
- environment
- generation
- non-adaptive trait
- population
- trait
- variation

Digital Tools

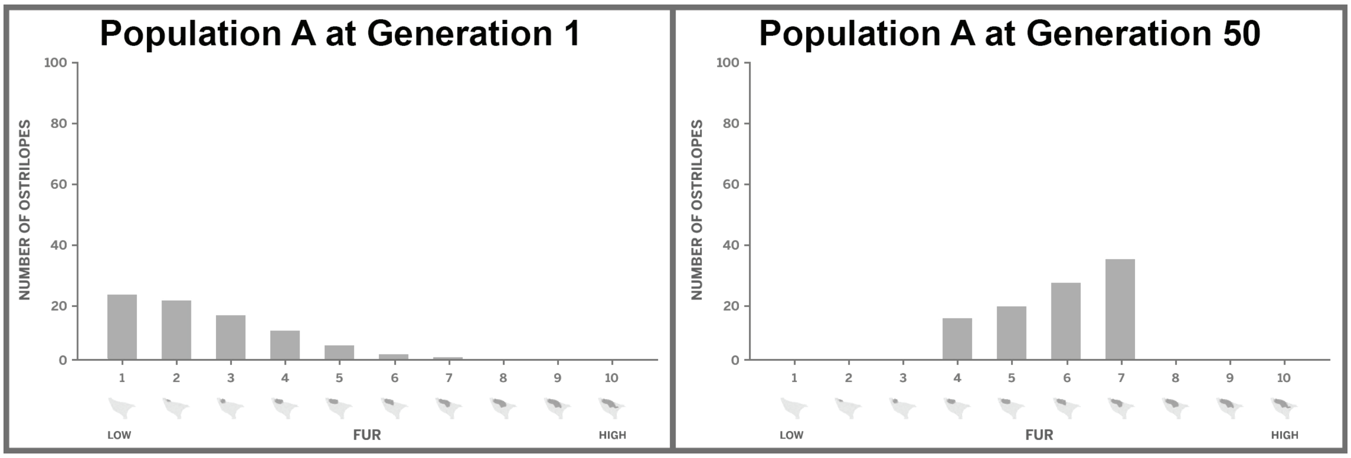
- *Natural Selection* Simulation
- *Natural Selection* Data Tool activity: Environment's Effect on Trait

Name: ______________________ Date: ______________

Warm-Up

Observing Populations at Two Generations

The histograms below show the distribution of fur-level traits in a population at two different points in time. Review the two histograms and answer the questions below.



1. Do the two histograms show the same amount of variation in the population at both generations? (check one)

☐ yes ☐ no

2. Do the two histograms show the same distribution of traits at both generations? (check one)

☐ yes ☐ no

Name: ______________________________ Date: ________________

Observing Fur Traits and Temperature in the Sim

Observing Fur Traits and Temperature in the Sim

Goal: Observe why the distribution of fur traits changes over time.

Do:

- Open the *Natural Selection* Simulation and open the mode: Fur and Temperature A.
- Change the temperature of the environment to cold (Level 1) by moving the Temperature slider.
- Press RUN and observe the population for at least 50 generations.
- Press ANALYZE and compare starting and ending histograms.

Tip:

- If there is time, press the Reset button and repeat your test to see if you observe the same changes each time.

1. Why do you think the distribution of fur traits changed over time?

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2. Which trait became more common over time? Why do you think this happened?

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Name: ______________________________ Date: ________________

Modeling Changes to the Distribution of Traits

Predicting Fur Traits in a Cooling Environment

Use the Modeling Tool activity: Fur and Temperature, Population B (on the next page) to show your prediction about how the distribution of traits in Population B will change as a result of the environment becoming cold.

Goal: Predict how and why Population B will change after the environment changes from warm to cold.

Do:

- Analyze Histogram 1 and label that histogram with any Trait labels that apply.
- Predict Histogram 2 by shading in the bars for the different trait levels.

Tip:

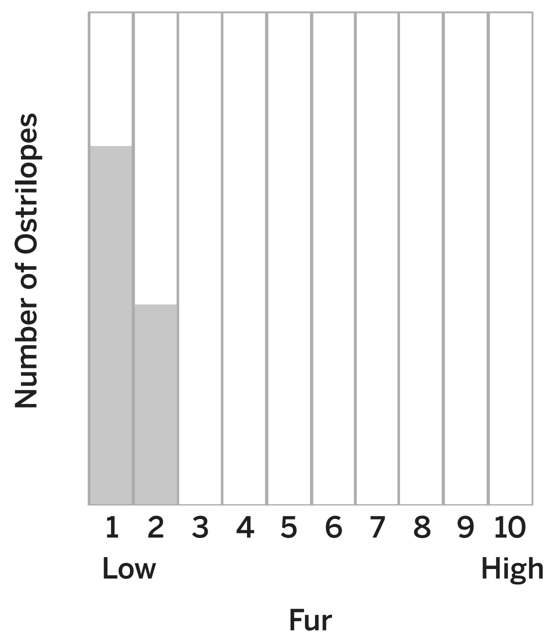
- You can use Trait labels more than once and you do not have to use all of them.

Name: ______________________________ Date: ________________

Fur and Temperature, Population B

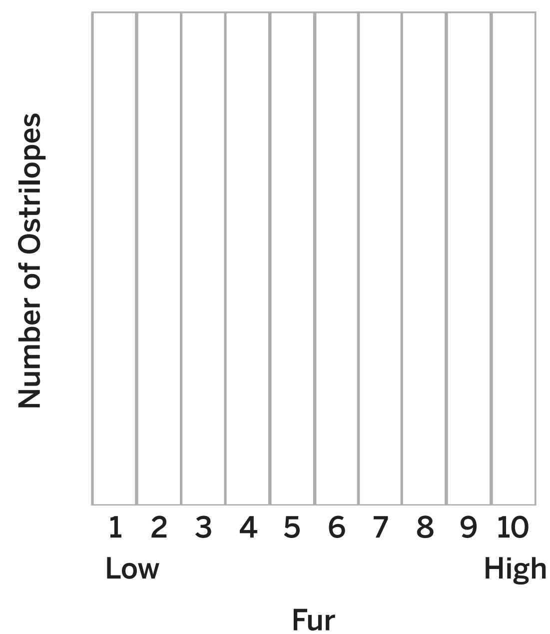
Goal: Predict how and why Population B will change after the environment changes from warm to cold.

1. Starting Population



Environment: changing from warm to cold

2. Population After 50 Generations



Environment: cold

Time

Trait Labels

+S = **more** likely to survive **-S** = **less** likely to survive

Name: ______________________ Date: ______________

Testing Predictions in the Sim

Simulating a Cooling Environment

Goal: Test your predictions about how the distribution of fur traits in Ostrilope Population B will change when the environment becomes colder over time.

Do:

- Open the *Natural Selection* Simulation and open the mode: Fur and Temperature B.
- Change the temperature of the environment to cold (Level 1) by moving the Temperature slider.
- Press RUN and observe the population for at least 50 generations.
- Zoom into the environment and observe several individuals with different traits.
- Use the Traits Histogram Window to observe the distribution of traits in the population.
- Press ANALYZE and compare starting and ending histograms.

Did Population B change in the way you predicted? Why or why not?

Name: ______________________ Date: ______________

Homework: Reading *Wildlife in the Woods*

1. First, read and annotate the “Common Garter Snake” article.
2. Next, choose two other articles to read and annotate.
3. Then, answer the reflection questions that go with the three articles you read.

“Common Garter Snake”

1. What part of the environment might make an individual more or less likely to survive?

____

____

2. Which traits does the common garter snake have that might be adaptive for the environment where it lives?

____

____

Article 2

Which organism did you read about? ______________________

1. What part of the environment might make an individual more or less likely to survive?

____

____

2. Which traits might be adaptive for that environment?

____

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Name: ______________________________ Date: ________________

Homework: Reading *Wildlife in the Woods* (continued)

Article 3

Which organism did you read about? ______________________________

1. What part of the environment might make an individual more or less likely to survive?

____

____

2. Which traits might be adaptive for that environment?

____

____

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ____________________ Date: ____________

Lesson 1.5: Adaptive Traits

What makes a trait an adaptive trait? Today, you will see a real-world example of how an organism's color can be an adaptive trait and then consider a claim about whether a yellow-color trait is always adaptive for ostrilopes in a yellow environment. After you support or refute the claim with evidence, you will apply your understanding of adaptive traits to a question about a new population: the thornpalms.

Unit Question

- Why do populations change over time?

Chapter 1 Question

- What caused this newt population to become more poisonous?

Key Concepts

- A population can be described by the traits present and by the number of individuals who have each trait.
- The number of individuals with each trait in a population can change over time.
- Over many generations, individuals with adaptive traits become more common in a population, while individuals with non-adaptive traits become less common.
- The traits that exist in a population determine which traits can become more common over many generations.

Vocabulary

- adaptive trait
- cause
- distribution
- effect
- environment
- generation
- non-adaptive trait
- population
- prediction
- trait
- variation

Digital Tool

- *Natural Selection* Simulation

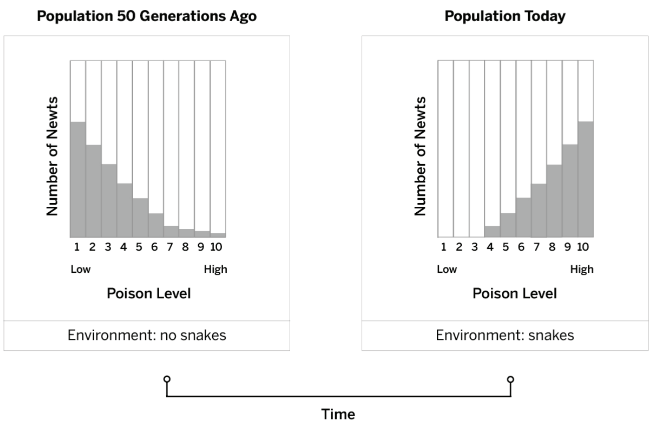
Name: ______________________ Date: ______________

Warm-Up

Read the message from Dr. Alex Young and answer the questions below.

To: Student Biologists
From: Dr. Alex Young, Head Biologist
Subject: New Evidence About Rough-Skinned Newts

We have new evidence about the population of rough-skinned newts that we want you to analyze. We have organized this data into two histograms: one showing the population 50 generations ago and one showing the population today.



1. Which description matches the histogram of the population 50 generations ago? (check one)

- ☐ Most of the newts had low-poison level traits; very few had high-poison level traits.
- ☐ Most of the newts had high-poison level traits; very few had low-poison level traits.
- ☐ All of the individuals in the population had high-poison level traits.
- ☐ None of the individuals in the population had high-poison level traits.

2. Which description matches the histogram of the population today? (check one)

- ☐ Most of the newts have low-poison level traits; very few have high-poison level traits.
- ☐ Most of the newts have high-poison level traits; very few have low-poison level traits.
- ☐ All of the individuals in the population have high-poison level traits.
- ☐ None of the individuals in the population have high-poison level traits.

3. How has the rough-skinned newt population changed?

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Name: ______________________________ Date: ________________

Investigating Adaptive Traits in the Sim

Part 1: Evaluating a Claim

Claim: Yellow color is always an adaptive trait in a yellow environment.

Do you agree or disagree with this claim? (circle one)

agree **disagree**

Part 2: Investigating Environment A in the Simulation

Goal: Gather evidence to support or refute the claim: Yellow color is always an adaptive trait in a yellow environment. Turn to page 28 if you are investigating Environment B.

Do:

- Open the *Natural Selection* Simulation and open the mode: Camouflage.
- Under Biotic Factors: Carnithons, make sure Include Carnithons is selected.
- Under Abiotic Factors, change the Surface-Color slider to Yellow Level 7.
- Press RUN and observe ostrilopes with different color traits for 50 generations. You can also refer to the Traits Histogram Window while the Sim is running.
- After 50 generations, press ANALYZE and compare the color traits in the starting ostrilope population to the population after 50 generations.

Tip:

- Do not change the initial ostrilope distribution of traits.

Which ostrilopes were more likely to survive and became more common in the population? Which ostrilopes were less likely to survive and became less common in the population?

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Name: ______________________ Date: ______________

Investigating Adaptive Traits in the Sim (continued)

The evidence that my partner and I observed (**supports** / **refutes**) the claim on page 27.

Explain what happened to the populations in both environments and why that supports or refutes the claim that yellow color is always an adaptive trait in a yellow environment.

Part 3: Investigating Environment B in the Simulation

Goal: Gather evidence to support or refute the claim that yellow color is always an adaptive trait in a yellow environment.

Do:

- Open the *Natural Selection* Simulation and open the mode: Camouflage.
- Under Biotic Factors: Carnithons, do not include Carnithons.
- Under Abiotic Factors, change the Surface-Color slider to Yellow Level 7.
- Press RUN and observe ostrilopes with different color traits for 50 generations. You can also refer to the Traits Histogram Window while the Sim is running.
- After 50 generations, press ANALYZE and compare the color traits in the starting ostrilope population to the population after 50 generations.

Which ostrilopes were more likely to survive and became more common in the population? Which ostrilopes were less likely to survive and became less common in the population?

Name: ______________________________ Date: ________________

Investigating Adaptive Traits in the Sim (continued)

The evidence that my partner and I observed (**supports** / **refutes**) the claim on page 27.

Explain what happened to the populations in both environments and why that supports or refutes the claim that yellow color is always an adaptive trait in a yellow environment.

Name: ______________________________ Date: ________________

Modeling Trait Distribution in Thornpalms

Use the Modeling Tool activity: Water Storage Prediction (on the next page) to show your prediction about how high levels of water storage could become more common in a population.

Goal: Predict how and why higher levels of water storage can become more common in a thornpalm population.

Do:

- Add Environment labels to both environment boxes.
- Analyze Histogram 1 and label that histogram with any Trait labels that apply.
- Predict Histogram 2.

Tip:

- You can use Environment and Trait labels more than once and you do not have to use all of them.

How does your model explain why the distribution of water-storage traits changed over time? Use words from the Word Bank in your explanation.

Word Bank

environment	survive	adaptive	non-adaptive

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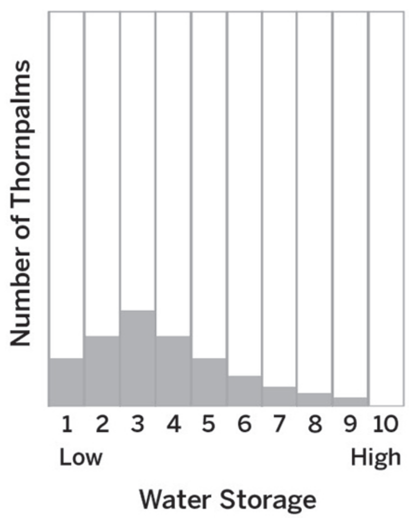
Name: ____________________ Date: ____________

Water Storage Prediction

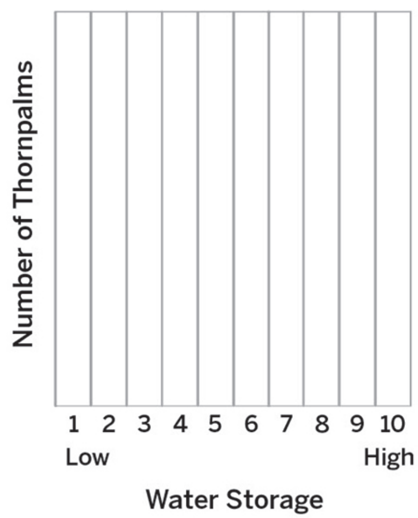
Goal: Predict how and why traits for increased levels of water storage can become more common in a thornpalm population.

1. Starting Population



Environment:
changing from ____________ rainfall to ____________ rainfall

2. Population After 50 Generations



Environment:
____________ rainfall

Time

Trait Labels
+S = **more** likely to survive **-S** = **less** likely to survive

Environment Labels
low medium high

Name: ______________________________ Date: ________________

Homework: Simulating Changes to Water-Storage Trait Distribution in Thornpalms

Goal: Create an environment where traits for increased levels of water storage become more common in the thornpalm population.

Do:

- Open the *Natural Selection* Simulation and open the mode: Thornpalm Water Storage.
- Under Abiotic Factors, make changes to the rainfall level that you think will make high water-storage traits become more common.
- Press RUN and observe the results over 50 generations.
- Press ANALYZE to compare initial and final histograms.
- If necessary, press BUILD and try again.
- Answer the questions below.

Tip:

- Use the Traits Histogram Window in Run to watch the Thornpalm Water Storage Histogram.

What environmental change caused high levels of water-storage traits to become more common? Why do you think this happened?

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Did the distribution of water-storage traits change in the way you predicted in your Modeling Tool activity? Why or why not?

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Name: ______________________ Date: ______________

Lesson 1.6: Explaining Changes in Trait Distribution

Today, you will be synthesizing everything you have learned in the chapter and reporting your findings to Dr. Alex Young. First, you will have some time to share your ideas about how populations change with your classmates. Then, you will be writing to Dr. Young to explain what you think may have caused this newt population to become more poisonous. Remember to think like biologists!

Unit Question

- Why do populations change over time?

Chapter 1 Question

- What caused this newt population to become more poisonous?

Key Concepts

- A population can be described by the traits present and by the number of individuals who have each trait.
- The number of individuals with each trait in a population can change over time.
- Over many generations, individuals with adaptive traits become more common in a population, while individuals with non-adaptive traits become less common.
- The traits that exist in a population determine which traits can become more common over many generations.
- Whether or not a trait is adaptive depends on the environment.
- Biologists analyze data about environmental conditions (the causes) to explain changes in the distribution of traits in populations (the effects).

Vocabulary

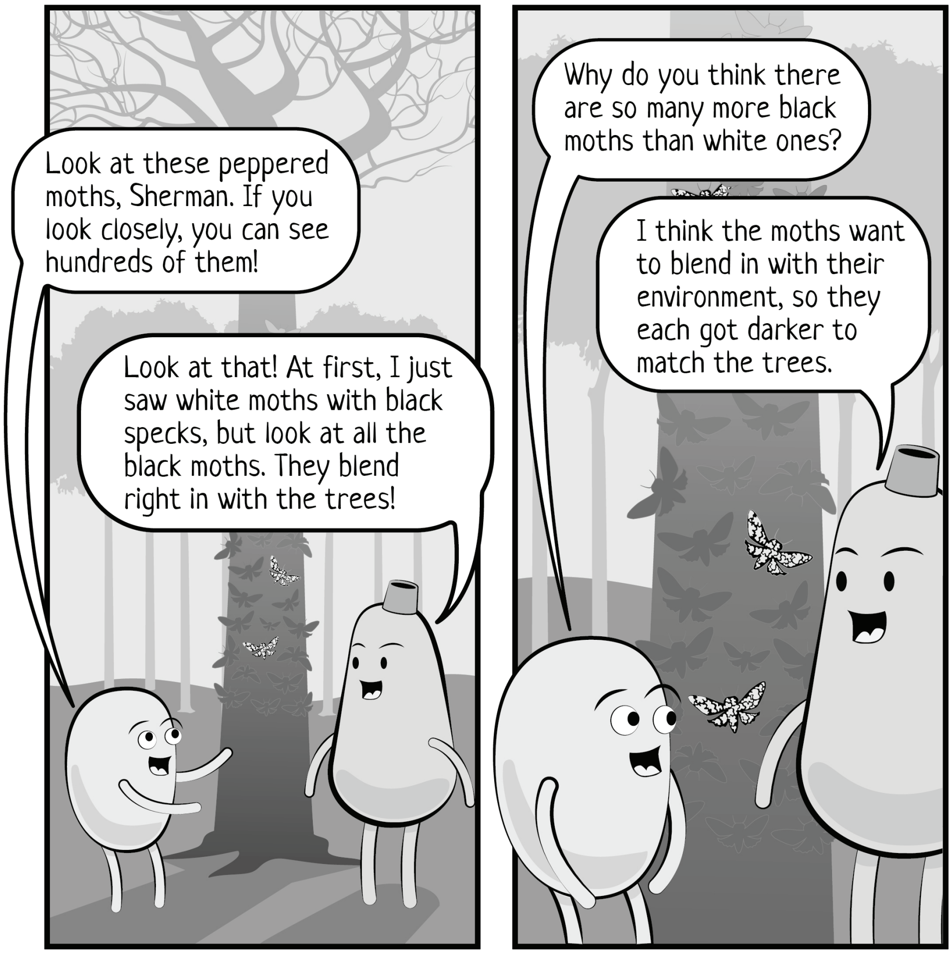
- adaptive trait
- claim
- distribution
- environment
- evidence
- non-adaptive trait
- population
- prediction
- reasoning
- scientific argument
- trait
- variation

Name: ______________________ Date: ______________

Warm-Up

Read the story and respond to Sherman below.

Sherman's Stories #1: Black and White Moths



Actually, Sherman, there are more black moths than white ones because . . .

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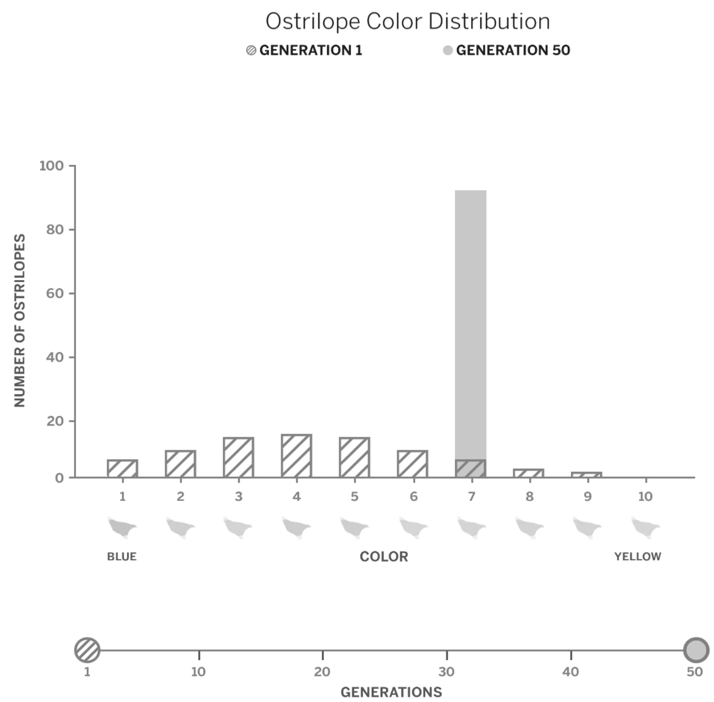
Name: ____________________ Date: ____________

Write and Share Routine: Student 1



Starting Population: many color traits, high variation
Ending Population: all Yellow Level 7 traits, no variation
Environment: changed to Yellow Level 7 surface color, includes predators

Based on the information above, how can you explain why the distribution of traits changed in this population?

Word Bank

adaptive trait	distribution	environment	non-adaptive trait	variation

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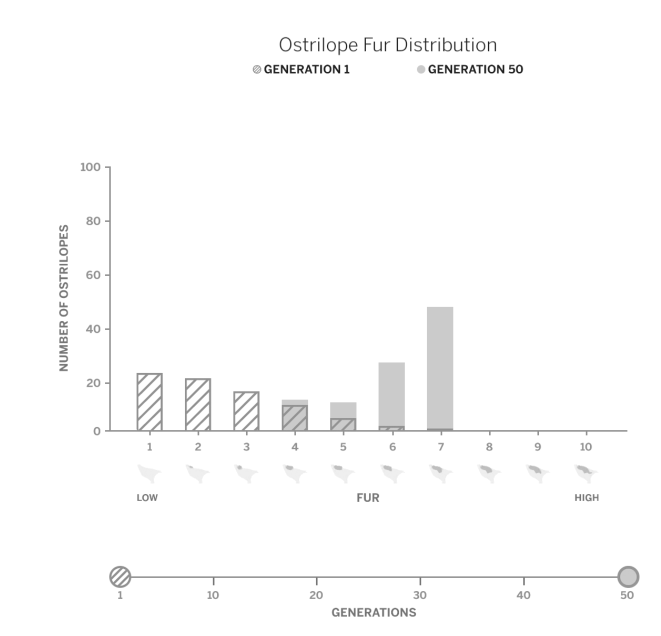
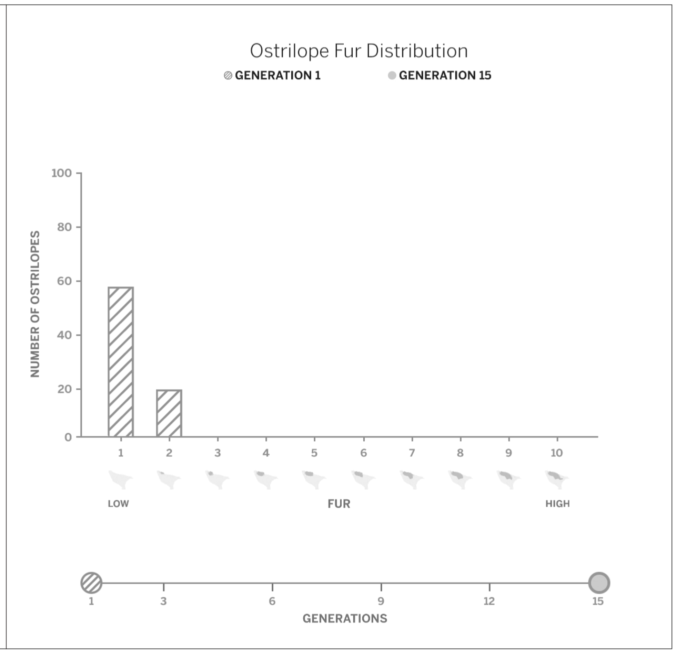
Name: ______________________________ Date: ________________

Write and Share Routine: Student 2





Starting Population: low fur level traits, medium variation **Ending Population:** medium fur level traits, medium variation **Environment:** changed to cold temperature	**Starting Population:** low fur level trait, low variation **Ending Population:** none **Environment:** changed to cold temperature

Based on the information above, how can you explain why the distribution of traits changed in this population?

Word Bank

adaptive trait	distribution	environment	non-adaptive trait	variation

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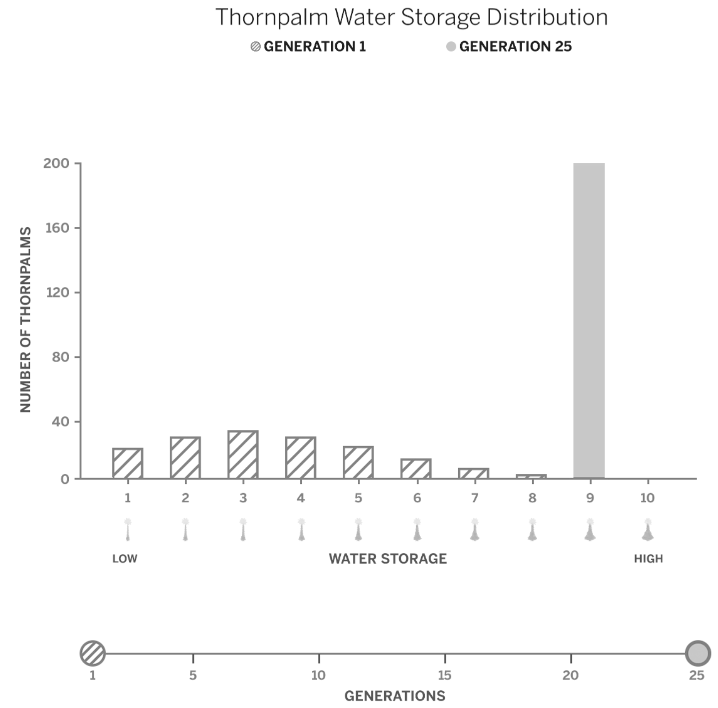
Name: ____________________ Date: ____________

Write and Share Routine: Student 3



Starting Population: mostly low, some medium, and some high water storage traits, high variation
Ending Population: high (Level 9) water storage traits, no variation
Environment: changed to low rainfall

Based on the information above, how can you explain why the distribution of traits changed in this population?

Word Bank

adaptive trait	distribution	environment	non-adaptive trait	variation

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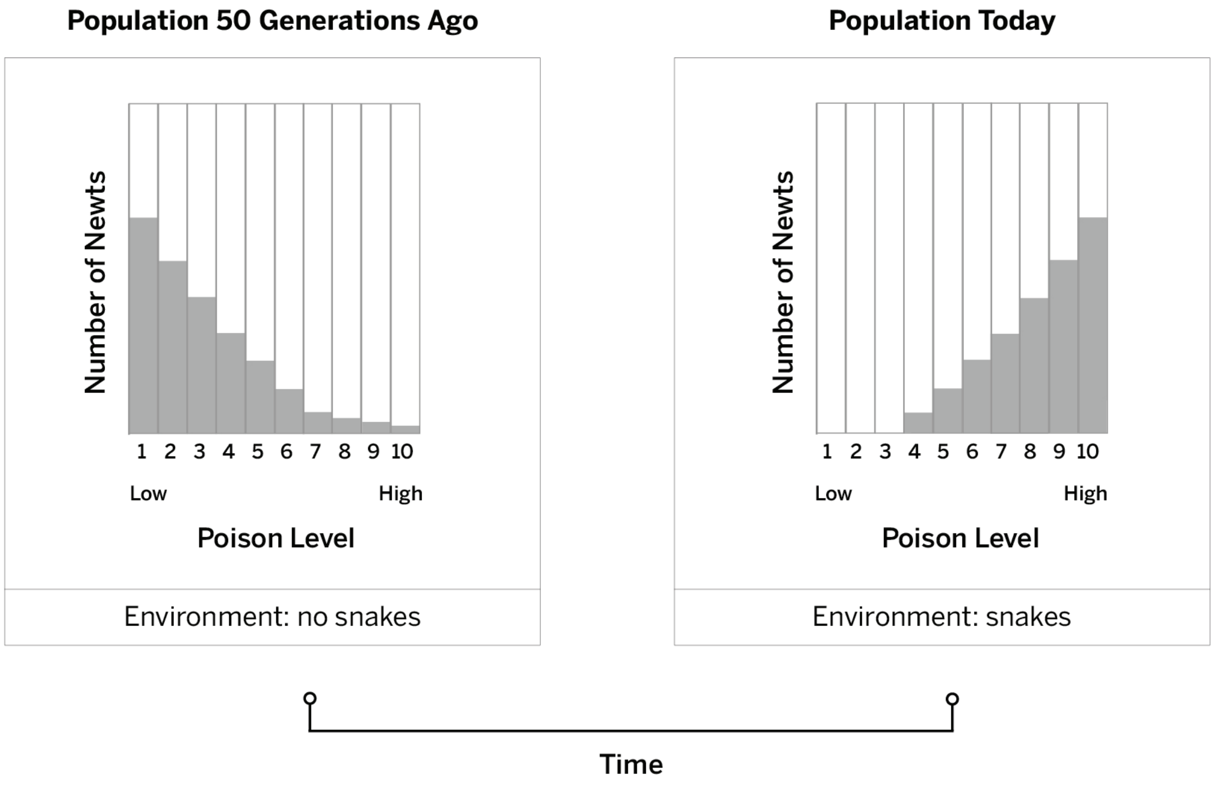
Name: ______________________________ Date: ________________

Explaining Changes in the Newt Population

Analyze the image and discuss the question below with a partner.



Consider these two facts:

- Since the time when the data was collected 50 generations ago, the distribution of traits in the population has shifted significantly. Now, many more individuals have Poison Level 10.
- Since the time the data was collected 50 generations ago, snakes became part of the newts' environment.

How could these facts be related? Create a statement with a partner about how these facts might be related in a cause-and-effect relationship. Hint: You may use this sentence frame to get started: I think _______ probably caused the effect of _______ because . . .

Name: ______________________________ Date: ________________

Explaining Changes in the Newt Population (continued)

Writing About the Rough-Skinned Newts

Dr. Alex Young would like to know about your progress in solving the mystery about the rough-skinned newts. In the space below, answer the Chapter 1 Question: *What caused this newt population to become more poisonous?*

Use what you have learned so far to consider these claims:

Claim 1: Individual newts became more poisonous because they wanted to.

Claim 2: The newt population became more poisonous because of something in the environment.

Revised Claim 2: The newt population became more poisonous because the snakes in this environment caused poison to be an adaptive trait.

Choose one or more claims to support with evidence and reasoning. You may also want to explain why one or more of the claims is definitely not correct.

Be sure to use some of the vocabulary words you have learned so far:

Word Bank

adaptive trait	distribution	environment	non-adaptive trait
population	trait	variation	

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Name: ______________________________ Date: ________________

Homework: Check Your Understanding

This is a chance to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. You have been investigating why the newt population in Oregon State Park became more poisonous over time in order to share your ideas with biologist Dr. Alex Young. Are you getting closer to figuring out why the trait for high-poison level became more common in the newt population over time?

1. I understand how a histogram can be used to represent and describe the traits in the newt population. (check one)

   ☐ yes ☐ not yet

Explain your answer choice.

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2. I understand why high-poison levels are adaptive in one environment but not adaptive in another. (check one)

   ☐ yes ☐ not yet

Explain your answer choice.

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3. I understand how the number of newts with high-poison levels increased over time. (check one)

   ☐ yes ☐ not yet

Explain your answer choice.

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Name: ______________________ Date: ______________

Homework: Check Your Understanding (continued)

4. I understand why a new trait may or may not become more common in a population. (check one)

☐ yes ☐ not yet

Explain your answer choice.

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5. What do you still wonder about how the trait for high-poison level became more common in the newt population over time?

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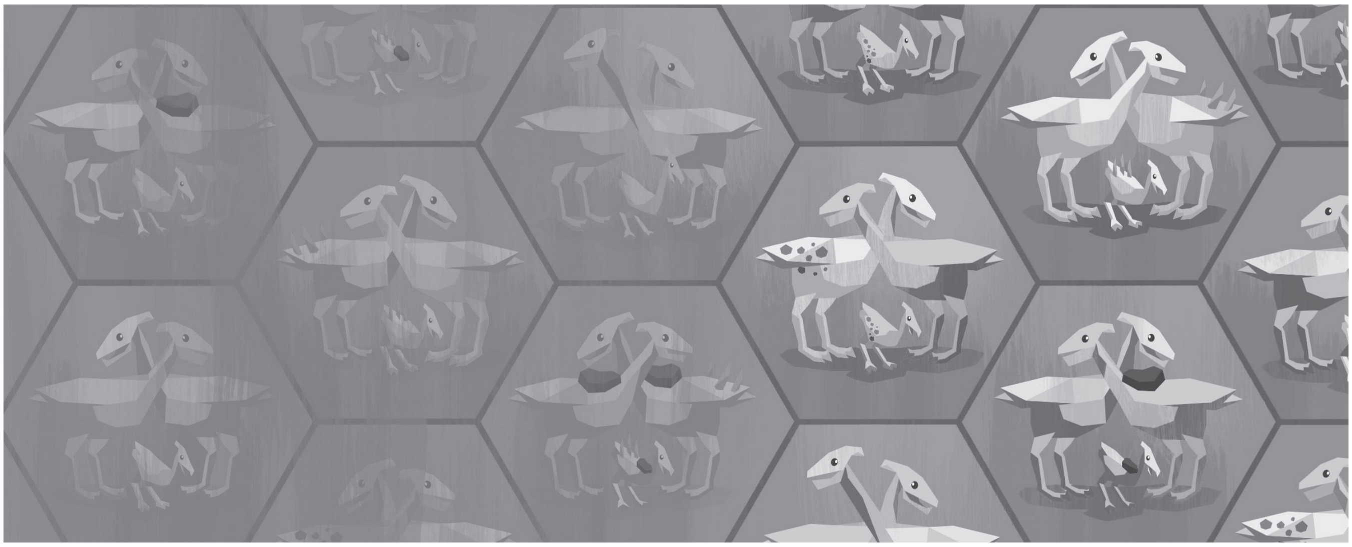
Name: ______________________________ Date: ________________

Chapter 2: Natural Selection and Reproduction
Chapter Overview

You now understand that something in the environment caused the trait for high-poison level to become an adaptive, more common trait. How do some traits become more common over many generations while others become less common? You will start this chapter's investigation by studying how individuals in a population end up with certain traits.



Name: ______________________________ Date: ____________________

Lesson 2.1: Reproduction and Traits

You have seen how much the distribution of traits can change in a population, and you know that adaptive traits become more common—but how does this happen? In this lesson, you will be using the *Natural Selection* Simulation, doing a hands-on activity, and reading an article to understand where individuals get their traits and how this affects the trait distribution across the entire population over many generations.

Unit Question

- Why do populations change over time?

Chapter 2 Question

- How did the trait for increased poison level become more common in the newt population?

Vocabulary

- adaptive trait
- cause
- claim
- distribution
- effect
- environment
- evidence
- gene
- generation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- refute
- trait
- variation

Digital Tools

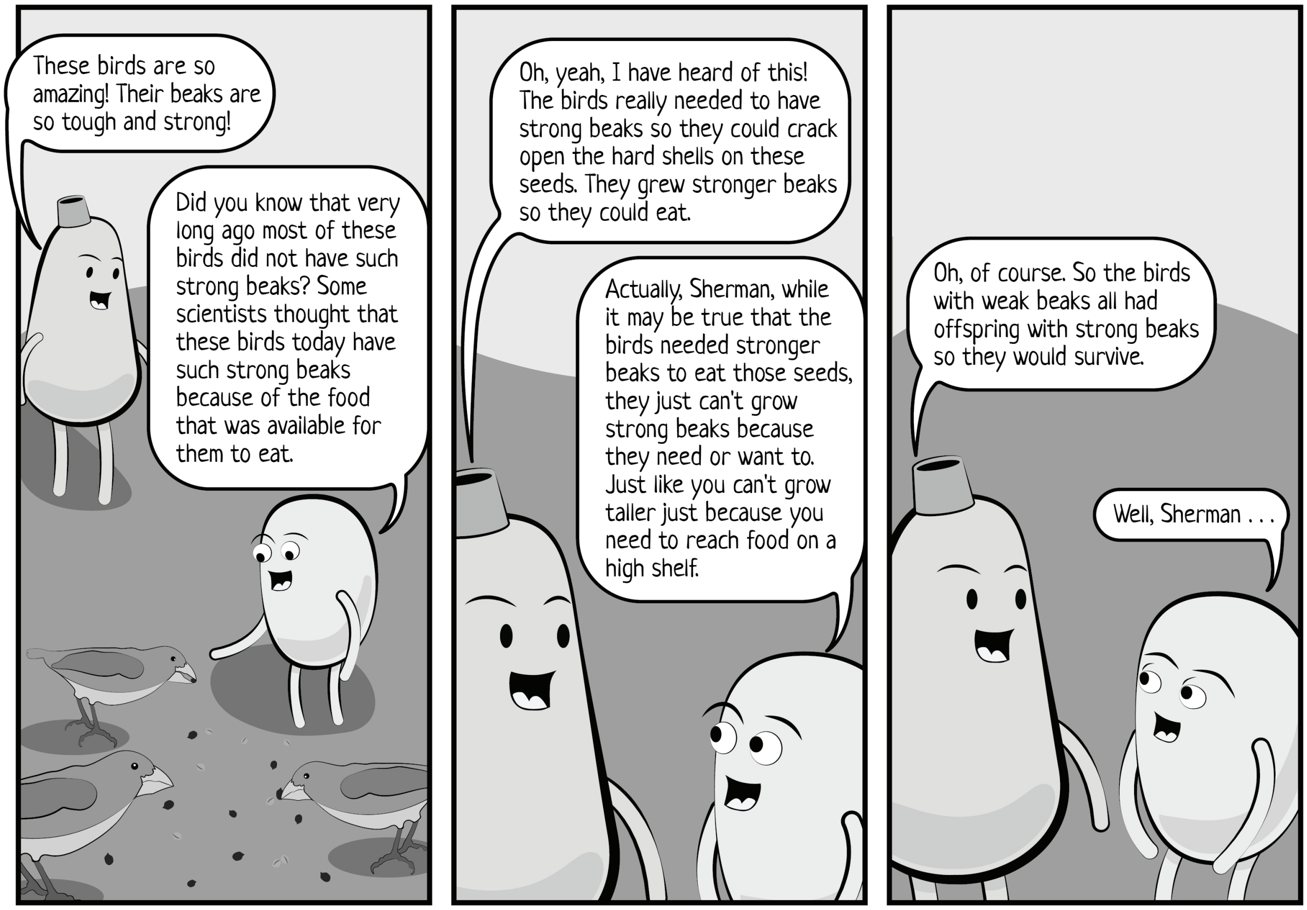
- *Natural Selection* Simulation

Name: ______________________________ Date: ________________

Warm-Up

Read the story and then answer the questions below and on the next page.

Sherman's Stories #2: Bird Beaks



1. In this environment, which trait is adaptive for the birds?

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Name: ______________________________ Date: ________________

Warm-Up (continued)

2. Did the birds choose to have the adaptive trait? (check one)

   ☐ yes ☐ no

3. Sherman suggests that reproduction always creates individuals with adaptive traits. Does this seem correct? Why or why not?

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Name: ______________________________ Date: ________________

Reproduction in the Sim

Part 1: Discussing a Claim About Reproduction

Claim: Reproduction always creates individuals with adaptive traits.

Discussion Prompt: Yellow color is adaptive in a Yellow Level 7 environment with carnithons. Do you think all ostrilopes who reproduce will create offspring with the adaptive yellow-color trait? Why or why not?

Part 2: Observing Reproduction in the *Natural Selection* Simulation

Goal: Gather evidence to support or refute the claim that reproduction always creates individuals with adaptive traits.

Do:

- Open the *Natural Selection* Simulation and open the mode: Reproduction Claims.
- Press RUN to complete the data tables below.

Tips:

- Slow down and pause the Sim to carefully observe traits after reproduction.
- Reset the Sim between trials.
- If the ostrilope you are following gets eaten before it reproduces, select and follow a similar ostrilope.

Ostrilopes with non-adaptive traits:

- Select and follow an ostrilope that does not blend into its environment (one that has a non-adaptive color trait).
- Follow the ostrilope until it reproduces. Pause the Sim.
- Observe and record the color-trait levels of both parents and the offspring in the data table on the next page.
- Reset the Sim. Repeat the above steps for Trial 2.

Name: ______________________________ Date: ________________

Reproduction in the Sim (continued)

	Parent color-trait level	Parent color-trait level	Offspring color-trait level
Trial 1			
Trial 2			

Ostrilopes with adaptive traits:

- Select and follow an ostrilope that blends into its environment (one that has an adaptive color trait).
- Follow the ostrilope until it reproduces. Pause the Sim.
- Observe and record the color-trait level of both parents and the offspring in the data table below.
- Reset the Sim. Repeat the above steps for Trial 2.

	Parent color-trait level	Parent color-trait level	Offspring color-trait level
Trial 1			
Trial 2			

Think about if the data you collected in the Sim supports or refutes the claim that reproduction always creates individuals with adaptive traits. You collected data about four offspring.

How many of the offspring that you observed had the adaptive trait of Yellow Color 7? (check one)

- ☐ none (0)
- ☐ some (1–3)
- ☐ all (4)

Name: ______________________________ Date: ______________

Reproduction in the Sim (continued)

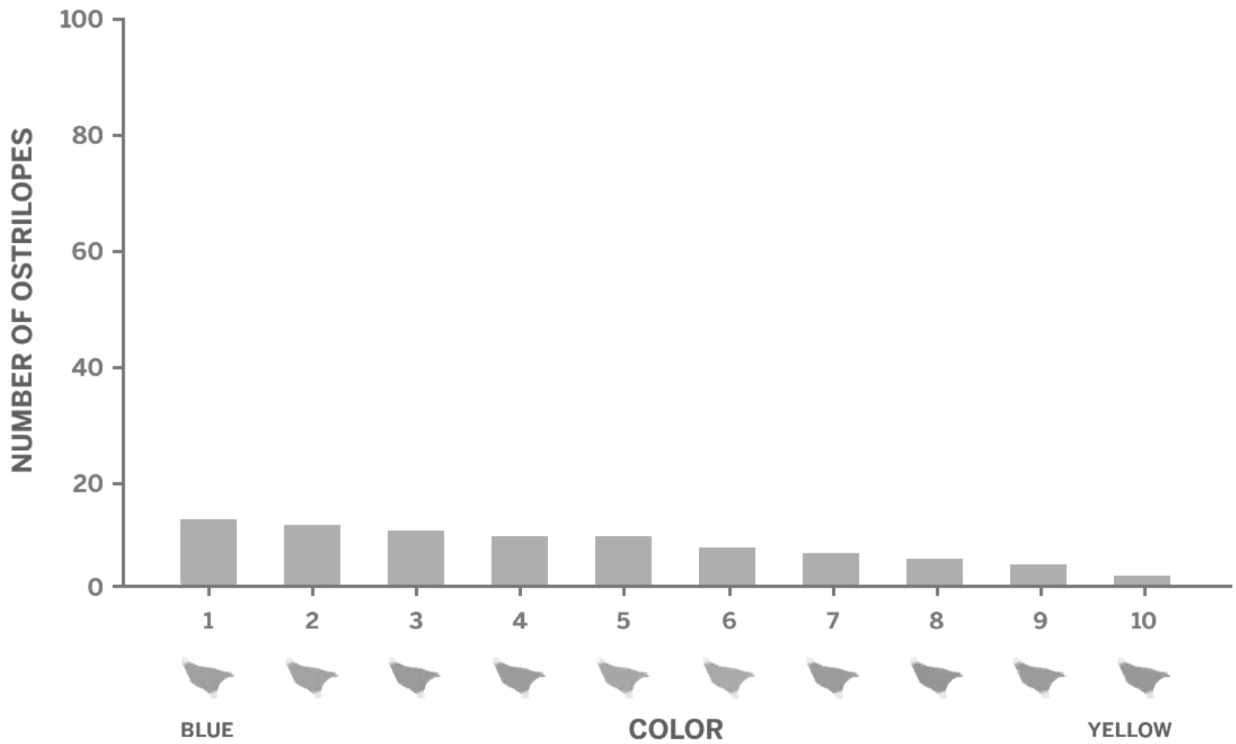
Part 3: Traits in a Population

Discussion Prompts

1. Does the data you collected support or refute the following claim? How does your data support or refute it?

   Claim: Reproduction always creates individuals with adaptive traits.

2. Is your data similar to or different from the data collected by the other members in your group?



Name: ______________________________ Date: ________________

Traits Over Generations

Using Cubes to Model Passing Traits

In this activity, we will be modeling a population of individuals, using colored cubes. This population's environment is blue, and a predator was just introduced into the environment.

You will be following a set of steps to see how the color traits in this population will change over four generations. The starting population has equal numbers of blue, purple, and green individuals.

- Make a prediction below about how you think the color trait in the population will change by Generation 4.
- Follow the instructions below to complete the activity.

Make a prediction: By Generation 4, I think there will be __________ individuals. (check one)

- ☐ mostly blue
- ☐ mostly purple
- ☐ mostly green

Follow the instructions on the next page to model how this population changes over time.

Name: ____________________ Date: ____________

Traits Over Generations (continued)

1. **Gather materials.** You will need one Traits Over Generations Data student sheet, one Traits Over Generations Graphic Organizer, one large Population bag (with 12 cubes), and three small Offspring bags (a bag of blue cubes, a bag of purple cubes, and a bag of green cubes).

2. **Create the first parent couples.** Shake the big bag with 12 cubes in it and randomly take out two cubes at a time. Group them together as mates in the Parents row of the Graphic Organizer.

3. **Create a starting histogram.** On your data sheet, draw a histogram of the population at Generation 0 (based on the 12 cubes in the Parents row).

4. **Model a generation:**

    - **Gain offspring from reproduction.** Each parent couple has two offspring: one offspring of each of the parent colors. For each parent couple, take two individuals from the Offspring bags of cubes and place them in the Offspring row on the Graphic Organizer.

    - **Lose individuals to death by predation.** Predators eat half of all the green cubes and two purple cubes. Place these in the Graveyard. In the blue environment, predators can not see the blue individuals, so leave the blue cubes.

    - **Place all remaining cubes back in your Population bag.**

    - **Find mates in the population and create new parent couples.** Shake the Population bag and randomly take out two cubes at a time. Form six parent couples in the Parents row on the Graphic Organizer.

    - **Lose remaining individuals to death by old age.** Any remaining individuals in the Population bag do not find a mate and eventually die without reproducing. Remove them from the Population bag and put them in the Graveyard.

    - **Record this generation.** Count how many individuals you have of each color in the Parents row and record these numbers on your data sheet.

5. **Repeat Step 4.** Continue until you have four generations of data. Note: If you run out of Offspring, you can borrow from the cubes in the Graveyard.

6. **Create an ending histogram.** Draw a histogram on your sheet of the population at Generation 4.

7. **Clean up.** Put 12 cubes (4 of each color) back in the Population bag and the remaining cubes back into the three small Offspring bags, separated by color.

Name: ______________________________ Date: ________________

Reflection

How do individuals in a population get their traits?

Use what you learned in this lesson to answer the Investigation Question.

1. Where do the genes that determine an individual's traits come from? (check one)
   - ☐ An individual can be born with any genes, since genes are random.
   - ☐ Individuals grow genes specific to their environment.
   - ☐ Parents pass their genes down to their offspring.
   - ☐ Parents choose which genes their offspring have when each individual is born.

2. How do genes determine an individual's traits? (check one)
   - ☐ Genes directly cause traits.
   - ☐ Genes are random and don't lead to traits.
   - ☐ Genes give organisms the ability to change their traits.
   - ☐ Genes are instructions for making protein molecules and protein molecules determine traits.

3. How can an individual be born with an adaptive trait? (check one)
   - ☐ The individual can choose to change to the adaptive trait when they want to.
   - ☐ The parents had genes for the adaptive trait, which they passed down to the individual.
   - ☐ The individual can choose to have the adaptive trait at birth.
   - ☐ The parents can choose for the offspring to have genes for the adaptive trait.

Name: ______________________________ Date: ________________

Lesson 2.2: Survival and Reproduction

In the previous lesson, you explored how traits are passed down from one generation to the next when organisms reproduce. How is it possible that, over many generations, some traits can become more common, while others become less common? Shouldn't each generation match the generation before it? Today, you will observe one more example of how individuals in a population get their traits through reproduction. Next, you will use the Sim to collect data and create a class data set for analysis. Then, you will read another of "Sherman's Stories" and use it to create a model to help Sherman understand how reproduction in birds resulted in more birds with strong beaks.

Unit Question

- Why do populations change over time?

Chapter 2 Question

- How did the trait for increased poison level become more common in the newt population?

Key Concept

- Genes are instructions for making protein molecules and protein molecules determine an organism's traits.
- Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.

Vocabulary

- adaptive trait
- cause
- claim
- distribution
- effect
- environment
- evidence
- gene
- generation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- trait
- variation

Digital Tools

- *Natural Selection* Simulation
- *Traits and Reproduction* Simulation
- *Natural Selection* Data Tool activity: Number of Offspring by Color

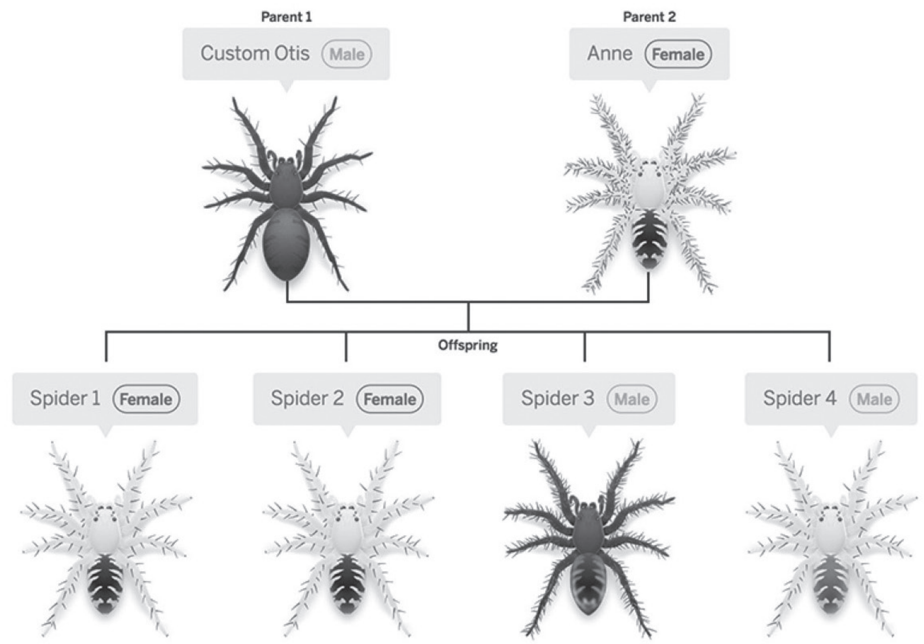
Name: ____________________ Date: ____________

Warm-Up

Observe the parents and offspring in the image and answer the questions below.

parents

offspring



1. What do you notice about the traits of the offspring compared to the traits of the parents?

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2. Where do organisms get their traits?

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Name: ______________________ Date: ______________

Observing Reproduction in the Sim

Part 1: Considering Why the Distribution of Traits Changes in a Population

Consider the key concept: *Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.*

Consider the Investigation Question: *How do some traits become more common over many generations while others become less common?*

Share your ideas about the Investigation Question with a partner.

Part 2: Observing Reproduction in the *Natural Selection* Simulation

Goal: Gather evidence to support or refute the claim that ostrilopes with adaptive traits have more offspring than ostrilopes with non-adaptive traits.

Do:

- Open the *Natural Selection* Simulation and open the mode: Reproduction Claims.
- Zoom into the environment in Build and select an ostrilope with one of the color traits in the table below.
- Press RUN and count the number of times that ostrilope reproduces before dying.
- Record that number in the data table below.
- Press Reset in the Sim, select an ostrilope with another color trait from the table below, and press Play to repeat your observations.

Tip:

- If the ostrilope dies before reproducing, record a 0 in the data table.

	Blue 1	**Blue 4**	**Yellow 7**	**Yellow 10**
Number of offspring				

Name: ______________________ Date: ______________

Observing Reproduction in the Sim (continued)

Part 3: Compiling Class Data

Investigation Question: *How do some traits become more common over many generations while others become less common?*

Discussion Questions

- What pattern describes the relationship between how long an ostrilope lived and how many offspring it had? *Hint: Try to complete this sentence: Ostrilopes that lived longer had (more / fewer / the same number of) offspring than . . .*
- Which ostrilopes became more common over time, and why?
- Which ostrilopes became less common over time, and why?
- If the color of the environment became blue, which ostrilopes do you think would become more or less common, and why?

Claim: Ostrilopes with adaptive traits are more likely to reproduce than ostrilopes with non-adaptive traits.

Does the data from the entire class support or refute this claim? (check one)

☐ supports

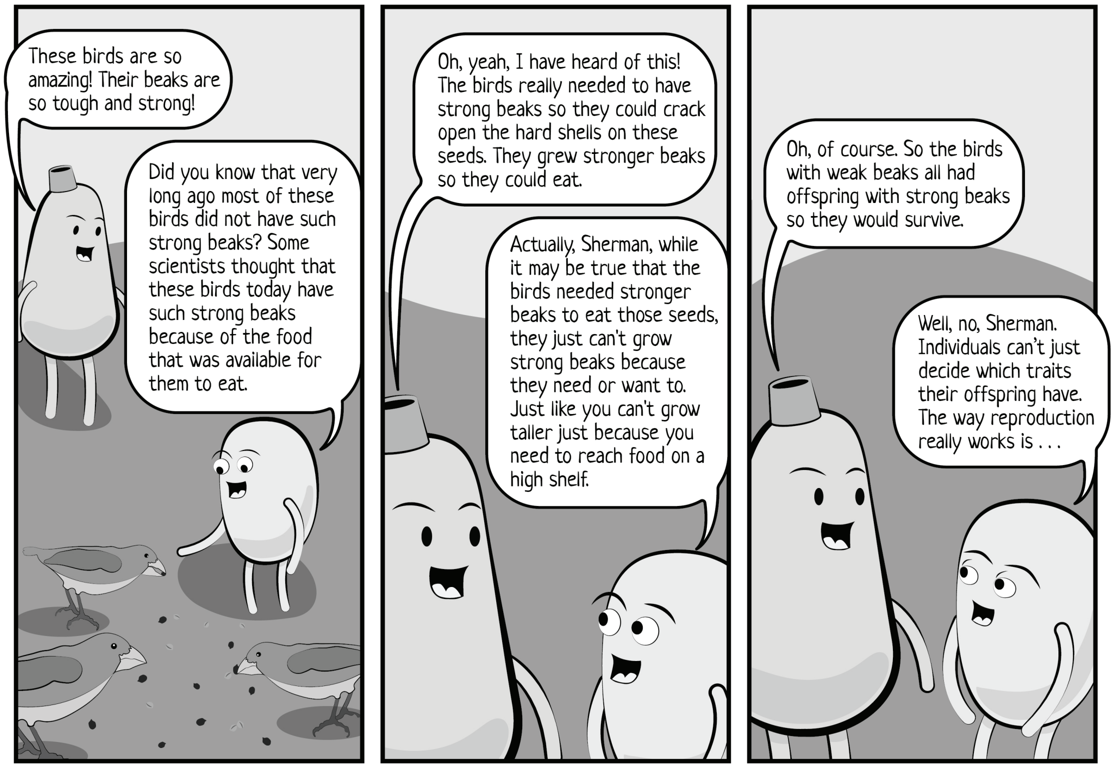
☐ refutes

Name: ______________________ Date: ______________

Responding to Sherman

Read the story and then read the instructions for creating a model and a written response for Sherman.

Sherman's Stories #2: Bird Beaks



Use the Modeling Tool activity: Beak Strength Explanation (on page 58) to represent your ideas. Follow the instructions below, and then answer the question on page 57.

Goal: Create a model to help explain to Sherman how beak-strength traits get passed down and how that can change the distribution of traits in a bird population.

Do:

- Analyze Histogram 1: Starting Population and label that histogram with any Trait labels that apply.
- Predict Histogram 2: Population After 50 Generations.

Tips:

- You can add multiple Trait labels on a single trait.
- You can use Trait labels more than once, and you do not have to use all of them.

Name: ______________________ Date: ______________

Responding to Sherman (continued)

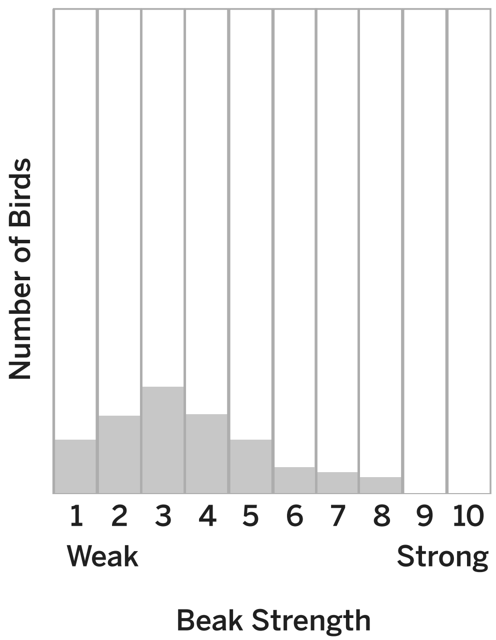
Explain why these birds now have strong beaks, even though most of them did not have strong beaks many generations ago. Be sure to include what you know about how individuals get their traits.

Name: ______________________ Date: ______________

Beak Strength Explanation

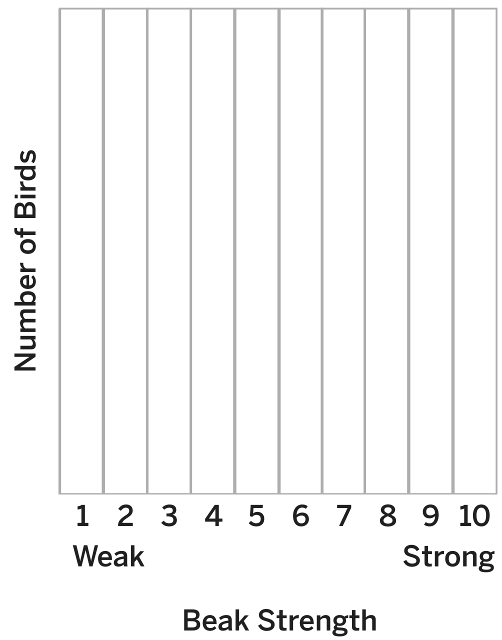
Goal: Create a model to help explain to Sherman how beak-strength traits get passed down and how that can change the distribution of traits in a bird population.

1. Starting Population



Environment: changing from **soft seeds** to **tough seeds**

2. Population After 50 Generations



Environment: **tough seeds**

Trait Labels

+S = **more** likely to survive

-S = **less** likely to survive

+O = likely to have **more** offspring

-O = likely to have **fewer** offspring

Name: ______________________ Date: ______________

Homework: Making Connections

Think of another science topic you have studied before. How does that topic connect to what we have learned about natural selection? Be creative!

Consider how the process of natural selection might affect the human microbiome and metabolism, traits and reproduction, ecosystems, energy transfer, or something else you have studied in science.

Name: ______________________ Date: ______________

Lesson 2.3: "The Deadly Dare"

We know that the rough-skinned newts are poisonous, but how exactly is being poisonous an adaptive trait? Today, you will read an article that explains how being poisonous helps newts stay alive as well as the effect that has on the population.

Unit Question

- Why do populations change over time?

Chapter 2 Question

- How did the trait for increased poison level become more common in the newt population?

Key Concept

- Genes are instructions for making protein molecules and protein molecules determine an organism's traits.
- Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.

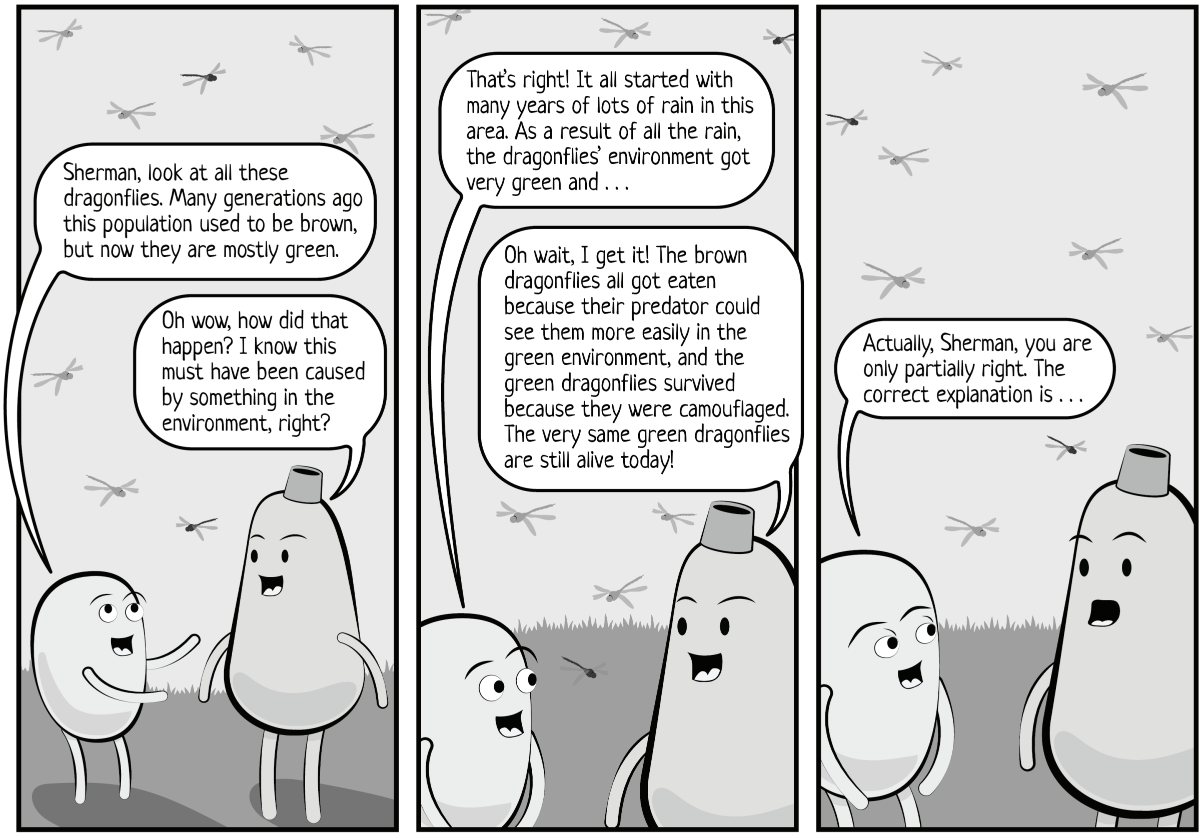
Vocabulary

- adaptive trait
- cause
- distribution
- effect
- environment
- evidence
- gene
- generation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- trait
- variation

Name: ______________________ Date: ______________

Warm-Up

Sherman's Stories #3: Green Dragonflies



Claim Additions from Lesson 2.2

1. Poison Level 10 is the most common because the newts with this trait were able to live longer than other newts.
2. Poison Level 10 is the most common because the newts with this trait reproduce more than other newts.

What do you think Sherman is right about?

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Name: ______________________________ Date: ________________

Warm-Up (continued)

What do you think Sherman is wrong about?

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Name: ____________________ Date: ____________

Reading "The Deadly Dare"

1. Read and annotate the article "The Deadly Dare."
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

What is something about the text that you discussed with your partner?

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Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ______________________ Date: ______________

Homework: Reading “Wallace and Darwin”

You have learned a lot about natural selection. To learn more about other scientists who have studied natural selection, read and annotate the “Wallace and Darwin” article and answer the question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ never
- ☐ almost never
- ☐ sometimes
- ☐ frequently/often
- ☐ all the time

What is one interesting thing you learned from reading the article?

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Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ______________________________ Date: ________________

Lesson 2.4: Reasoning About the Newt Mystery

Today, you will be returning to "The Deadly Dare" to gather evidence about the poisonous newts. Alex Young needs to know why and how the newts are so much more poisonous now, and by the end of this lesson, you'll be prepared to explain what you know so far! In the meantime, you and your fellow student biologists will review the evidence and discuss how it can be used to make the most convincing argument to Alex's team. Finally, you will choose one of the claims about how the newts became so poisonous and use the evidence to explain your position.

Unit Question

- Why do populations change over time?

Chapter 2 Question

- How did the trait for increased poison level become more common in the newt population?

Key Concept

- Genes are instructions for making protein molecules and protein molecules determine an organism's traits.
- Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.

Vocabulary

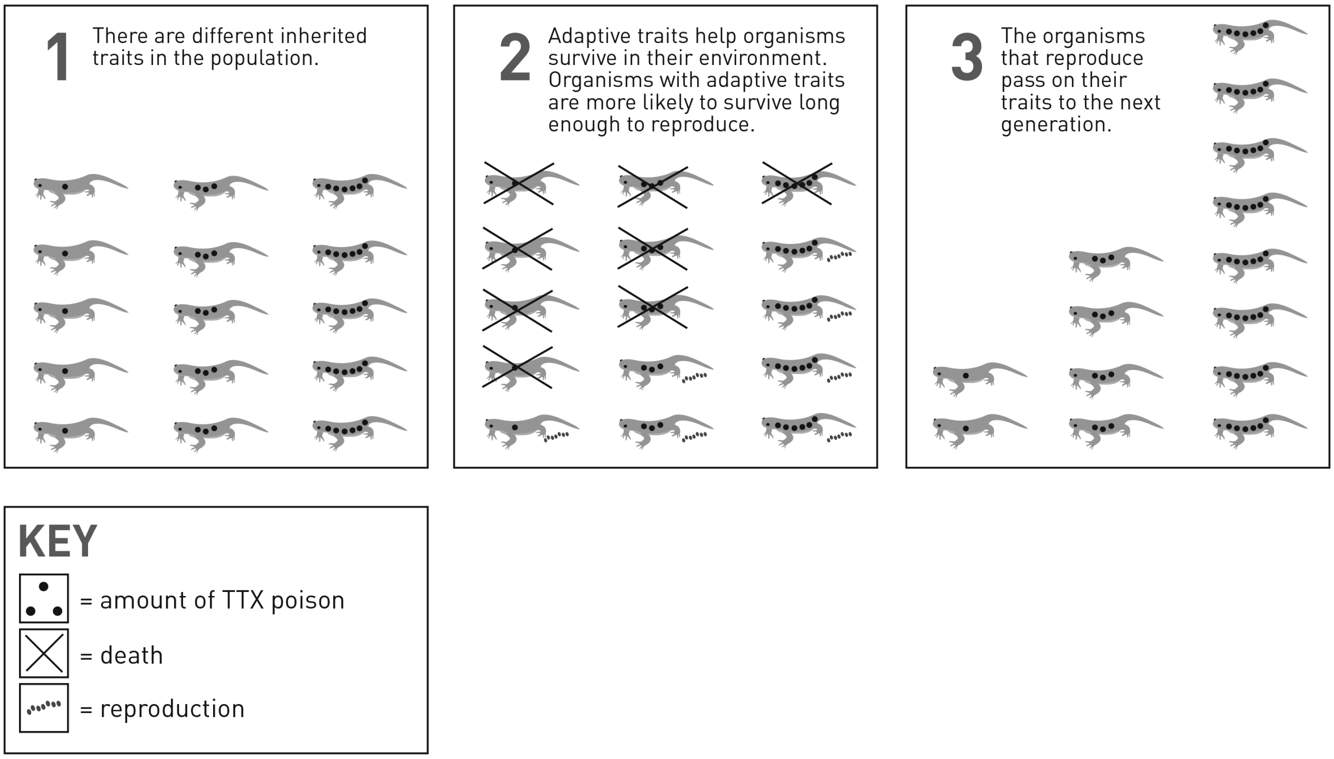
- adaptive trait
- cause
- claim
- distribution
- effect
- environment
- evidence
- gene
- generation
- natural selection
- non-adaptive trait
- population
- protein molecule
- reasoning
- refute
- scientific argument
- trait
- variation

Name: ______________________ Date: ______________

Warm-Up

Examine the visual representation. Then answer the questions below. (Note: Your teacher will project a color version of this image.)

How Natural Selection Works



1. Look at Diagram 1. How could you describe this newt population? (check one)

   ☐ There are fifteen poison levels shown, and each individual has a different amount of poison.

   ☐ There is one poison level shown, and all newts have the same amount of poison.

   ☐ There are three poison levels shown, and no poison-level trait is more common than the others.

   ☐ There are three poison levels shown, and one poison-level trait is the most common.

2. Look at Diagrams 2 and 3. Did newts from all poison levels reproduce? (check one)

   ☐ yes ☐ no

Name: ______________________________ Date: ________________

Warm-Up (continued)

3. Look at Diagram 2. Did newts from all poison levels die? (check one)

   ☐ yes ☐ no

4. Look at Diagram 3. How could you describe this newt population? (check one)

   ☐ There are fifteen poison levels shown, and each individual has a different amount of poison.

   ☐ There is one poison level shown, and all newts have the same amount of poison.

   ☐ There are three poison levels shown, and no poison-level trait is more common than the others.

   ☐ There are three poison levels shown, and one poison-level trait is the most common.

5. What other questions or connections do you have about this visual representation?

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Name: ______________________________ Date: ________________

Rereading "The Deadly Dare"

Part 1: Understanding How Adaptive Traits Become More Common by Reproduction

Reread the section "How Adaptive Traits Spread" in the "The Deadly Dare" article, and then work with a partner to answer the questions. Remember to pay close attention to the diagram.

1. Which individuals are most likely to die before reproducing, those with adaptive traits or non-adaptive traits? Why? *(Hint: You may use the newt population as an example in your explanation.)*

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2. When many individuals with the same trait die before reproducing, what happens to the distribution of that trait in the population? Why?

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3. Why are there more newts with a high-poison level in the population in Diagram 3 than in the population in Diagram 1?

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4. Are the newts with high poison in Diagram 3 simply the oldest newts? How do you know?

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Name: ______________________________ Date: ________________

Rereading "The Deadly Dare" (continued)

Part 2: Considering What the Claim Additions Mean

Work with your partner to complete the statement and to answer the question below.

Some people think the **cause** of the change in the newt population is that the more poisonous newts lived longer than other newts. Other people think the **cause** of the change in the newt population is that the more poisonous newts reproduced more than other newts. The **effect** is that more newts now have the trait for high-poison level.

Add more detail to this statement to make it more accurate: "The less poisonous newts died and the more poisonous ones lived." (Hint: Start with *"The less poisonous newts . . . and the more poisonous ones . . . "*)

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The newt population became more poisonous because the snakes in this environment caused poison to be an adaptive trait. Which claim addition provides the most accurate explanation for this change? (check one)

- ☐ **Claim 1:** Poison Level 10 is the most common because the newts with this trait were able to live longer than other newts.
- ☐ **Claim 2:** Poison Level 10 is the most common because the newts with this trait reproduce more than other newts.
- ☐ Neither claim addition is accurate on its own.
- ☐ Both claim additions are accurate.

Name: ______________________________ Date: ________________

Reasoning About the Rough-Skinned Newts

Use the Reasoning Tool to connect each piece of evidence to the combined claim. Use the histogram on page 71 as a visual support if needed.

Claim: The newt population became more poisonous because the snakes in this environment caused poison to be an adaptive trait.

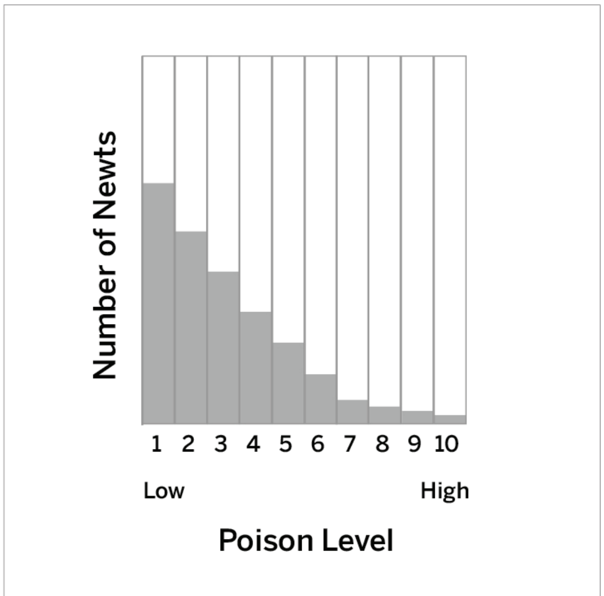
Revised Claim Addition: Poison Level 10 is the most common because the newts with this trait were able to live longer and reproduce more than other newts.

Evidence	This matters because . . .	Therefore, . . .
Sometime between 50 generations ago and today, snakes became part of this newt population's environment.		
50 generations ago, most newts had the trait for Poison Level 1. Today, most newts have the trait for Poison Level 10.		
50 generations ago, some newts had each of the poison-level traits. Today, no newts have the trait for Poison Level 1.		
From "The Deadly Dare": "Even more important, predators can smell and taste TTX poison. The main predator of rough-skinned newts is the garter snake. Scientists have found evidence that garter snakes use their senses of smell and taste to tell whether a rough-skinned newt is too poisonous to eat."		

Name: ______________________________ Date: ________________

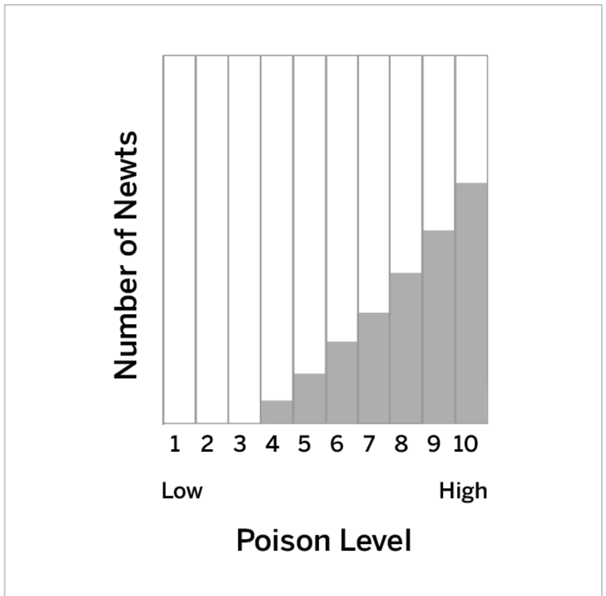
Reasoning About the Rough-Skinned Newts (continued)

Population 50 Generations Ago



Environment: no snakes

Population Today



Environment: snakes

Time

Name: ______________________________ Date: ________________

Homework: Writing About the Rough-Skinned Newts

Now that you have a better understanding of natural selection, write Alex Young an argument for the claim you think is best supported about the mystery of the rough-skinned newts.

Be sure to use some of the vocabulary words you have learned so far.

Word Bank

adaptive trait	distribution	environment	gene
generation	natural selection	non-adaptive trait	population
protein molecule	trait	variation	

Name: ______________________ Date: ______________

Homework: Writing About the Rough-Skinned Newts (continued)

Name: ______________________________ Date: ________________

Lesson 2.6: Reviewing Key Ideas About Natural Selection

Today, you will be considering changes in the distribution of traits in populations over time. You will be assigned to a group with a specific task. Each group will look at a specific ostrilope population in a particular environment, and your task will be to consider how the environment affects each population.

Unit Question

- Why do populations change over time?

Chapter 2 Question

- How did the trait for increased poison level become more common in the newt population?

Key Concepts

- A population can be described by the traits present and by the number of individuals who have each trait.
- The number of individuals with each trait in a population can change over time.
- Over many generations, individuals with adaptive traits become more common in a population, while individuals with non-adaptive traits become less common.
- The traits that exist in a population determine which traits can become more common over many generations.
- Whether or not a trait is adaptive depends on the environment.
- Biologists analyze data about environmental conditions (the causes) to explain changes in the distribution of traits in populations (the effects).
- Genes are instructions for making protein molecules and protein molecules determine an organism's traits.
- Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.
- Individuals with adaptive traits are more likely to live longer and have offspring; individuals with non-adaptive traits are more likely to die without having offspring.

Name: ______________________ Date: ______________

Lesson 2.6: Reviewing Key Ideas About Natural Selection (continued)

Vocabulary

- adaptive trait
- cause
- distribution
- effect
- environment
- gene
- generation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- trait
- variation

Digital Tools

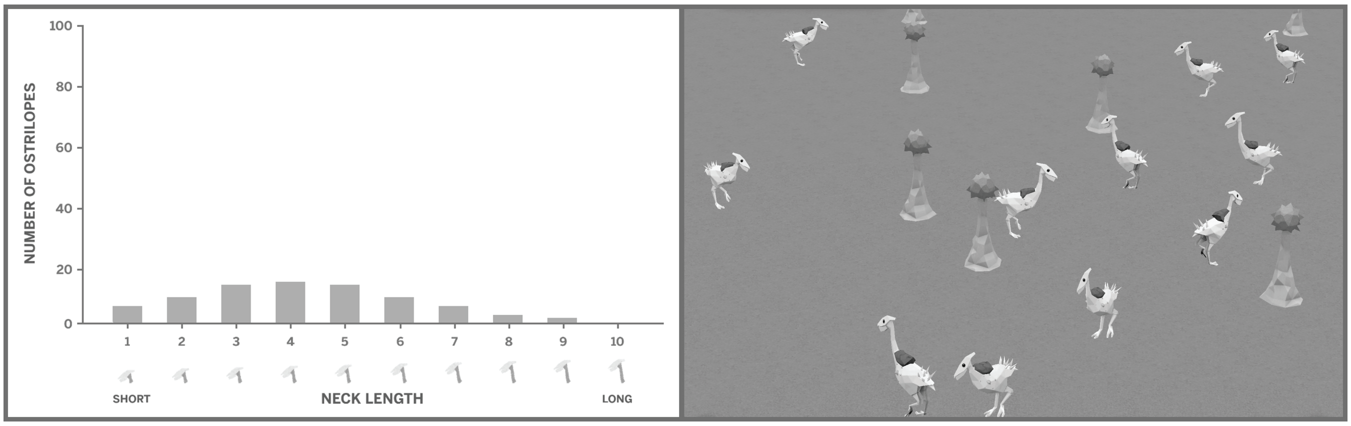
- *Natural Selection* Simulation
- *Natural Selection* Sorting Tool activity: Ostrilope Armor (Green Group) or Ostrilope Armor (Purple Group)

Name: ____________________ Date: ____________

Green Group: Warm-Up

Observing Traits

In today's lesson you will complete a Sim activity. Review the Neck-Length Histogram below of an ostrilope population from that Sim activity as well as the image of some individuals from that population. Then, answer the questions.



Which neck-length traits are present in this population of ostrilopes? (circle all that apply)

1	3	5	7	9
2	4	6	8	10

Read the statements about this ostrilope population. If the statement is true, write "T" on the line before the statement. If the statement is false, write "F" on the line before the statement.

_________ Some ostrilopes have short necks.

_________ Some ostrilopes have long necks.

_________ Most ostrilopes have medium-length necks.

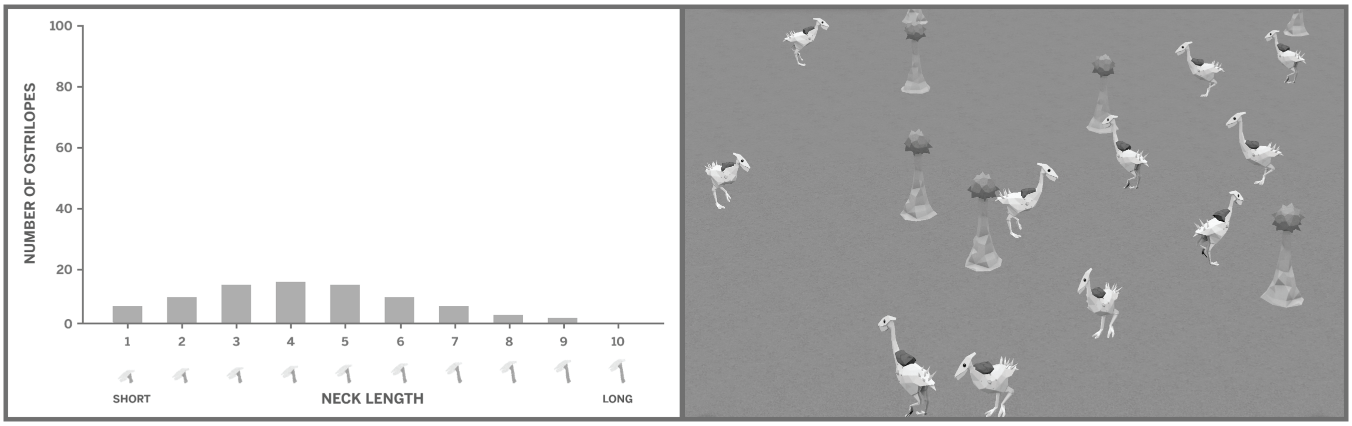
_________ There are no ostrilopes with very long (Level 10) necks.

_________ All ostrilopes have the same neck lengths.

Name: ____________________ Date: ____________

Green Group: Investigating Adaptive Traits

Part 1: Predicting Changes to Ostrilope Populations



Consider a population of ostrilopes that live in an environment where all the thornpalms are tall (Level 8). The ostrilope population has the distribution of neck lengths shown in the histogram above. Longer necks make it easier for ostrilopes to eat taller thornpalms.

Based on this information, make predictions about what will happen to the ostrilope population.

1. According to the histogram, which traits for neck length are the most common in the starting population? (check one)

   - ☐ short necks (Levels 1–2)
   - ☐ medium-short necks (Levels 3–5)
   - ☐ medium-long necks (Levels 6–7)
   - ☐ long necks (Levels 8–9)

2. Which traits for neck length do you predict will be the most helpful for survival in this environment? (check one)

   - ☐ short necks (Levels 1–2)
   - ☐ medium-short necks (Levels 3–5)
   - ☐ medium-long necks (Levels 6–7)
   - ☐ long necks (Levels 8–9)

Name: ______________________________ Date: ________________

Green Group: Investigating Adaptive Traits (continued)

3. Which traits for neck length do you predict will become most common over time? (check one)

- ☐ short necks (Levels 1–2)
- ☐ medium-short necks (Levels 3–5)
- ☐ medium-long necks (Levels 6–7)
- ☐ long necks (Levels 8–9)

Part 2: Simulating an Ostrilope Population in a Tall Thornpalm Environment

Open the *Natural Selection* Simulation, open the Ostrilope Neck Length mode, and perform the two tests below and on page 79.

Test 1

- Press RUN and observe the results over 25 generations.
- Press ANALYZE and compare starting and ending histograms.
- Answer the questions below.

Test 1 Reflection Questions

Did any traits completely disappear from the population? Why?
Which traits became more common over time? Why?

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Name: ______________________________ Date: ________________

Green Group: Investigating Adaptive Traits (continued)

Test 2

- Press BUILD, press the Thornpalm icon, and increase the thornpalm height to tall (Level 10) by adjusting the Trait-Level slider.
- Press RUN and observe the results.
- Press ANALYZE and compare initial and final histograms.

Test 2 Reflection Question

Use your observations from Test 2 to explain what is wrong with the following statement: “If the ostrilope population needs traits for longer necks, individuals will just get longer necks.”

Name: ______________________________ Date: ________________

Green Group: Understanding Reproduction and Adaptive Traits

Ostrilope Reproduction and Adaptive Traits

Goal: Open the *Natural Selection* Sorting Tool activity: Ostrilope Armor, and sort the ostrilope cards with your partner, according to the instructions below. Then answer the questions.

Do:

- Read the ostrilope cards.
- Sort the cards three times. Rearrange cards as necessary each time you resort.
  - First, sort the cards by armor level (weakest to strongest).
  - Then, sort the cards by number of offspring (fewest to most).
  - Finally, sort the cards by lifespan (shortest to longest).

1. Which armor trait is adaptive and will become more common over many generations? (check one)

   ☐ 1

   ☐ 3

   ☐ 5

   ☐ 7

   ☐ 10

2. Check any of the responses below that help explain how that trait will become more common. Discuss your answer with your partner.

   ☐ Parents with any traits will have offspring with this trait because they need to.

   ☐ Ostrilopes with this trait have the longest lifespan.

   ☐ Ostrilopes with this trait will reproduce most.

   ☐ Ostrilopes will change their traits during their lifetime.

Name: ______________________________ Date: ________________

Green Group: Understanding Reproduction and Adaptive Traits (continued)

3. What pattern did you notice when sorting the cards by armor level, number of offspring, then by lifespan?

4. Why does this pattern exist?

5. After many generations, which trait will be most common? Why?

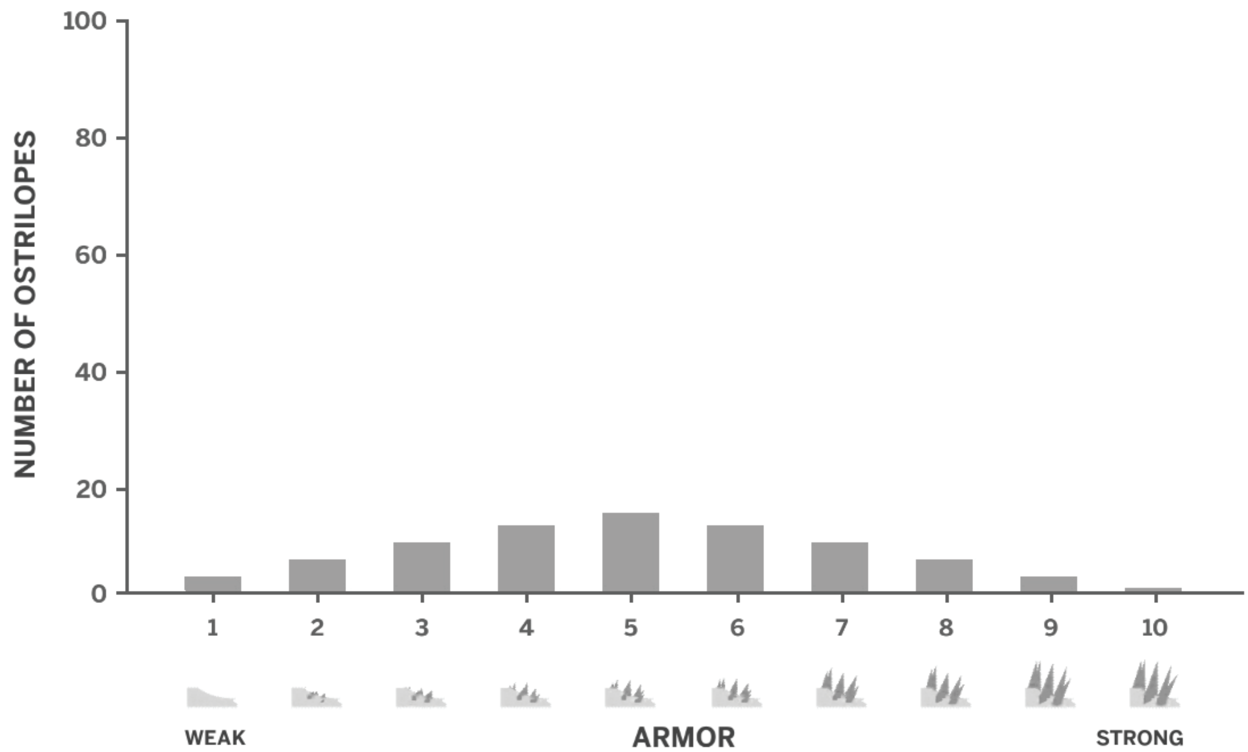
Name: ______________________ Date: ______________

Purple Group: Warm-Up

Exploring a New Population

In this lesson, you will investigate a population of ostrilopes with variation for armor traits. There are carnithons in the environment, and carnithons are more likely to eat ostrilopes with less armor.

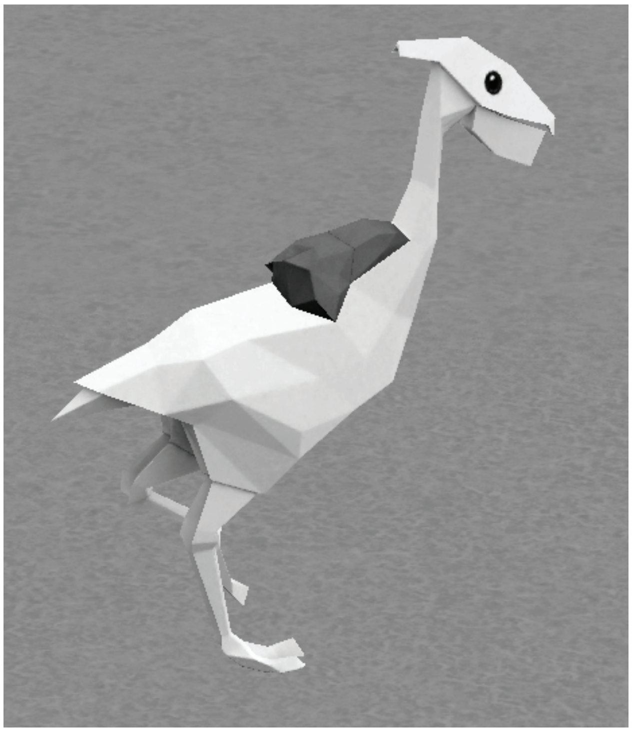
- Observe the histogram and images of the ostrilopes below.
- Make predictions about what will happen to the ostrilopes in an environment with carnithons by answering the questions on the next page.



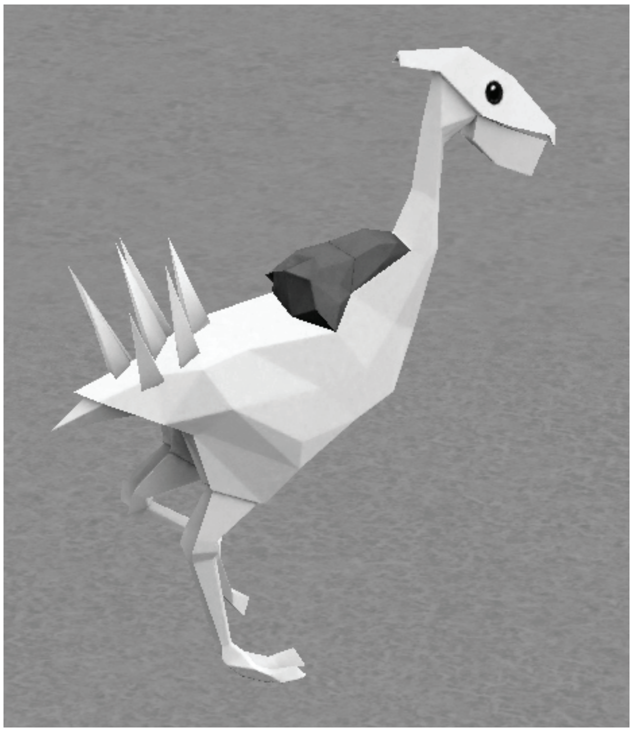
Name: ____________________ Date: ____________

Purple Group: Warm-Up (continued)

This ostrilope has the trait Armor Level 1.



This ostrilope has the trait Armor Level 10.



1. Look at the ostrilope above with Armor Level 1. What do you think is likely to happen to this ostrilope? (check one)

   ☐ It will most likely die because it has a non-adaptive trait.

   ☐ It will most likely live because it has an adaptive trait.

2. Which ostrilope pictured above do you think will likely have more offspring? Why?

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Name: ______________________________ Date: ________________

Purple Group: Investigating Adaptive Traits

Ostrilope Reproduction and Adaptive Traits

Goal: Open the *Natural Selection* Sorting Tool activity: Ostrilope Armor, and sort the ostrilope cards with your partner, according to the instructions below. Then answer the questions.

Do:

- Read the ostrilope cards.
- Sort the cards three times. Rearrange cards as necessary each time you re-sort.
  - First, sort the cards by armor level (weakest to strongest).
  - Then, sort the cards by number of offspring (fewest to most).
  - Finally, sort the cards by lifespan (shortest to longest).

1. Which armor trait is adaptive and will become more common over many generations? (check one)

   ☐ 1

   ☐ 3

   ☐ 5

   ☐ 7

   ☐ 10

2. Check any of the responses below that help explain how that trait will become more common. Discuss your answer with your partner.

   ☐ Parents with any traits will have offspring with this trait because they need to.

   ☐ Ostrilopes with this trait have the longest lifespan.

   ☐ Ostrilopes with this trait will reproduce most.

   ☐ Ostrilopes will change their traits during their lifetime.

Name: ______________________ Date: ______________

Purple Group: Investigating Adaptive Traits (continued)

3. What pattern did you notice when sorting the cards by armor level, number of offspring, then by lifespan?

4. Why does this pattern exist?

5. After many generations, which trait will be most common? Why?

Name: ____________________ Date: ____________

Purple Group: Understanding Reproduction and Adaptive Traits

Reading "Otters and the Bottleneck Effect"

Read and annotate the article. Then, answer the reflection questions below.

1. What trait do otters have that is adaptive to their ocean environment?

2. How did the otters' environment change from the years 1741–1911?

3. Why did this change cause a bottleneck effect in the otter population?

Name: ______________________________ Date: ________________

Purple Group: Understanding Reproduction and Adaptive Traits (continued)

4. Do you think the population will ever returm to restore its former distribution? Explain why or why not.

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Name: ____________________ Date: ____________

Blue Group: Warm-Up

Understanding Environmental Conditions

1. List some examples of environmental conditions that could determine which traits are adaptive. (For example, temperature is an environmental condition that would affect which traits are adaptive.)

2. Check the statement below that best describes how environmental conditions affect an individual's likelihood of survival and reproduction.

- [ ] Environmental conditions make all individuals equally likely to survive.
- [ ] Environmental conditions make some individuals more likely to survive and others less likely to survive.
- [ ] Environmental conditions do not have any effect on survival.
- [ ] I need more information; it depends on the conditions.

3. Explain why you chose the answer you did to the question above.

Name: ______________________ Date: ______________

Blue Group: Investigating Adaptive Traits

Reading "Otters and the Bottleneck Effect"

Read and annotate the article. Then, answer the reflection questions below.

1. What trait do otters have that is adaptive to their ocean environment?

2. How did the otters' environment change from the years 1741–1911?

3. Why did this change cause a bottleneck effect in the otter population?

Name: ______________________________ Date: ________________

Blue Group: Investigating Adaptive Traits (continued)

4. Do you think the population will be able to restore its former distribution? Explain why or why not.

Name: ______________________________ Date: ________________

Blue Group: Understanding Reproduction and Adaptive Traits

Creating a Bottleneck Effect in an Ostrilope Population in the Sim

Goal: In fewer than 30 generations, change the starting ostrilope population into a population of at least 70 individuals with low variation in color traits (4 traits or fewer). Do this without adding a predator.

Do:

- Decide on a strategy to reduce the variation of the ostrilope population.
- Open the *Natural Selection* Simulation and open the mode: Color Change Mission.
- Try out your strategy by making any changes in either Build or Run.
- Use the histograms in Analyze or the Traits Histogram Window in Run to see if your strategy was successful.

Tips:

- You can modify abiotic factors in Run at any time by pressing the Abiotic Factors icon in the lower-right corner of the screen.
- Do not make any changes to the starting ostrilope population settings.
- Return to Build and press REBUILD to reset the Sim to the default settings.

1. How did you change the distribution of color traits in the ostrilope population?

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2. Why do you think your strategy worked?

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Name: ______________________________ Date: ________________

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. You have been investigating why the newt population in Oregon State Park became more poisonous over time in order to share your ideas with biologist Dr. Alex Young. Are you getting closer to figuring out why the trait for high-poison level became more common in the newt population over time?

1. I understand how a histogram can be used to represent and describe the traits in the newt population. (check one)

☐ yes ☐ not yet

Explain your choice above.

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2. I understand why high-poison levels are adaptive in one environment but not adaptive in another. (check one)

☐ yes ☐ not yet

Explain your choice above.

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3. I understand how the number of newts with high-poison levels increased over time. (check one)

☐ yes ☐ not yet

Explain your choice above.

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Name: ______________________ Date: ______________

Homework: Check Your Understanding (continued)

4. I understand why a new trait may or may not become more common in a population. (check one)

☐ yes ☐ not yet

Explain your choice above.

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5. What do you still wonder about how the trait for high-poison level became more common in the newt population over time?

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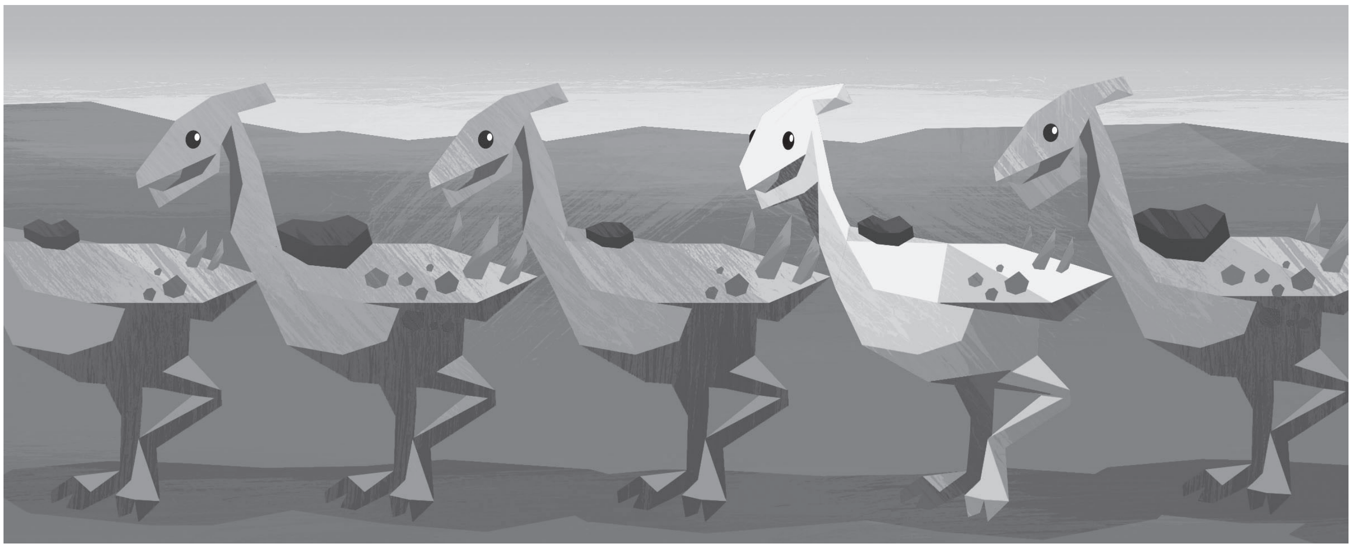
Name: ______________________ Date: ______________

Chapter 3: Mutation and Adaptive Traits
Chapter Overview

You now know how traits for high-poison levels were passed down through many generations of the newt population. In Chapter 3, you will discover something surprising about the newt population: The trait for an extremely high-poison level was not always present in the population. How could this have become the most common trait? In this chapter, you will investigate how new traits can sometimes appear in populations.



Name: ______________________________ Date: ____________________

Lesson 3.1: Introduction to Mutations

Alex Young has sent some surprising information about the rough-skinned newt population. This new data will present a unique challenge to explaining the mystery of the poisonous newts. You're going to need to do a bit more research in order to fully explain this surprising piece of evidence! First, you will actively read an article all about mutations. For homework, you will have a chance to use the *Natural Selection* Simulation to understand this new idea.

Unit Question

- Why do populations change over time?

Chapter 3 Question

- How did a poison-level trait that wasn't always present in the newt population become the most common trait?

Vocabulary

- adaptive trait
- cause
- distribution
- effect
- environment
- gene
- generation
- mutation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- trait

Digital Tool

- *Natural Selection* Simulation

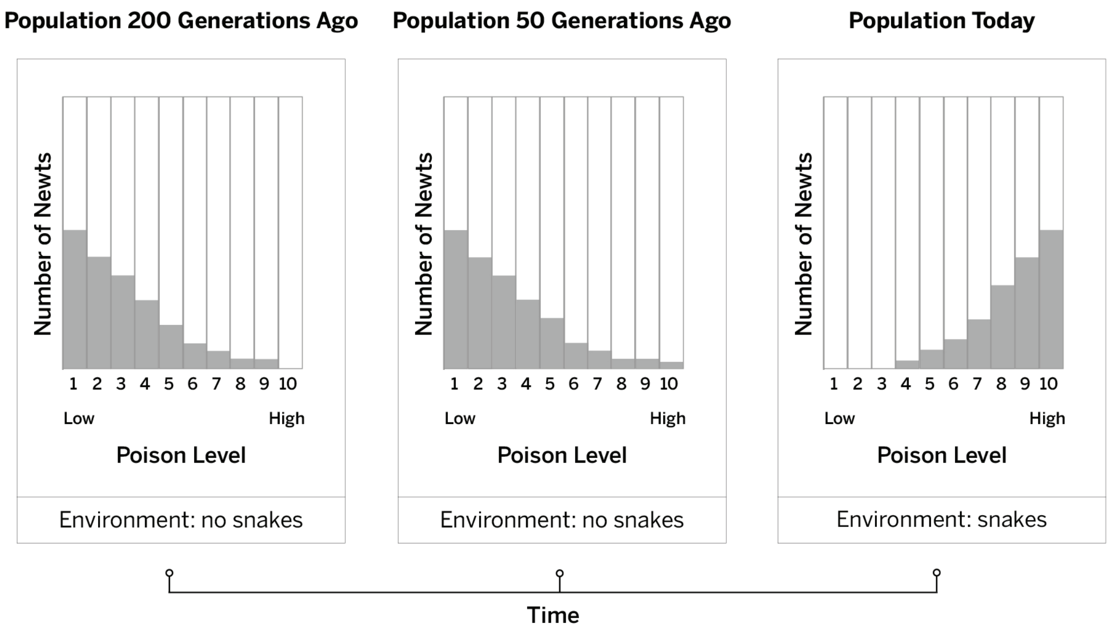
Name: ____________________ Date: ____________

Warm-Up

Rough-Skinned Newt Histogram from Many Generations Ago

New evidence about the rough-skinned newts is available. Below is a histogram from many years in the past, 200 generations ago! Observe the histogram and answer the questions below.

Poison Levels in the Oregon State Park Newt Population



1. How did the distribution of the poison-level traits change from 200 generations ago to 50 generations ago?

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2. What could explain this change? Record any ideas that you have.

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Name: ______________________________ Date: ________________

Reading *Mutations: Not Just for Superheroes*

1. Read and annotate the introduction to the article set *Mutations: Not Just for Superheroes*.
2. Choose one of the remaining three articles to read and annotate.
3. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
4. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
5. Answer the reflection question below.

What is something about the text that you discussed with your partner?

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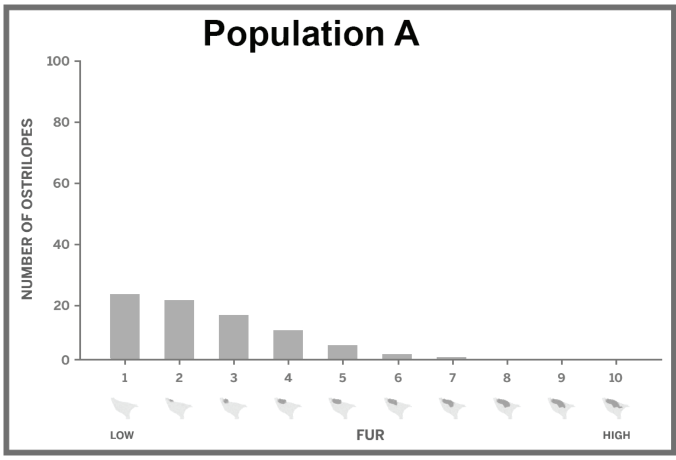
Active Reading Guidelines

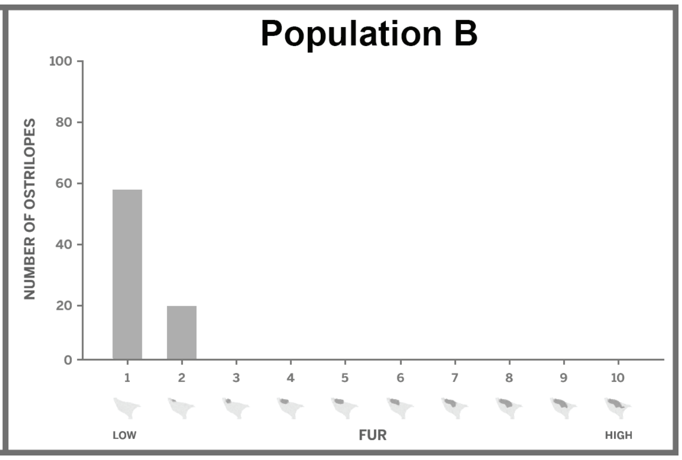
1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ______________________________ Date: ________________

Homework: Predicting Changes in Ostrilope Populations

These two histograms show the initial distribution of fur traits in two populations from an earlier Sim activity. In both cases, the ostrilopes' environment became much colder and the populations did not experience any mutations. Choose the statement for each histogram that best describes what happened to these populations.





1. This population survived and traits for more fur became more common. (circle one)

   Population A **Population B**

2. This population died out because it did not have the fur traits needed to survive. (circle one)

   Population A **Population B**

You will be completing another Sim activity where you make the environment of Population B much colder. However, this time the ostrilope population will experience mutations that can cause new traits to appear in the population.

3. What do you think will happen to Population B when they can experience mutations and when their environment gets colder? Use what you know about adaptive traits, environments, and mutations to make a prediction.

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Name: ______________________________ Date: ________________

Homework: Predicting Changes in Ostrilope Populations (continued)

Goal: Use the Sim to test your prediction about what will happen to the ostrilope population with mutations when the environment gets colder. Since mutations occur randomly, be sure to perform multiple tests.

Do:

- Open the *Natural Selection* Simulation to the mode: Mutations Introduction.
- Change the temperature of the environment to cold (Level 1) by moving the Temperature slider.
- Turn ostrilope fur-trait mutations on by pressing the Ostrilope icon and then by pressing the Mutations toggle to on.
- Press RUN and observe the population for at least 70 generations.
- Press ANALYZE and compare starting and ending histograms.

4. Which fur trait was most common in the population at Generation 70? (circle one)

1	3	5	7	9
2	4	6	8	10

5. Was that trait present in the starting ostrilope population? (check one)

☐ yes ☐ no

6. This population died out when there were no mutations. How did having mutations allow the population to survive the environmental change?

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Name: ______________________________ Date: ________________

Lesson 3.2: Mutations in a Population

In the previous lesson, you learned about how mutations can introduce new traits into a population. Today, you will continue to think about how mutations can affect the distribution of traits in a population over time. You will revisit the article that you read in the last lesson and pay close attention to how a new trait introduced by a mutation affected a population. Then, you will investigate mutant traits in the Sim to figure out what determines whether a new trait becomes more common in a population.

Unit Question

- Why do populations change over time?

Chapter 3 Question

- How did a poison-level trait that wasn't always present in the newt population become the most common trait?

Vocabulary

- adaptive trait
- distribution
- environment
- evolution
- fossil
- gene
- generation
- histogram
- mutation
- natural selection
- non-adaptive trait
- pattern
- population
- protein molecule
- scientific community
- trait
- variation

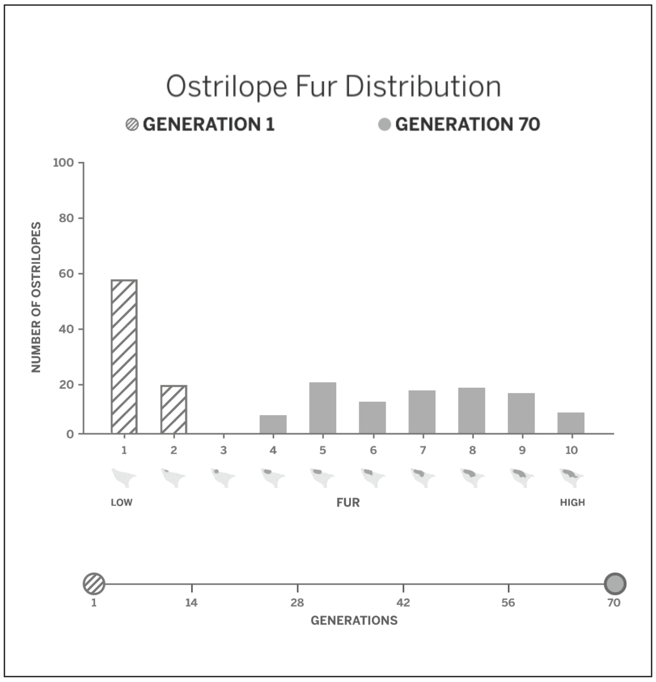
Digital Tools

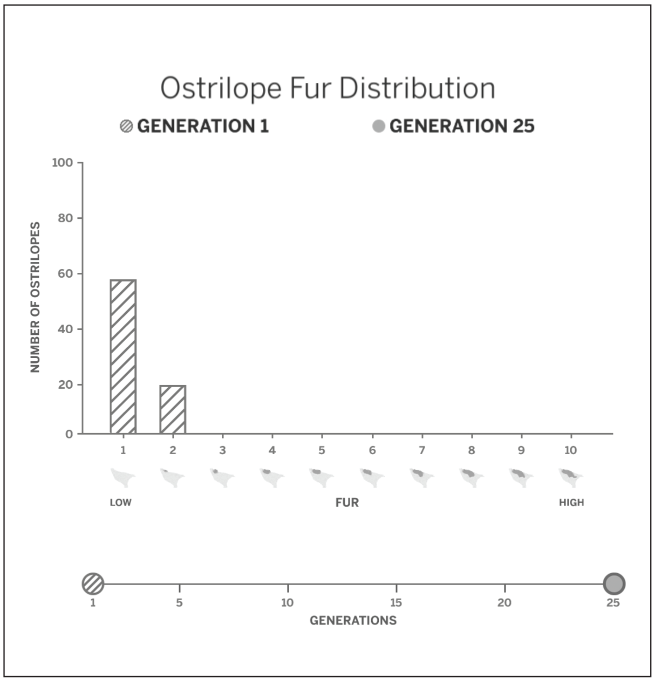
- *Natural Selection* Simulation
- *Natural Selection* Data Tool activity: Population Changes Over Time

Name: ______________________ Date: ______________

Warm-Up

1. Examine the two images below, showing fur-trait histograms from the Mutations Introduction Sim activity in the previous lesson.
2. Answer the two questions below the images.





1. What similarities do you notice in what happened to the population with mutations and to the population without mutations?

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2. What differences do you notice in what happened to the population with mutations and to the population without mutations?

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Name: ____________________ Date: ____________

Rereading *Mutations: Not Just for Superheroes*

Returning to Mutation Case Studies

- Reread the mutation example you read in the previous lesson and then work with a partner to answer the questions.
- Pay close attention to the diagrams.

1. Did this population change?

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2. What was the cause?

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3. What was the effect?

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Name: ______________________________ Date: ________________

Investigating Mutant Fur Traits in the Sim

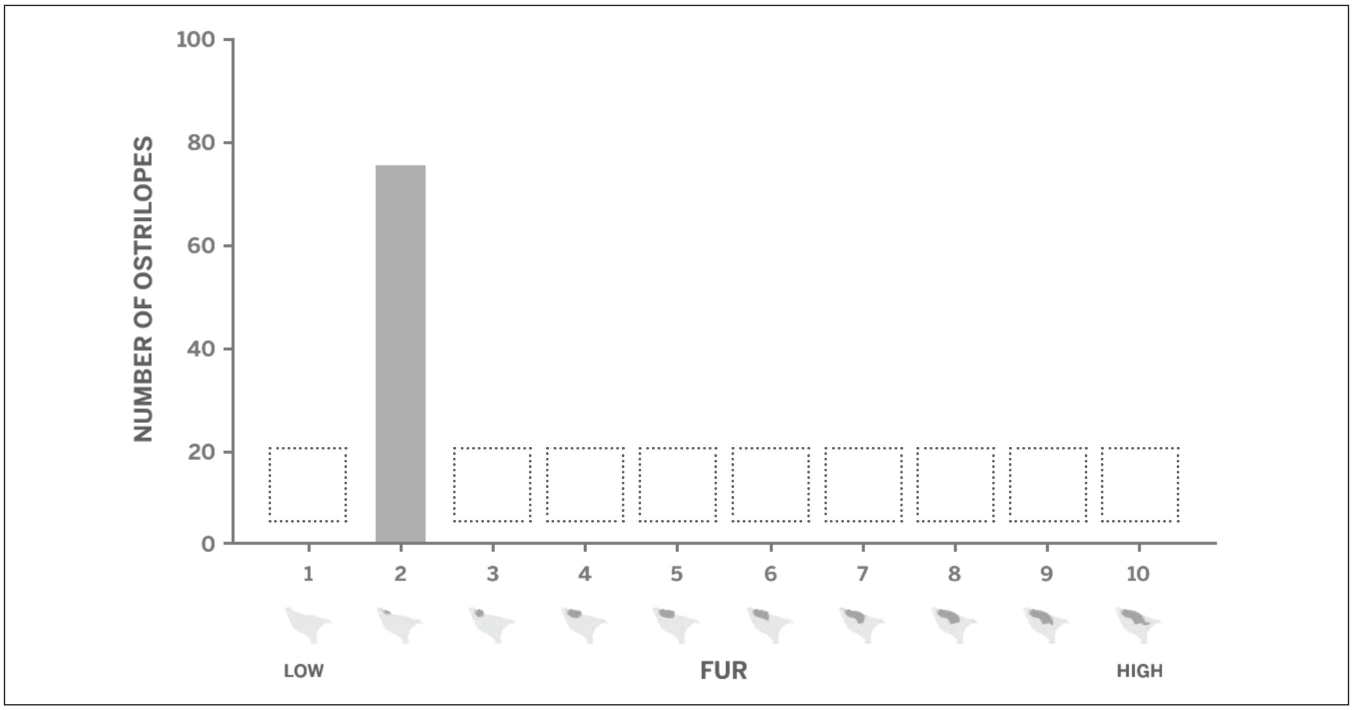
Observing Mutations in the *Natural Selection* Simulation

In the Sim activity that follows, you will investigate a low-fur population of ostrilopes with the trait distribution shown in the histogram below.

- In the Sim, you will be able to turn on mutations for fur traits.
- You will make the environment for this population cold.
- Before you do this, study the histogram below and answer the questions that follow.

Part 1: Making a Prediction

Think about which new traits would be adaptive and non-adaptive in a cold environment. Label any traits that would be adaptive with an A. Label any traits that would be non-adaptive with an NA.



Are all traits that are introduced by mutations adaptive? Do you think non-adaptive traits can be introduced into a population through mutations? Why or why not?

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Name: ____________________ Date: ____________

Investigating Mutant Fur Traits in the Sim (continued)

Part 2: Testing Predictions in the *Natural Selection* Simulation

Goal: Perform tests in the Sim to see if mutations can introduce both adaptive and non-adaptive traits into the population.

Do:

- Open the *Natural Selection* Simulation and open the mode: Mutations and Traits.
- Change the temperature of the environment to cold (Level 1) by moving the Temperature slider.
- Turn ostrilope fur-trait mutations on by pressing the Ostrilope icon and pressing the Mutations toggle.
- Press RUN and observe the population for at least 50 generations.
- Press ANALYZE and use the Generations slider to carefully observe new traits in the population.
- Answer the questions below.

Tips:

- Press the Histogram icon in the lower-left corner of Run to observe the introduction of traits into the population.
- Look for the red indicator above the heads of ostrilopes that are born with mutant traits.

Look at an ostrilope fur-trait histogram from Generation 50 or above and determine if there are any adaptive traits that were introduced through mutations. How do you know the traits you identified in the histogram were adaptive?

Name: ______________________________ Date: ________________

Investigating Mutant Fur Traits in the Sim (continued)

Look at an ostrilope fur-trait histogram from Generation 5 and determine if there are any non-adaptive traits that were introduced through mutations. How do you know the traits you identified in the histogram were non-adaptive?

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Revise your earlier answer to these questions: Are all traits that are introduced by mutations adaptive? Do you think non-adaptive traits can be introduced into a population through mutations? Why or why not?

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Name: ______________________________ Date: ________________

Reflection

Reflecting on Mutations

Read each of the statements below.

If the statement is true, write "T" on the line before the statement. If the statement is false, write "F" on the line before the statement.

_________ Mutations sometimes result in an adaptive trait.

_________ Mutations sometimes result in a non-adaptive trait.

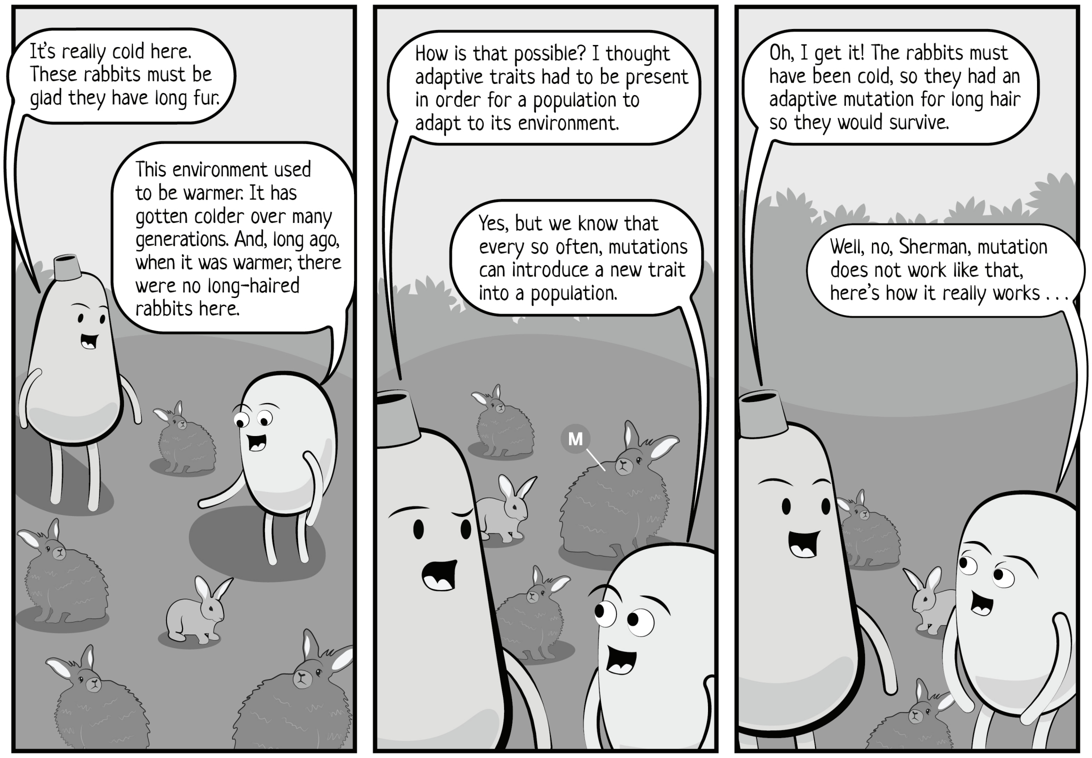
_________ Traits introduced by mutation will always become more common in a population.

_________ Traits introduced by mutation will sometimes become more common in a population.

Name: ______________________________ Date: ____________________

Homework: Reading and Responding to Sherman

Sherman's Stories #4: Long-Haired Rabbits



1. Complete the explanation to Sherman.

   Well, no Sherman, mutation does not work like that, here's how it really works . . .

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2. If there had been a mutation that led to no fur, what would have happened? (check one)

   ☐ The trait would have been adaptive.

   ☐ The trait would have been non-adaptive.

   ☐ The trait would have become more common over time.

   ☐ The trait would have become less common over time.

Name: ______________________________ Date: ______________

Lesson 3.3: Wrapping Up the Mystery

Congratulations, student biologists! You have figured out how a new trait could be introduced into a population. Now, you are ready to help the Oregon State Park visitors understand why the rough-skinned newt population has become so much more poisonous. First, you will participate in the Write and Share routine to think about how mutations affect the distribution of traits in a population. Then, you will apply what you learn to review evidence about the newt population and use the Modeling Tool to create a final explanation for Alex Young. For homework, you will read about sticklebacks, dragonflies, and salmon to prepare for a new natural selection mystery.

Unit Question

- Why do populations change over time?

Chapter 3 Question

- How did a poison-level trait that wasn't always present in the newt population become the most common trait?

Key Concepts

- Mutations are changes to genes that can lead to changes to protein molecules, which can result in changes to traits.
- Mutations to genes can sometimes introduce new traits into a population.
- A new trait will only become more common in a population if it is adaptive.

Vocabulary

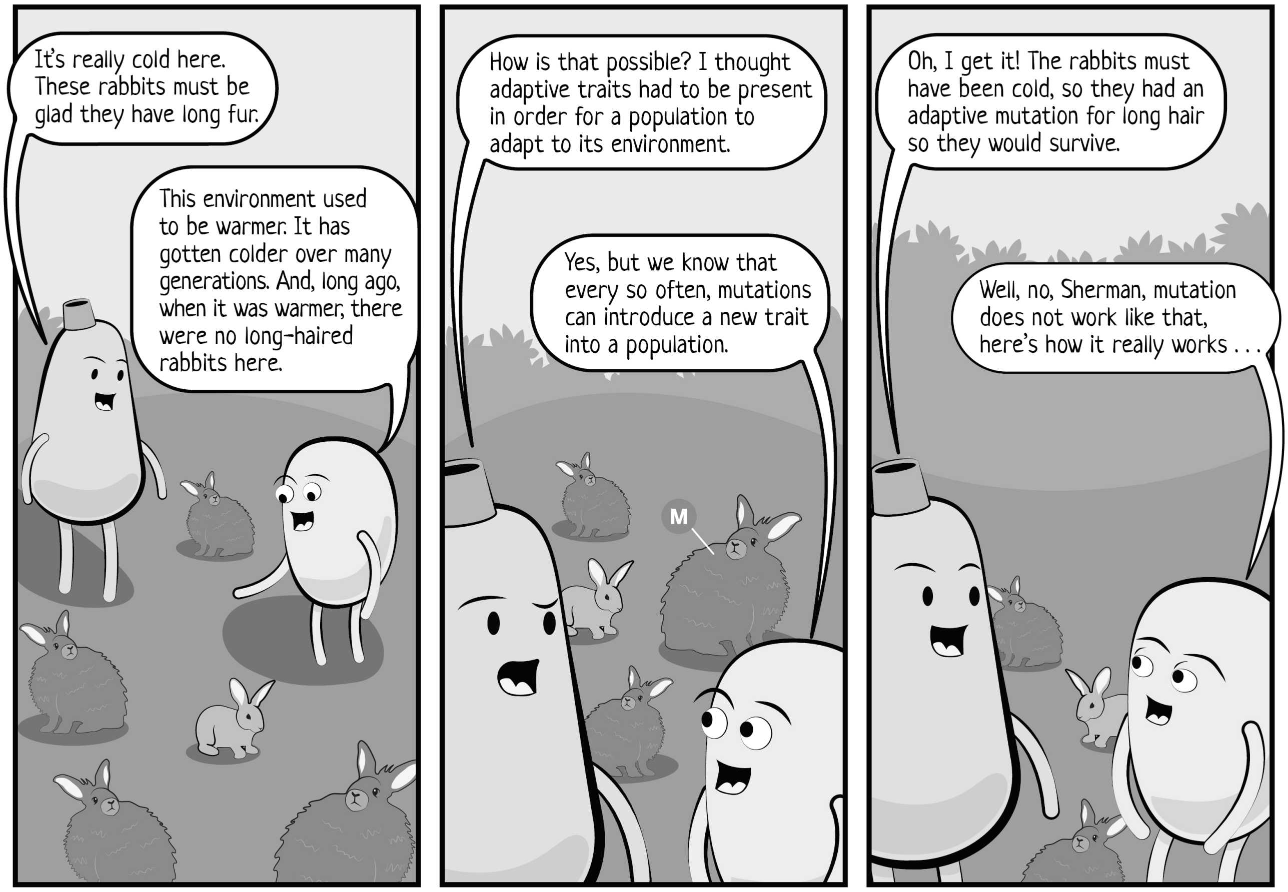
- adaptive trait
- cause
- claim
- distribution
- effect
- environment
- evidence
- gene
- generation
- mutation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- reasoning
- refute
- scientific argument
- trait
- variation

Name: ____________________ Date: ____________

Warm-Up

Reread the story below and then respond to the question.

Sherman's Stories #4: Long-Haired Rabbits



Why did the mutation that resulted in a long-hair trait in these rabbits become more common in the population?

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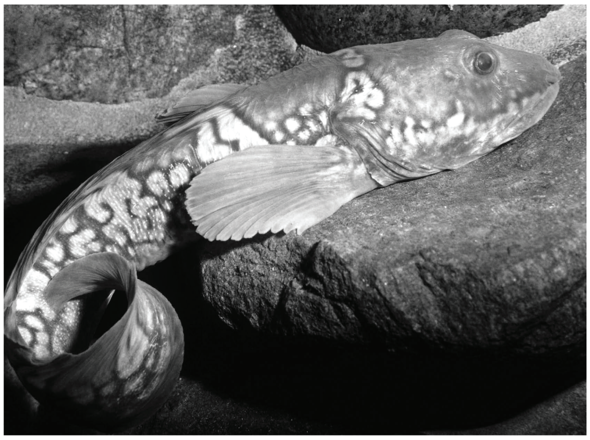
Name: ______________________________ Date: ________________

Write and Share Routine

Discussing How Mutations Change Trait Distribution



Antarctic eelpouts are a type of fish that can be up to three-feet long and that look like eels. They can range in color from yellow to brown. They are found in very cold water, such as in the water near Antarctica.

There are three histograms on your sheet. At Time 1, Antarctic eelpouts used to live in warmer water. When land masses moved millions of years ago, the water became much colder. Time 2 represents some time after the environment changed. Time 3 represents many generations after the environment changed.

Each student in your group will consider a different data set that shows possible changes in a population, given these conditions.

Did mutations affect which trait was the most common at Time 3? Why or why not?

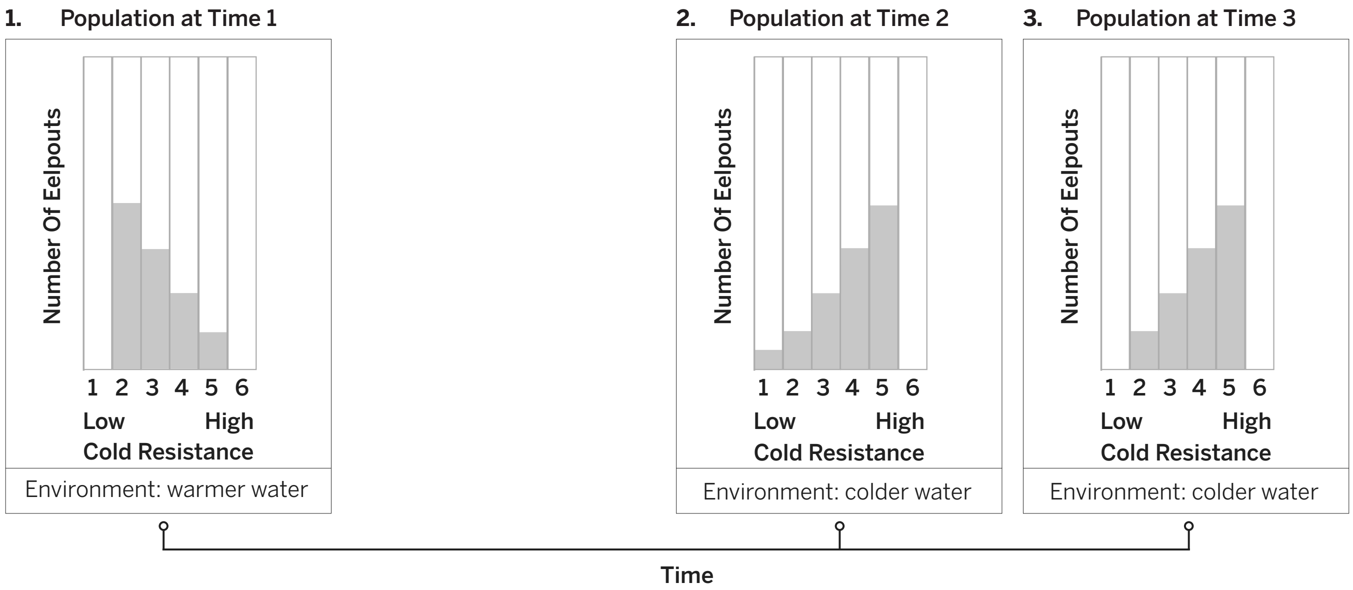
Find the sheet that has the number you were assigned (1, 2, or 3) on the following pages. Follow the instructions below to participate in the Write and Share routine.

1. Carefully read and annotate the information you are given.
2. Answer your prompt, using the vocabulary words listed.
3. After everyone in your group has had a chance to write, take turns introducing your prompts and sharing your responses.
4. While one student is presenting, the other two listen carefully.
5. After each student presents, the other students in the group can ask questions or make comments.

Name: ____________________ Date: ____________

Write and Share Routine: Student 1

At Time 1, the Antarctic eelpout lived in warmer water. When land masses moved millions of years ago, the water became colder. Time 2 represents some time after the environment changed. Time 3 represents many generations after the environment changed. Review the histograms below.



Did mutations affect which trait was the most common at Time 3? Why or why not?

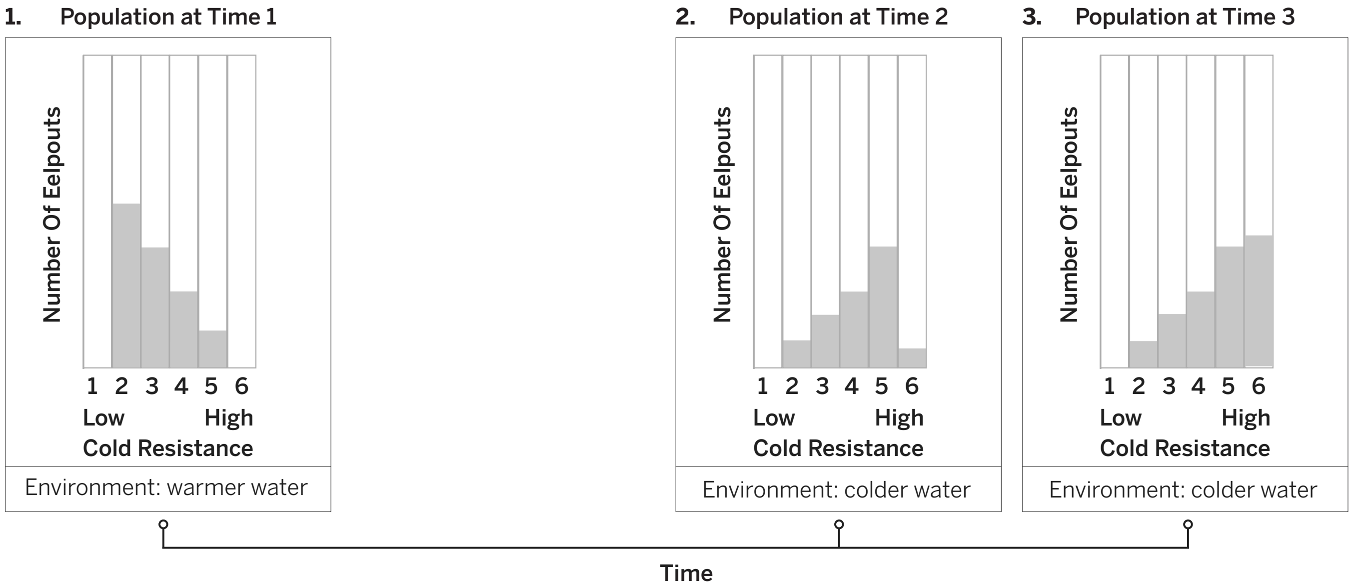
Add annotations to the histograms to help you answer this question. Then, write an explanation about your annotations below. Use all of these words in your explanation:

- adaptive trait
- environment
- mutation
- non-adaptive trait

Name: ______________________ Date: ______________

Write and Share Routine: Student 2

At Time 1, the Antarctic eelpout lived in warmer water. When land masses moved millions of years ago, the water became colder. Time 2 represents some time after the environment changed. Time 3 represents many generations after the environment changed. Review the histograms below.



Did mutations affect which trait was the most common at Time 3? Why or why not?

Add annotations to the histograms to help you answer this question. Then, write an explanation about your annotations below. Use all of these words in your explanation:

- adaptive trait
- environment
- mutation
- non-adaptive trait

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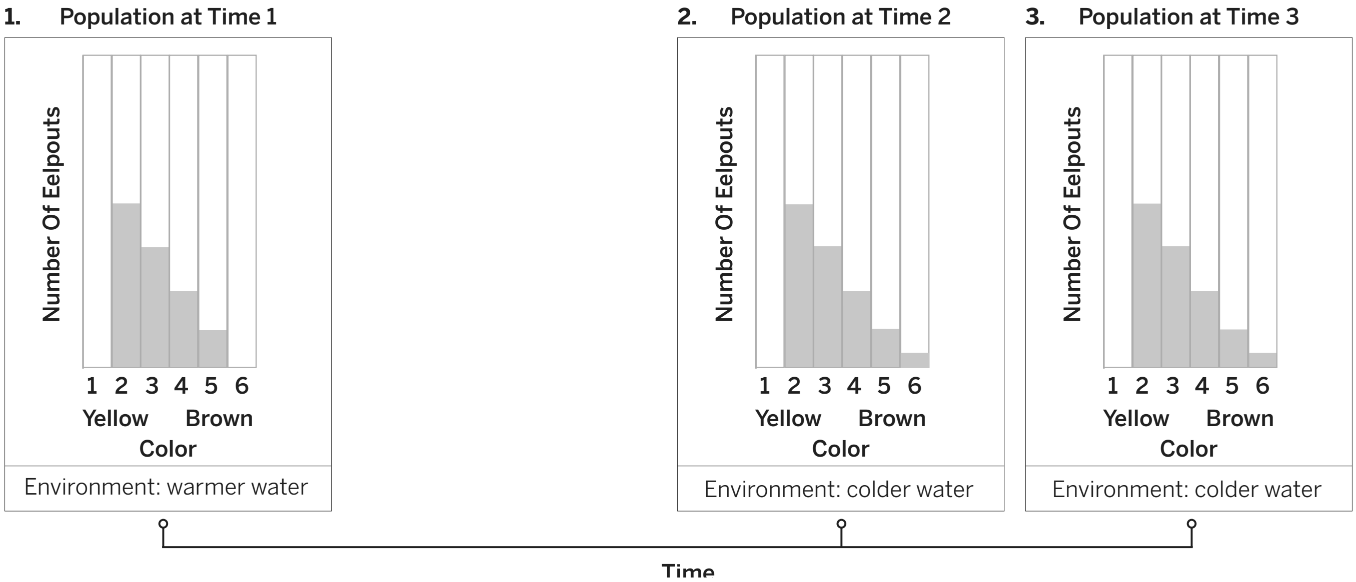
Name: ______________________ Date: ______________

Write and Share Routine: Student 3

At Time 1, the Antarctic eelpout lived in warmer water. When land masses moved millions of years ago, the water became colder. Time 2 represents some time after the environment changed. Time 3 represents many generations after the environment changed. Review the histograms below.



Did mutations affect which trait was the most common at Time 3? Why or why not?

Add annotations to the histograms to help you answer this question. Then, write an explanation about your annotations below. Use all of these words in your explanation:

- adaptive trait
- environment
- mutation
- non-adaptive trait

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Name: ______________________________ Date: ________________

Preparing Your Final Report to Alex Young

Goal: Show what caused there to be some extremely poisonous newts in today's newt population when there were none in the newt population 200 generations ago.

Do:

- Analyze all four histograms and environment descriptions.
- Label Histogram 3 with any Trait labels that apply.

Tips:

- You can add multiple Trait labels to a single trait.
- You can use Trait labels more than once, and you do not have to use all of them.

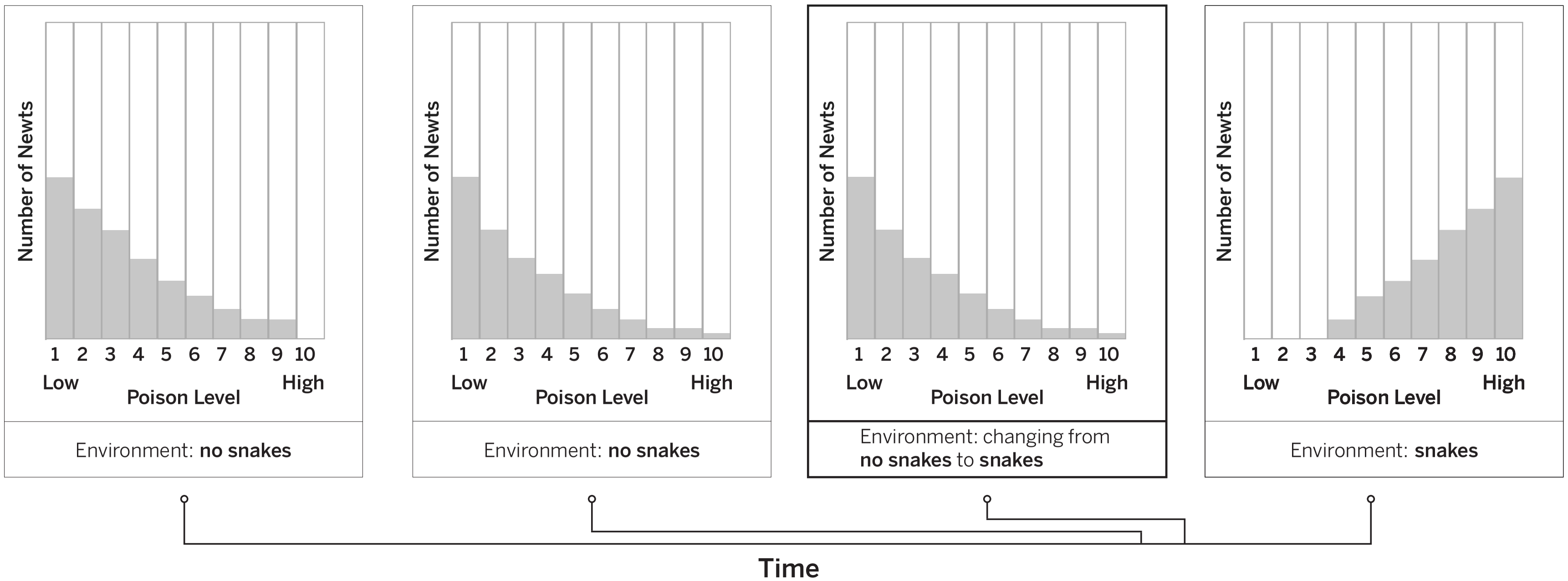
Complete your Newt Mystery Explanation model on the next page, then explain how your model answers the question: *How did a poison-level trait that wasn't always present in the newt population become the most common trait?*

Name: ______________________ Date: ____________

Newt Mystery Explanation

Goal: Show what caused there to be some extremely poisonous newts in today's newt population when there were none in the newt population 200 generations ago.

1. Population 200 Generations Ago | 2. Population 50 Generations Ago | 3. Population 40 Generations Ago | 4. Population Today



Trait Labels

+s = **more** likely to survive

-s = **less** likely to survive

+o = likely to have **more** offspring

-o = likely to have **fewer** offspring

m = trait introduced by mutation

Name: ______________________________ Date: ______________

Homework: Reading "The Stickleback Fish in Its Environment"

Read and annotate the "The Stickleback Fish in Its Environment" article and answer the reflection question.

What are some of the traits described in the article that are present in the stickleback population?

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Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ______________________ Date: ______________

Homework: Reading “The Stickleback Fish in Its Environment”
(continued)

What is one interesting thing you learned from reading this article?

Name: ____________________ Date: ____________

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

Scientists investigate in order to figure things out. You have been investigating why the newt population in Oregon State Park became more poisonous over time in order to share your ideas with biologist Dr. Alex Young. Are you getting closer to figuring out why the trait for high-poison level became more common in the newt population over time?

1. I understand how a histogram can be used to represent and describe the traits in the newt population. (check one)

   ☐ yes ☐ not yet

Explain your choice above.

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2. I understand why high-poison levels are adaptive in one environment but not adaptive in another. (check one)

   ☐ yes ☐ not yet

Explain your choice above.

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3. I understand how the number of newts with high-poison levels increased over time. (check one)

   ☐ yes ☐ not yet

Explain your choice above.

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Name: ______________________ Date: ______________

Homework: Check Your Understanding (continued)

4. I understand why a new trait may or may not become more common in a population. (check one)

☐ yes ☐ not yet

Explain your choice above.

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5. What do you still wonder about how the trait for high-poison level became more common in the newt population over time?

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Name: ______________________ Date: ______________

Chapter 4: Science Seminar
Chapter Overview

Newts aren't the only organisms that have changed over time. Natural selection is happening all around us! In Chapter 4, you will apply what you have learned and use evidence to decide how a population of stickleback fish could have less armor and become faster over time.

Name: ______________________________ Date: ____________________

Lesson 4.1: Examining Evidence About Sticklebacks

Alex Young has one final mission for you. In the next few lessons, you will learn more about a new organism, the three-spined stickleback fish. Other student biologists have been studying a population of stickleback fish that has changed dramatically over only 13 generations. The distribution of traits in this population shifted from mostly slower, more armored individuals to faster, less armored individuals. Today, you will receive evidence about the sticklebacks, their predators, and their prey. You will analyze this evidence and then discuss with a partner how this new evidence relates to the claims about what caused the stickleback population to change. The work you do today will help you prepare for the Science Seminar in the next lesson.

Unit Question

- Why do populations change over time?

Chapter 4 Question

- What caused the stickleback population to have less armor and become faster?

Key Concepts

- A population can be described by the traits present and by the number of individuals who have each trait.
- The number of individuals with each trait in a population can change over time.
- Over many generations, individuals with adaptive traits become more common in a population, while individuals with non-adaptive traits become less common.
- The traits that exist in a population determine which traits can become more common over many generations.
- Whether or not a trait is adaptive depends on the environment.
- Biologists analyze data about environmental conditions (the causes) to explain changes in the distribution of traits in populations (the effects).
- Genes are instructions for making protein molecules and protein molecules determine an organism's traits.
- Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.
- Individuals with adaptive traits are more likely to live longer and have offspring; individuals with non-adaptive traits are more likely to die without having offspring.

Name: ______________________________ Date: ________________

Lesson 4.1: Examining Evidence About Sticklebacks (continued)

Key Concepts

- Mutations are changes to genes that can lead to changes to protein molecules, which can result in changes to traits.
- Mutations to genes can sometimes introduce new traits into a population.
- A new trait will only become more common in a population if it is adaptive.

Vocabulary

- adaptive trait
- claim
- distribution
- environment
- evidence
- gene
- generation
- mutation
- natural selection
- non-adaptive trait
- pattern
- population
- protein molecule
- reasoning
- scientific argument
- trait
- variation

Name: ______________________ Date: ______________

Warm-Up

Learning About a New Organism

In the next few lessons, you will be learning about an organism called the stickleback fish.

- Reread the first paragraph of the article, "The Stickleback Fish In Its Environment."
- Observe the image of the sticklebacks underneath the paragraph and read the caption.
- Then, answer the questions below.

The less armor a stickleback fish has, the faster it swims.

1. Describe an environment where a lot of armor is an adaptive trait.

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2. Describe an environment where armor is a non-adaptive trait.

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Name: ____________________ Date: ____________

Introducing Sticklebacks

To: Student Biologists
From: Dr. Alex Young, Head Biologist
Subject: New Question About Sticklebacks

Thank you for your thorough explanations of what happened to the population of rough-skinned newts. I will be presenting your findings to the park visitors with the hope of helping them better understand this population here in the park!

Now, I have a new mission for you. My colleagues would like your help with an ongoing study of sticklebacks, a type of small fish found all over the Northern Hemisphere. These fish can live in saltwater or freshwater environments. I have shared several evidence cards with you, so you can determine which claim is supported by evidence. Good luck!

Name: ______________________________ Date: ________________

Examining Evidence About Sticklebacks

Annotating Evidence

Science Seminar Question: *What caused the stickleback population to have less armor and become faster?*

Claim 1: The sticklebacks have less armor so that they can escape predators.

Claim 2: The sticklebacks have less armor so that they can catch prey.

- Carefully read and annotate each evidence card. Write connections and questions you think of as you read.
- If you come across a word you don't know, circle it. Write a short summary on each card after you read it.

Name: ______________________________ Date: ________________

Discussing Evidence and Claims

Sorting the Evidence

1. With a partner, discuss whether each piece of evidence supports *or* goes against Claims 1 and 2. Use the sentence starters below if you need help getting started.
2. Make annotations on each evidence card:
   - If the evidence supports a claim, write: "supports Claim 1 *or* 2" on that card.
   - If the evidence goes against a claim, write: "goes against Claim 1 *or* 2" on that card.
   - If the evidence on one card connects with another, write: "connects with Evidence Card A (*or* B, C, D, E, F)" on that card.
3. Sort the evidence by placing the cards underneath the claim it supports on the appropriate Argument Organizer.

Sentence Starters

- I think this evidence supports this claim because . . .
- I don't think this evidence supports this claim because . . .
- I agree because . . .
- I disagree because . . .
- I think that . . .

Name: ______________________________ Date: ________________

Lesson 4.2: Engaging in a Science Seminar

Why did the stickleback population change? In today's Science Seminar, you and your fellow student biologists will discuss this question, using all the evidence you have collected to argue whether the predators or prey were the factor that caused the high-speed trait to become more common in the stickleback population. By the end of the lesson, you will be ready to write a convincing scientific argument.

Unit Question

- Why do populations change over time?

Chapter 4 Question

- What caused the stickleback population to have less armor and become faster?

Key Concepts

- A population can be described by the traits present and by the number of individuals who have each trait.
- The number of individuals with each trait in a population can change over time.
- Over many generations, individuals with adaptive traits become more common in a population, while individuals with non-adaptive traits become less common.
- The traits that exist in a population determine which traits can become more common over many generations.
- Whether or not a trait is adaptive depends on the environment.
- Biologists analyze data about environmental conditions (the causes) to explain changes in the distribution of traits in populations (the effects).
- Genes are instructions for making protein molecules and protein molecules determine an organism's traits.
- Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.
- Individuals with adaptive traits are more likely to live longer and have offspring; individuals with non-adaptive traits are more likely to die without having offspring.
- Mutations are changes to genes that can lead to changes to protein molecules, which can result in changes to traits.
- Mutations to genes can sometimes introduce new traits into a population.
- A new trait will only become more common in a population if it is adaptive.

Name: ______________________________ Date: ______________

Lesson 4.2: Engaging in a Science Seminar (continued)

Vocabulary

- adaptive trait
- cause
- claim
- distribution
- effect
- environment
- evidence
- gene
- generation
- mutation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- reasoning
- refute
- scientific argument
- trait
- variation

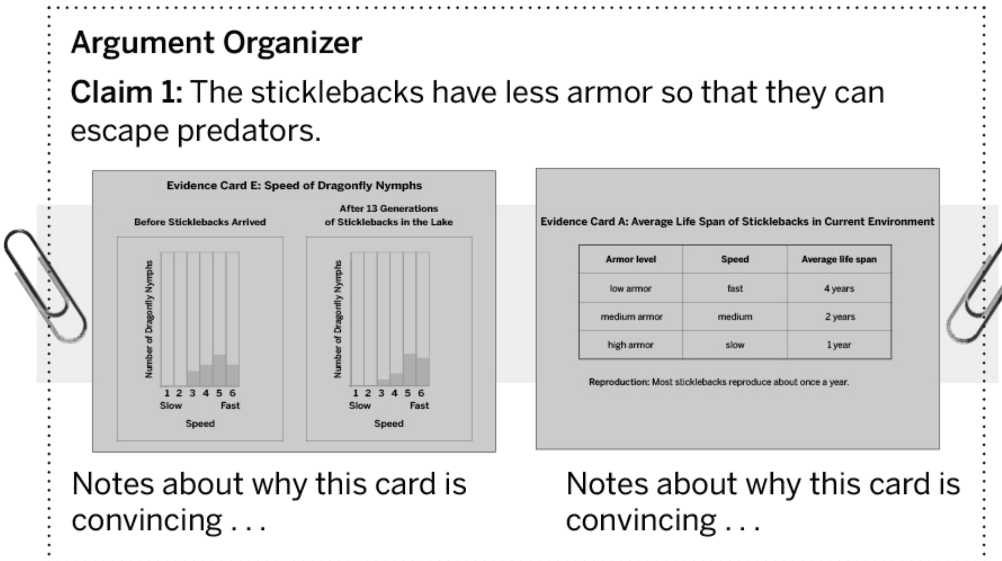
Name: ______________________________ Date: ________________

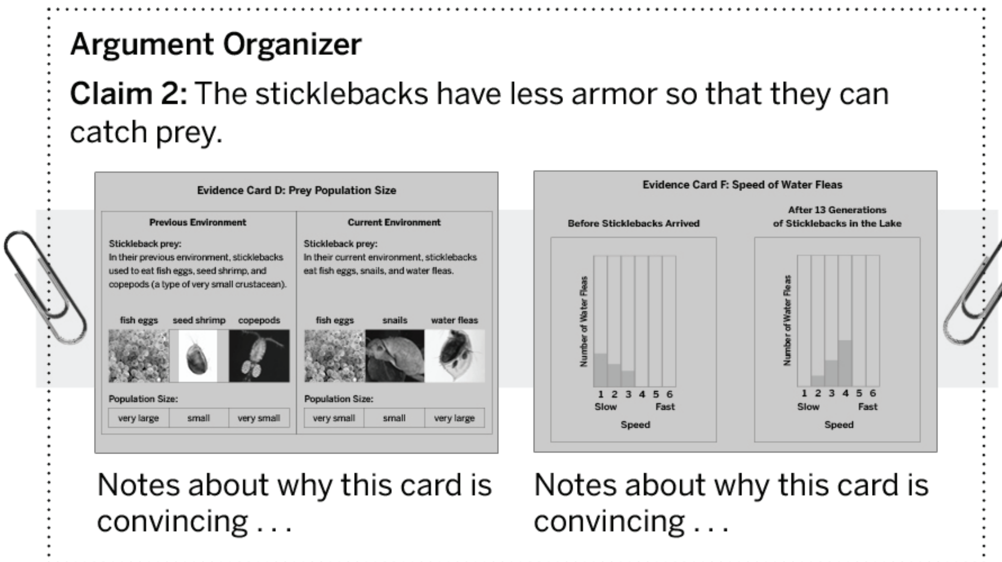
Warm-Up

Revisiting the Evidence

Take out your Argument Organizer sheets.

1. Examine each evidence card carefully.
2. Choose the two cards that are most convincing for Claim 1. Clip these on top of the Argument Organizer sheet for Claim 1. Clip any remaining cards underneath as shown below.
3. Choose the two cards that are most convincing for Claim 2. Clip these on top of the Argument Organizer sheet for Claim 2. Clip any remaining cards underneath as shown below.
4. Record some notes on the Argument Organizer sheets that will help you remember what you want to say about your most convincing cards.





Name: ____________________ Date: ____________

Preparing for the Science Seminar

Preparing Your Science Seminar Argument

1. With your partner, take turns sharing which claim you think is the most convincing and why.
2. Use your Warm-Up responses and the Scientific Argument Sentence Starters (below) for help.
3. Refer to the Stickleback Evidence Cards and claims below as needed.

What caused the stickleback population to have less armor and become faster?

Claim 1: The sticklebacks have less armor so that they can escape predators.

Claim 2: The sticklebacks have less armor so that they can catch prey.

Scientific Argument Sentence Starters	
Describing evidence:	**Describing how the evidence supports the claim:**
The evidence that supports my claim is . . .	If ____________, then . . .
My first piece of evidence is . . .	This change caused . . .
Another piece of evidence is . . .	The effect of this change was . . .
This evidence shows that . . .	This is important because . . .
	Since ____________, . . .
	Based on the evidence, I conclude that . . .
	This claim is stronger because . . .

Name: ______________________ Date: ______________

Science Seminar Observations

Write a check mark in the right-hand column every time you hear one of your peers say or do something listed in the left-hand column. If you hear an interesting idea, write it in the last row of the table.

Observations during the seminar	Check marks
I heard a student use evidence to support a claim.	
I heard a student respectfully disagree with someone else's thinking.	
I heard a student explain how her evidence is connected to her claim.	
I heard a student evaluate the quality of evidence.	
I heard an idea that makes me better understand one of the claims. That idea is: ______________________ ______________________ ______________________ ______________________	

Name: ______________________ Date: ______________

Homework: Reflecting on the Science Seminar

Now that the Science Seminar is over, think back on the claim you selected. After participating in the discussion, you may have changed your mind about which claim is best. Describe your current thinking by answering the questions below.

What caused the stickleback population to have less armor and become faster?

1. Which claim do you think is the most convincing? (circle one).

   Claim 1: The sticklebacks have less armor so that they can escape predators.

   Claim 2: The sticklebacks have less armor so that they can catch prey.

2. Did the Science Seminar cause you to change your thinking about the claims? Explain your answer.

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Name: ______________________________ Date: ______________________

Lesson 4.3: Writing a Scientific Argument

What explains the change in the stickleback population? Why are stickleback fish faster, and why do they have less armor compared to 13 generations ago? Is it to escape predators or to catch prey? It is time for you to write your scientific argument. Today, you will review the evidence, using the Reasoning Tool to organize your thinking. You will then make your case to Alex Young, explaining why the stickleback population has changed so much. Before you start, think about how you can make your argument even more convincing.

Unit Question

- Why do populations change over time?

Chapter 4 Question

- What caused the stickleback population to have less armor and become faster?

Key Concepts

- A population can be described by the traits present and by the number of individuals who have each trait.
- The number of individuals with each trait in a population can change over time.
- Over many generations, individuals with adaptive traits become more common in a population, while individuals with non-adaptive traits become less common.
- The traits that exist in a population determine which traits can become more common over many generations.
- Whether or not a trait is adaptive depends on the environment.
- Biologists analyze data about environmental conditions (the causes) to explain changes in the distribution of traits in populations (the effects).
- Genes are instructions for making protein molecules and protein molecules determine an organism's traits.
- Individuals inherit their genes from their parents. Genes, and therefore traits, in a population are passed down from generation to generation.
- Individuals with adaptive traits are more likely to live longer and have offspring; individuals with non-adaptive traits are more likely to die without having offspring.
- Mutations are changes to genes that can lead to changes to protein molecules, which can result in changes to traits.

Name: ______________________ Date: ______________

Lesson 4.3: Writing a Scientific Argument (continued)

Key Concepts

- Mutations to genes can sometimes introduce new traits into a population.
- A new trait will only become more common in a population if it is adaptive.

Vocabulary

- adaptive trait
- cause
- claim
- distribution
- effect
- environment
- evidence
- gene
- generation
- mutation
- natural selection
- non-adaptive trait
- population
- prediction
- protein molecule
- reasoning
- refute
- scientific argument
- trait
- variation

Name: ______________________ Date: ______________

Warm-Up

Making a Convincing Argument

As you know, reasoning is what connects your evidence to your claim. Sometimes, before you use reasoning, you can combine two pieces of evidence in order to best support a claim.

- Read the claims and the evidence below about wolves and dogs.
- Consider which two pieces of evidence you could combine in order to best support each claim.

Claim 1: Dogs still act like wolves in many ways.

Claim 2: Dogs are more tame than wolves.

Evidence Card A	Evidence Card B	Evidence Card C	Evidence Card D
Dogs can smell prey from far away.	Wolves can smell prey from far away.	Wolves hunt and kill prey in order to survive.	Most dogs do not hunt prey anymore.

1. The evidence cards that can best be combined together to support Claim 1 are: (check one)

☐ Evidence Cards A and B

☐ Evidence Cards A and C

☐ Evidence Cards B and D

☐ Evidence Cards C and D

2. The evidence cards that can best be combined together to support Claim 2 are: (check one)

☐ Evidence Cards A and B

☐ Evidence Cards A and C

☐ Evidence Cards B and D

☐ Evidence Cards C and D

Name: ______________________ Date: ______________

Using the Reasoning Tool

When scientists support a claim, they show their reasoning process, making it clear how the evidence connects to the claim. This makes their arguments convincing.

Use the Science Seminar Reasoning Tool sheet to explain how the evidence supports your claim. Follow the instructions below.

Claim 1: The sticklebacks have less armor so that they can escape predators.

Claim 2: The sticklebacks have less armor so that they can catch prey.

Using the Reasoning Tool to Support Your Claim

1. In the right column, record the claim that you think is best supported by the evidence. You may record your own claim if you prefer.
2. In the left column, tape the evidence cards that support your claim. You do not need to use all of the evidence cards, but you should use more than one to support your claim.
3. In the middle column, record how the evidence card in the left column connects to the claim in the right column.

Evidence	**This matters because . . .** (How does this evidence support the claim?)	**Therefore . . .** (claim)

Name: ______________________________ Date: ________________

Preparing to Write

Plan how you will use your Reasoning Tool to write your argument. Use the example to guide you.

Organizing Your Reasoning Tool

- Draw a circle around your strongest piece of evidence.
- Draw an X over a piece of evidence if you do not plan to use it in your argument.
- Draw an arrow to connect two pieces of evidence if you think that they go together.

Example

Evidence	This matters because . . . (How does this evidence support the claim?)	Therefore, . . . (claim)
Example Evidence Card A	Your ideas about how the evidence supports the claim	Your claim
Example Evidence Card B	Your ideas about how the evidence supports the claim	
Example Evidence Card C	Your ideas about how the evidence supports the claim	

Name: ____________________ Date: ____________

Writing a Scientific Argument

Scientific Argument Sentence Starters	
Describing evidence: The evidence that supports my claim is . . . My first piece of evidence is . . . Another piece of evidence is . . . This evidence shows that . . .	**Describing how the evidence supports the claim:** If __________, then . . . This change caused . . . The effect of this change was . . . This is important because . . . Since __________, . . . Based on the evidence, I conclude that . . . This claim is stronger because . . .

Write a scientific argument to Alex Young that addresses the question: W*hat caused the stickleback population to have less armor and become faster?*

1. Review your completed Reasoning Tool. Be sure to include your strongest piece of evidence in your argument and make a connection between the pieces of evidence that go together.
2. State your claim and show how it could explain the change in the population. Then, use evidence to support your claim.
3. Use the Scientific Argument Sentence Starters to help you explain your thinking.
4. To make your argument more convincing, be sure to consider the following questions:
   - Does your argument clearly explain why the distribution of traits has shifted so much in the stickleback population?
   - Do you describe your supporting evidence?
   - Do you thoroughly explain how the evidence supports your claim?

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Name: ______________________ Date: ______________

Writing a Scientific Argument (continued)

Name: ______________________ Date: ______________

Homework: Revising an Argument

1. Reread your scientific argument about why the stickleback population has less armor and is faster compared to 13 generations ago. If needed, finish writing your argument.

2. Then, look for ways you could make your argument clearer or more convincing. Consider reading your argument aloud or having another person read it.

3. Consider the following questions as you review your argument:
   - Does your argument clearly explain why the distribution of traits have shifted so much in the stickleback population?
   - Do you describe your supporting evidence?
   - Do you thoroughly explain how the evidence supports your claim?

4. Rewrite any sections of your argument that could be clearer or more convincing.

Name: ______________________ Date: ______________

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

1. I understand that scientists connect evidence to their claims to make stronger arguments. (check one and explain your answer choice)
   ☐ yes ☐ not yet

____

____

____

____

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2. What are the most important things you have learned in this unit about how populations change over time?

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3. What questions do you still have?

____

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Natural Selection Glossary

adaptive trait: a trait that makes it more likely that an individual will survive in a specific environment

rasgo adaptativo: un rasgo que hace más probable que un individuo sobreviva en un ambiente específico

ancestor: a related organism from a previous generation

ancestro: un organismo emparentado de una generación anterior

camouflage: a way of hiding by looking the same as the background

camuflaje: una manera de esconderse luciendo igual que el fondo

cause: an event or process that leads to a result or change

causa: un evento o proceso que provoca un resultado o cambio

chromosome: a long piece of DNA that contains many genes

cromosoma: un pedazo largo de ADN que contiene muchos genes

distribution: the number of individuals with each trait in a population

distribución: el número de individuos que tienen cada rasgo en una población

DNA: a type of molecule that genes and chromosomes are made of

ADN: un tipo de molécula de la que están hechos los genes y los cromosomas

effect: a result or change that happens because of an event or process

efecto: un resultado o cambio que ocurre debido a un evento o proceso

environment: everything (living and nonliving) that surrounds an organism

ambiente: todo (viviente y no viviente) lo que rodea a un organismo

feature: a characteristic that all members of a species have

atributo: una característica que tienen todos los individuos de una especie

gene: an instruction for making a protein molecule

gen: una instrucción para formar una molécula de proteína

gene version: a specific form of a gene that provides instructions for making a particular protein molecule

versión de gen: una forma específica de un gen que proporciona instrucciones para hacer una molécula de proteína particular

Natural Selection Glossary (continued)

generation: a group of individuals born and living at about the same time

generación: un grupo de individuos que nacieron y viven aproximadamente al mismo tiempo

histogram: a graph that uses bars to show how characteristics or values are distributed within a group

histograma: una gráfica que usa barras para mostrar cómo se distribuyen las características o los valores dentro de un grupo

inherit: to receive genes from a parent

heredar: recibir genes de uno de los padres

mutation: a random change to a gene that sometimes results in a new trait

mutación: un cambio aleatorio a un gen que a veces da como resultado un rasgo nuevo

natural selection: the process by which the distribution of traits in a population changes over many generations

selección natural: el proceso por medio del cual cambia la distribución de rasgos en una población con el paso de muchas generaciones

non-adaptive trait: a trait that makes it less likely that an individual will survive in a specific environment

rasgo no adaptativo: un rasgo que hace menos probable que un individuo sobreviva en un ambiente específico

nymph: a young insect that looks somewhat different from the adult

ninfa: un insecto joven que luce un poco diferente al adulto

offspring: an organism produced as a result of reproduction

descendencia: un organismo producido como resultado de la reproducción

organisms: living things, such as plants, animals, and bacteria

organismos: seres vivientes, como plantas, animales y bacterias

population: a group of the same type of organism living in the same area

población: un grupo del mismo tipo de organismo que vive en la misma área

predator: an animal that hunts and kills other animals for food

depredador: un animal que caza y mata a otros animales para alimentarse

Natural Selection Glossary (continued)

prediction: an idea about what might happen that is based on what you already know

predicción: una idea acerca de lo que podría suceder que está basada en lo que tú ya conoces

prey: an animal that is hunted or killed by another animal for food

presa: un animal al cual otro animal caza o mata para alimentarse

protein molecule: a type of large molecule that performs important functions inside organisms

molécula de proteína: un tipo de molécula grande que desempeña funciones importantes dentro de organismos

selection pressure: something in the environment that affects an individual's chances of surviving

presión de selección: algo en el ambiente que afecta las posibilidades de sobrevivir de un individuo

sexual reproduction: the process in which two parents pass on their genes to create offspring

reproducción sexual: el proceso en el cual un padre y una madre transmiten sus genes para generar descendencia

species: a group of organisms of the same kind (in one or more populations) that do not reproduce with organisms from any other group

especie: un grupo de organismos del mismo tipo (que viven en una o más poblaciones) que no se reproducen con organismos de ningún otro grupo

survive: to stay alive

sobrevivir: mantenerse vivo

trait: a specific characteristic of an individual organism

rasgo: una característica específica de un organismo individual

variation: any difference in traits between individual organisms

variación: cualquier diferencia de rasgos entre organismos individuales

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Natural Selection:

Poisonous Newts

Article Compilation

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The Rough-Skinned Newt

Rough-skinned newts may not appear dangerous: they are no longer than 20 centimeters (8 inches), with stubby legs and teeth that look like tiny bumps. However, some of these newts are the most poisonous animals in the Pacific Northwest. One rough-skinned newt can have enough poison in its body to kill dozens of humans!

Rough-skinned newts have brown, bumpy skin on their backs, with bright orange skin on their bellies. When threatened by predators, newts curl their bodies to show the orange undersides of their necks and tails. The orange color warns predators to stay away, and most predators do. The only predators that regularly eat rough-skinned newts are common garter snakes.

Newts hatch in the water, but they spend most of their lives on land, often hiding under fallen leaves or bark. At night, they hunt for insects, tiny fish, and other small prey. When they are ready to mate, rough-skinned newts return to the water, where males and females swim together in pairs. The females lay poisonous eggs and attach them to underwater plants.

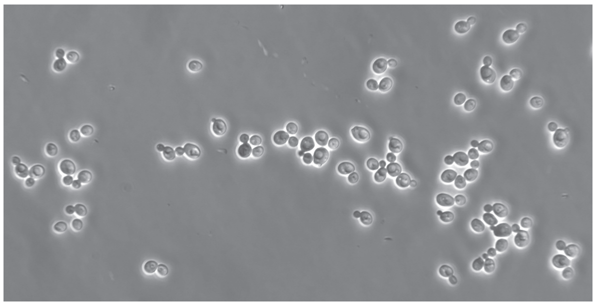
Rough-skinned newts have brown, bumpy skin on their backs and orange skin on their bellies.

Rough-skinned newts spend most of their time on land, but return to the water when it's time to mate.

Meet a Scientist Who Studies Natural Selection

Dr. Dave Yuan studies natural selection using yeast. Since yeast reproduce very quickly, he can change the yeast organisms' environment and watch how their traits are passed down over many generations.

Dave Yuan spends his days surrounded by millions of yeast, the one-celled organisms used to make bread rise. However, Yuan isn't a baker—he's a geneticist who studies natural selection. Yeast are good organisms for studying natural selection, because they reproduce very quickly. Scientists can control the yeast organisms' environment and watch what happens to many generations of yeast in a short period of time as they pass genes down. "We use a special tool to bar code different lineages (family lines) of yeast—there are about half a million unique lineages," says Yuan. "We can watch natural selection under all kinds of conditions. For example, we can grow yeast until there's no more food or space for them, then transfer them to a fresh environment and see what happens." Yuan and his team do this type of experiment 50 to 100 times over a few months, then see how certain traits are distributed in the population of yeast. Lineages that developed adaptive traits should be more common in the population because they have lived long enough to pass on their genes, while lineages that developed non-adaptive traits should be less common in the population.



These are tiny living yeast cells seen through a microscope.

It's no surprise to Yuan that he grew up to be a scientist. He's always been interested in science, especially in understanding how there came to be so many different types of organisms on Earth. He majored in biology in college, then worked as a lab assistant for a few years—he wanted to try out scientific research as a job to see whether he liked it. After a few years, he decided to go to graduate school, and today he works as a researcher studying natural selection at the molecular level.

For Yuan, studying natural selection is exciting because he sometimes learns things that nobody has ever known before. “I like that whatever I work on, I’m working toward discovery of some kind,” he says. “You’re in the lab all day, but at a higher level, what you’re doing is on the cutting edge of what we’re learning. We’re actually discovering things.”

On the other hand, he says things don’t always go as planned. “Failure is something that every lab scientist is very familiar with, but I think that’s not well known outside of research,” he says. Since he and his team are working with new information and technologies, they sometimes run into problems that nobody expected—and they have to solve them. “These are experimental systems,” he says. “We make things up as we go and troubleshoot, look at what we have and try to deal with very complicated machines. A lot of times, things just don’t work, and it can be frustrating.”

When Yuan thinks about his path to working as a scientist, he wishes he could tell his younger self a few things—like the importance of learning as much math as he could. “I was pretty good at math in junior high and high school, but I didn’t like it. I thought, ‘you just have to get through this and then never use it again,’ but that’s not really true.” Yuan says he uses math and statistics every day in his research. A background in computer coding would be helpful, too. Computer coding is “a very useful tool” for scientific research, according to Yuan.

Yuan plans to continue studying natural selection—but he hopes someday to do his work outside of the lab. Some biologists study natural selection in the field, taking trips to different environments to observe and gather information, and Yuan hopes to be one of them: “I’ve always wanted to do something where I get to go out into nature,” he says. “It’s rare, but there are people who do it!”

Wildlife in the Woods

Chapter 1: Introduction

The forests of Oregon are full of organisms—animals and plants, big and small, furry and feathered and scaly. All of these organisms have traits that make them well-suited to living in the environment of Oregon. To learn about some of the organisms of the Oregon forest, read one or more of the chapters that follow.

Parts of Oregon are covered with forests. Those forests are home to all kinds of organisms.

Chapter 2: Western Harvest Mouse

Western harvest mice are tiny, even for mice: an adult only grows to about 7.6 centimeters (3 inches) long, plus a tail of about the same length. These mice have large, hairless ears, pale bellies, and dark stripes down their backs. Like all mice, they have large front teeth that are good for gnawing hard food.

Western harvest mice got their name because they harvest (pick and eat) the seeds of plants in grassy areas. They hide extra food underground using holes left behind by other small animals. Western harvest mice weave grass into soft nests about the size and shape of a baseball, where they hide all day. These tiny mice mostly come out at night and are especially active on dark, moonless nights when it is harder for predators to see them.

Predators that eat western harvest mice include snakes, owls, hawks, and foxes. To avoid being eaten, the mice spend a lot of time hiding in covered places: they build their nests deep in grass, underground, or under fallen trees.

These tiny mice usually live less than a year, but they reproduce a lot: about once a month, each female may give birth to up to nine babies.

The adult western harvest mouse is only about 7.6 cm (3 in) long.

Chapter 3: Common Garter Snake

Common garter snakes are colorful snakes with long stripes that may be green, blue, red, orange, yellow, or brown. They can grow up to 1.2 meters (4 feet) long, but they are slender and harmless to humans.

Often living along the edges of lakes and ponds, common garter snakes hunt small prey both on land and in the water. Their excellent sense of smell helps them to find and catch young fish, frogs, newts, worms, insects, and other small animals. Like most snakes, they swallow prey whole.

Garter snakes' stripes make it harder for predators to see them when they are hiding in grass or reeds. Predators that eat garter snakes include larger snakes, birds, fish, and dogs. If caught, garter snakes produce a foul odor to try to drive their predators away. Unlike many other snakes, common garter snakes do not lay eggs. Instead, they give birth to live young—as many as 40 little snakes at once!

The stripes of common garter snakes make them harder to see when they're hiding in grass or reeds.

Chapter 4: Western Screech-Owl

The gray-and-white feathers of the western screech-owl blend in perfectly against tree bark, helping it to hide during the day. This small owl has large yellow eyes and two feathery tufts on its head. Western screech-owls often live in tall Douglas fir trees, usually at the edges of ponds or grassy areas.

At night, western screech-owls use their excellent senses of sight and hearing to watch and listen for small prey. They swoop silently down from trees to grab mice, small birds, and large insects with their powerful feet. However, due to their small size, screech-owls have to be on the lookout for larger night predators that might eat them, such as great horned owls, raccoons, and skunks. Western screech-owls use camouflage to stay safe from predators: they stretch to be as tall as possible, hold their feathers flat against their bodies, and close their eyes so they look like part of the branch they're sitting on.

Western screech-owls lay their eggs in holes in trees without adding any sticks or other nesting material. Males and females work together to guard their nests and bring food for the young birds once they hatch. These owls guard their nests boldly, and may even attack humans who come too close.

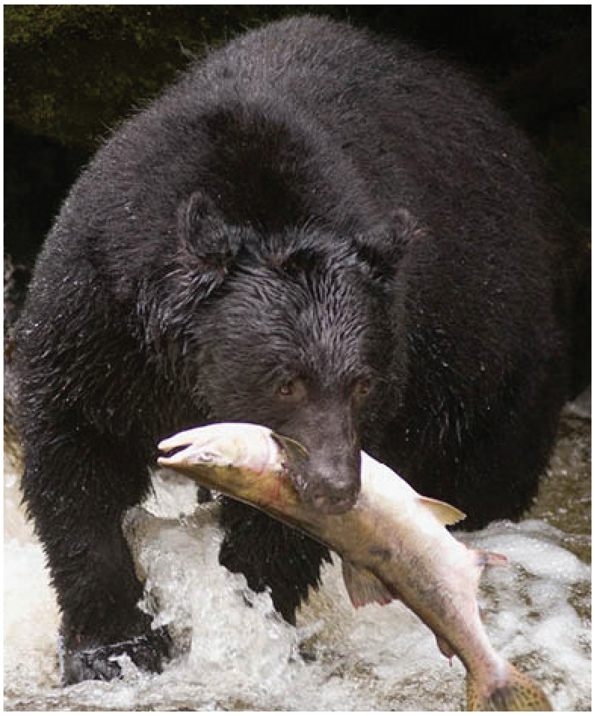
A western screech-owl's markings act as camouflage when it sits in a tree

Chapter 5: American Black Bear

American black bears are not always black: their fur may be brown, reddish, or even white! Large males often grow to weigh about 250 kilograms (550 pounds). Black bears' powerful legs are tipped with long, sharp claws excellent for fighting, climbing trees, and clawing beehives open.

Hungry black bears will eat almost anything. Most of their food comes from plants, including nuts, berries, tree bark, and soft young leaves. They also eat honey, as well as bees, ants, and other insects. Many black bears hunt for salmon in rivers. Black bears don't usually hunt for land animals, but they will eat dead animals when they find them. Black bears are smart and curious, exploring their environment for anything they might be able to eat.

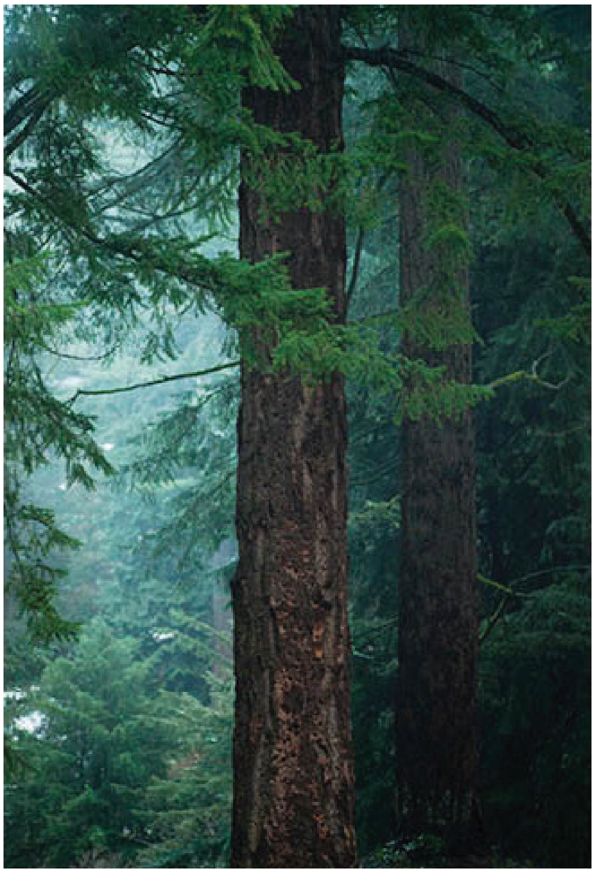
Adult black bears are so big that they are rarely attacked by predators. Instead, the most dangerous part of black bears' environment is people. Many bears are killed by hunters or hit by cars, and the more bears come into contact with humans, the more likely they are to be killed. Black bears also sometimes die because they can't find enough food—it takes a lot of fish, nuts, berries, honey, and insects for such a large animal to stay alive. Bears that must compete with many other bears for their food, or that live in places where food is scarce, may not survive for long.



Black bears eat almost anything, including salmon they hunt in rivers.

Chapter 6: Douglas Fir Tree

Douglas firs are some of the tallest trees on Earth. They can grow more than 91 meters (300 feet) tall, with trunks up to 6 m (20 ft) across! These evergreen trees have blue-green needles and seed-filled cones. Once they shoot up from tiny seeds, Douglas fir trees may live 1,000 years or more. The Douglas fir supplies many other species with the food they need to survive: many birds, insects, and other small animals eat the seeds of Douglas firs, and deer eat soft new needles early in the spring. Black bears like to scrape the bark off young trees and eat the sticky sap that drips out. These species feed off the Douglas fir, but they do not kill it.



Douglas fir trees can grow more than 91 m (300 ft) tall and have trunks more than 6 m (20 ft) across.

One threat to the Douglas fir tree is fire. However, Douglas firs have thick bark that can protect their wood from the heat of forest fires. Insects can also threaten Douglas firs: certain types of beetle burrow into the trees' trunks and can eventually kill the trees. To discourage beetles from invading, Douglas firs can put out large streams of sap that pour down the sides of their trunks. The thick sap fills in any holes the beetles have made, trapping the beetles inside and drowning them. Beetles on the outside of the tree may also be stuck in the sap and die.

Humans are one of the biggest threats to Douglas firs. For thousands of years, people have cut down Douglas firs and used the wood to build houses, boats, and other things. Ancient Hawaiians found Douglas fir logs from across the Pacific Ocean washed up on beaches and used them to build huge canoes.

Chapter 7: Oregon Grape-Holly

Oregon grape-holly was named for its berries, which look like grapes, and its leaves, which look like holly leaves. Like holly, this plant has sharp spines sticking out from the edges of its leaves. The sharp spines protect the leaves from deer and other leaf-eating animals.

In spring, bright yellow flowers bloom on Oregon grape-holly plants—these flowers are the official state flower of Oregon. The flowers give way to clusters of berries in summer, which ripen to become dark purple. Birds, black bears, and other animals eat these sour berries.

Oregon grape-holly berries are dark purple when they're ripe.

Glowing Jellies

Imagine splashing in a calm ocean cove at night. As you splash, you notice green flashes in the water: glowing jellies! These are called crystal jellies. They can't sting humans, so you can swim and watch them glow green as you bump into them.

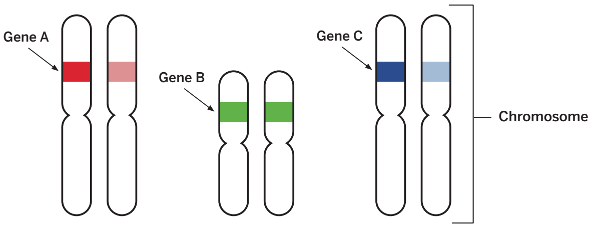
Where does this trait of being able to glow come from? In 1992, some scientists decided to find out. They examined the cells of crystal jellies and discovered that the glow comes from a protein. They gave the protein the name Green Fluorescent Protein, or GFP for short. To find out how these jellies make GFP, scientists investigated the jellies' genes. A gene is instructions for an organism's cells to make a particular protein. Scientists were able to find the gene that gave the jellies' cells instructions to make the GFP protein.

If a jelly has the GFP gene, its cells can make green fluorescent protein. If its cells make green fluorescent protein, the jelly can glow. The gene leads to the protein, which leads to the trait.

How does a jelly get the gene for glowing? When a pair of adult jellies reproduce, each one passes down genes to the offspring. Genes are found on chromosomes and chromosomes come in pairs. An organism has two copies of any given gene because there is one copy on each chromosome in a pair. However, the two copies of any particular gene can be the same version or different versions. These different versions of a gene are called alleles. When jellies reproduce sexually, each parent passes down one of each of their chromosomes (with all their genes on it) to the offspring. If at least one of the adult jellies has the version of the gene that is instructions for GFP, then that gene could be passed down to the offspring. Offspring with that gene will have cells that produce GFP, so they will glow, also.

Scientists think that jellies glow as a defense against predators. The bright glow might startle or confuse predators, or it might attract bigger predators that could scare away or eat the jelly's attacker! Glowing is an adaptive trait for jellies because it helps them survive in their environment.

A protein molecule called Green Fluorescent Protein (GFP) causes some jellies to glow in the dark!



This diagram shows three pairs of chromosomes. Chromosomes have many genes, but in this diagram only shows one for each chromosome. There are two copies of each gene, one on each chromosome of the pair. When an organism reproduces sexually, it gives the offspring one of each of its chromosomes and therefore one copy of each gene.

The Deadly Dare

Rough-Skinned Newt Defenses

Rough-skinned newts may look harmless, but they are extremely poisonous.

In 1979, friends dared a 29-year-old man in Oregon to swallow a living rough-skinned newt. The man didn't realize how poisonous rough-skinned newts are. A lethal, fast-acting poison called tetrodotoxin (TTX) oozes from their skin. The man swallowed the newt whole and started feeling weak a few minutes later. He described a numb feeling all over his body. His friends tried to take him to a hospital, but he refused. Just 20 minutes later, the man was dead.

Of course, the newt the man swallowed died, too. In that particular case, being poisonous didn't help that individual newt survive. If newts have to be eaten in order to defend themselves, being poisonous doesn't sound like a very good defense! How is being poisonous—having a high level of TTX poison—an adaptive trait for a rough-skinned newt?

Why Poison Is Adaptive

One reason TTX is adaptive is that it acts quickly. A predator that tries to eat a poisonous newt may become sick before it's able to kill the newt, allowing the newt to escape. In fact, TTX acts so quickly that sometimes predators die before finishing their meals. Scientists have observed rough-skinned newts crawling out of dead or paralyzed predators.

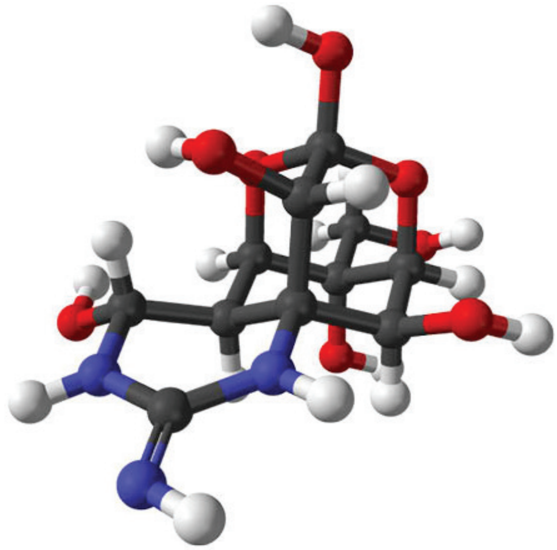
Even more important, predators can smell and taste TTX poison. The main predator of rough-skinned newts is the garter snake. Scientists have found evidence that garter snakes use their senses of smell and taste to tell whether a rough-skinned newt is too poisonous to eat. They have even observed garter snakes doing quick "taste tests"—licking rough-skinned newts before deciding whether to eat them.

Scientists have studied whether garter snakes are able to detect TTX poison in newts. Biologists have placed one newt and one garter snake together in a cage to see whether the snake would eat the newt. They have tried this test over and over again, using different snakes and different newts. Even though the newts are placed directly in front of the snakes, not every newt gets eaten! Biologists are able to consider the cause-and-effect relationship between high poison levels and survival in newts by examining a population of newts with high variation. The newts in the test range from having no poison to having very high levels of TTX in their bodies. In these tests, the snakes consistently eat the newts with the lowest levels of TTX, and do not eat the newts with high levels of TTX. These results are evidence that garter snakes can detect TTX and that they prefer to eat rough-skinned newts with lower levels of TTX. The more poisonous a rough-skinned newt is, the less likely it is to be eaten by a garter snake. That means high levels of TTX are an adaptive trait in rough-skinned newts that live near garter snakes.

The common garter snake is one predator that eats rough-skinned newts.

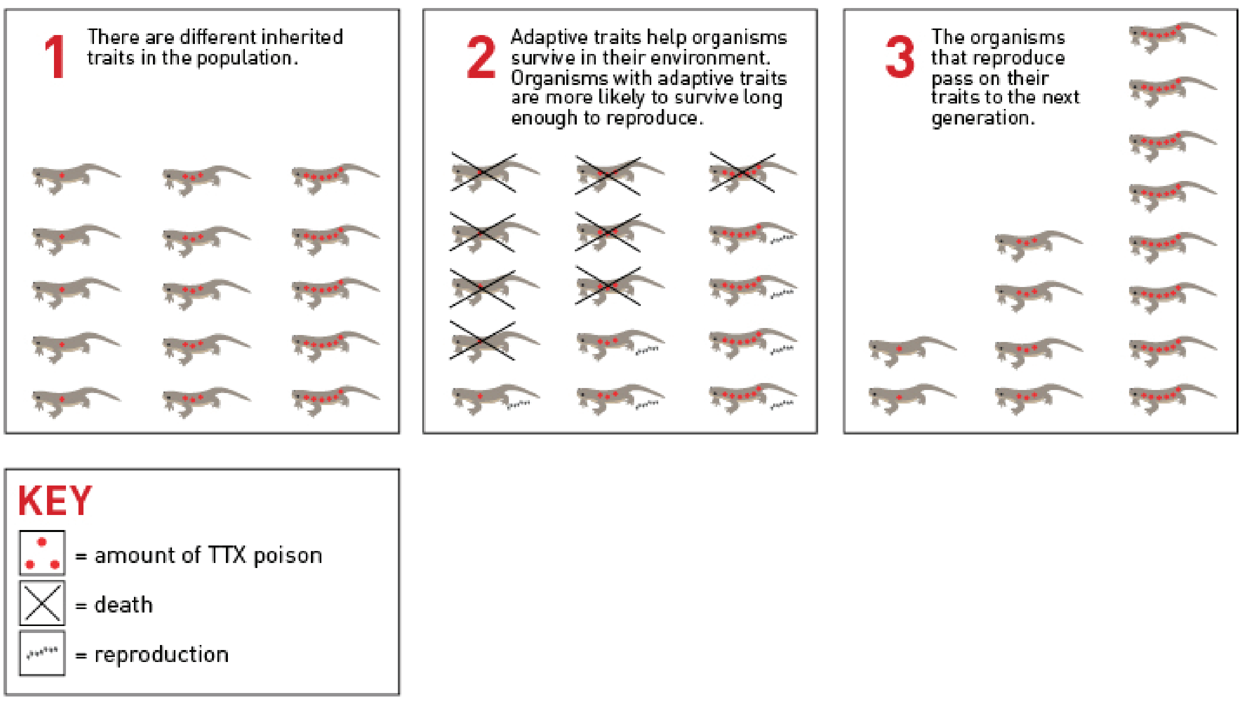
How Adaptive Traits Spread

If snakes are in its environment, a poisonous newt is less likely to die from being eaten than a newt that isn't poisonous. The newts that don't get eaten have a better chance of living longer, and that's important because it means more chances to reproduce. Organisms have to reproduce in order to pass on their genes, which are the instructions for making the protein molecules that determine traits: if they don't reproduce, their traits die with them. In the newt population, more poisonous newts are more likely to survive long enough to reproduce and pass down their genes, and therefore the trait of being poisonous, to the next generation. As a result, there will be more and more highly poisonous rough-skinned newts in each generation. This will cause the distribution of traits in the population to change over many generations. Scientists call this process natural selection. This process does not only happen in rough-skinned newts. It has been observed in populations of different species all over the world.



A rough-skinned newt's poison is a type called tetrodotoxin, or TTX for short. This is a model of a molecule of TTX.

How Natural Selection Works



Other Poisonous Organisms

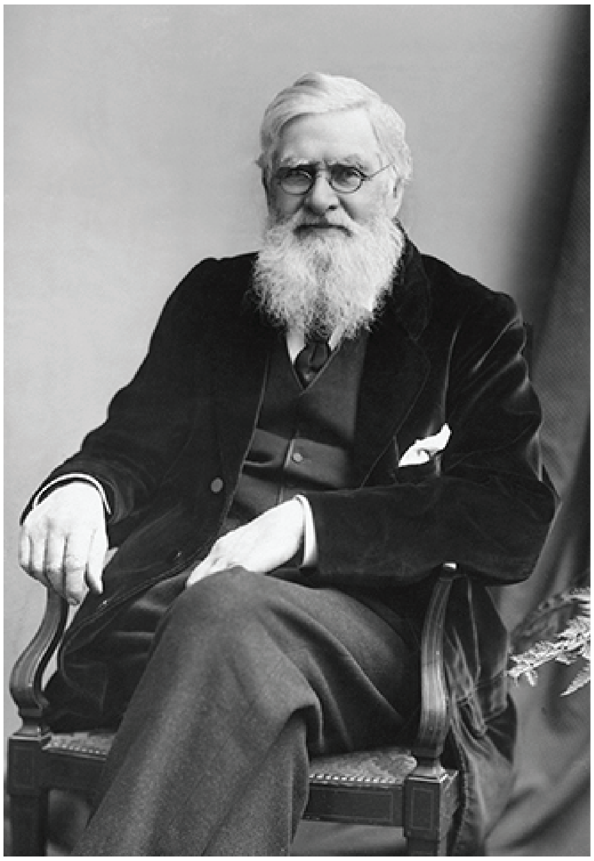
Being poisonous is an adaptive trait for many different organisms, not just rough-skinned newts. There are many poisonous plants, such as deadly nightshade, hemlock, and mint. You might be surprised to see mint on this list, since you've probably eaten mint yourself! The poisons in mint are harmless to humans, but deadly to some plant-eating insects. These poisons are what give mint its minty taste and smell—they are warning signals telling insects to stay away.

Like rough-skinned newts, poisonous plants are poisonous as a defense against being eaten. Plants can't run away from animals that want to eat them, so they have to defend themselves in other ways—with adaptive traits like tough bark, sharp thorns, and being poisonous.

Deadly nightshade (left) is an extremely poisonous plant; eating just a few berries can kill a human. Mint (right) is harmless to humans, but deadly to some insects.

Besides poison, plant defenses include sharp thorns and thick bark.

Wallace and Darwin



Alfred Russel Wallace spent many years studying plants and animals all over the world. He came up with the idea of natural selection at about the same time that Charles Darwin did.

Charles Darwin came up with the idea of natural selection—right? In his book *On the Origin of Species*, Darwin introduced the idea of natural selection and the way it changes populations over time. However, Darwin wasn't actually the only scientist who was working to explain how populations change over time. Many other scientists were already thinking along the same lines. In fact, there was one other scientist who came up with nearly the same idea at the same time. His name was Alfred Russel Wallace.

Wallace studied plants and animals all over the world. He spent four years near the Amazon River in South America and eight years in what are now Indonesia, Malaysia, and Singapore. While he traveled, he collected about 126,000 specimens of plants and animals, many of which had never been seen by people who didn't live in those locations. As Wallace learned about the plants and animals in those places, he realized that they were changing slowly over long periods of time. He also saw that they were changing in different ways depending on their environments.

In 1858, while he was still in Asia, Wallace wrote his ideas down and sent them to Darwin back in England. Darwin was already a well-known scientist at this time. Darwin was planning to publish *On the Origin of Species* soon, after 20 years of thinking about his ideas. He saw that Wallace's essays included many of the same ideas he was planning to include in his own work. Darwin had Wallace's essays published with himself listed as a co-author. Sending letters between England and Malaysia took so long that the essays were already published by the time Darwin received Wallace's permission to publish. Historians don't agree

Alfred Russel Wallace's Travels

Alfred Russel Wallace lived in England but spent 4 years in the Amazon in South America and 8 years in Malaysia, Indonesia, and Singapore.

on Darwin's reasons for publishing Wallace's work without permission or for adding his own name. Some think Darwin was trying to help Wallace by publishing his work and using his own influence to help spread Wallace's ideas, while others think he was trying to stop Wallace from publishing first. Either way, Wallace was happy to hear that Darwin had embraced his work and had it published.

Although Wallace's work on natural selection isn't as well-known as Darwin's, he continued to do scientific research for the rest of his life and made many important discoveries. In fact, several of the places he visited and species he introduced to his fellow scientists have been named for him. There's even an imaginary line called the Wallace Line. It divides the places where Asian animal species live from the places where animals of the South Pacific and Australia live. When Wallace died, he was one of the most famous scientists in the world. Wallace was very famous even outside of the scientific community—just not for coming up with the idea of natural selection.

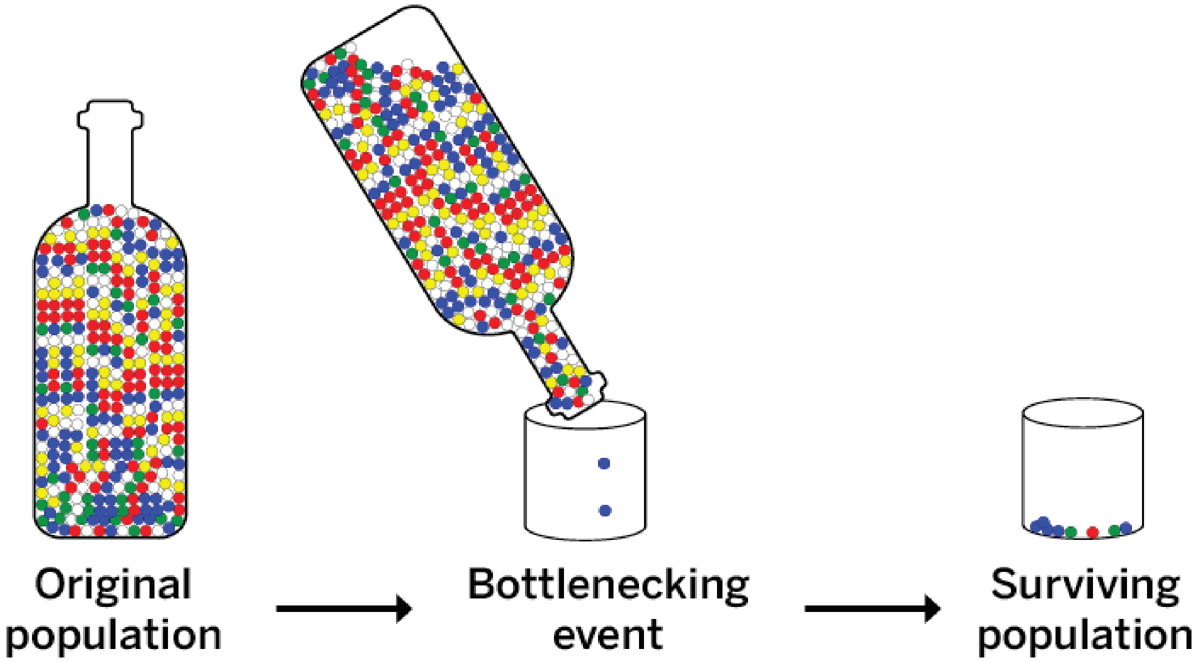
Sea otters have thick fur that keeps them warm and dry in cold ocean water.

Otters and the Bottleneck Effect

Have you ever tried to shake small objects, like jelly beans, out of a bottle with a narrow neck? It isn't easy. With each shake, only a few jelly beans come out of the bottle. The neck of the bottle is so narrow that the rest stay stuck inside. Scientists use the idea of a bottleneck to describe what happens genetically to certain populations of organisms during hard times. They call it the bottleneck effect. A bottleneck effect occurs when a population shrinks suddenly, usually due to an outside cause like a natural disaster or a rapid change in the environment. (In this case, it's different types of genes, not jelly beans, that get stuck when there aren't very many organisms left to reproduce.) Bottleneck effects change the genetic makeup of the population because only the genes of the survivors are passed on. The traits carried by the genes of the organisms that were wiped out have been erased from the population.

Many species have gone through genetic bottlenecks. One species that experienced a recent bottleneck is still recovering: the sea otter. Sea otters spend most of their time in cold water. Even though they live in the ocean, otter skin stays warm and dry because of their thick fur. In fact, otters have the thickest fur on Earth—up to one million hairs per square inch at the densest spots!

Between the 1700s and 1911, humans killed nearly all of the sea otters in the world. That may sound like a long time ago, but compared to the whole history of the sea otter, it's not very long at all! By 1911, when the governments of the world agreed to stop hunting sea otters, there were only about 2,000 otters spread over the whole Pacific Ocean. This group of 2,000 that remained had much less genetic variation than the original population did. Today, the sea otter population has recovered to more than 100,000 otters. However, the population is still affected by



After a genetic bottleneck, the variety of genes in a species is much smaller than it was before the bottleneck.

the bottleneck. Since otters pass their genes for traits on to their offspring, there is still a lot less genetic variation in the population than before the 1700s. If a big change happens in the sea otter's environment sometime in the future, they will be less likely to have traits in the population that could be adaptive since there are fewer traits overall.

Some species are going through bottlenecks today. Any species that is endangered is currently going through a bottleneck. If the species recovers and the population grows, the population will still have much less variation than it had before the bottleneck.

Otters' thick fur helps them survive in the wild, but it is so appealing to hunters that most of the otters in the world were killed between the 1700s and 1911.

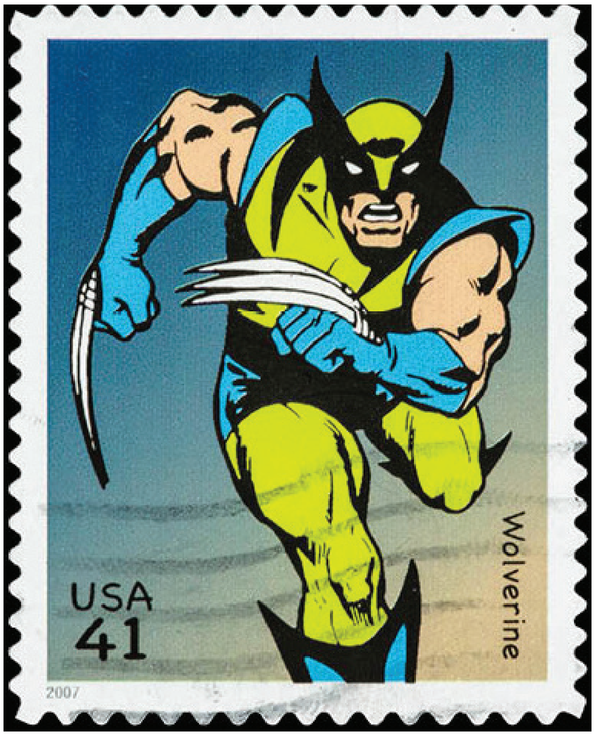
Mutations: Not Just for Superheroes

Chapter 1: Movie Mutations

In movies, mutations are always exciting: they might give someone special powers or extra limbs. However, real mutations can be very boring: they might not have any noticeable effect at all. What is a mutation, anyway? The answer has to do with genes and the way they are passed down when organisms reproduce.

Genes are instructions for making protein molecules, and those protein molecules determine an organism's traits. When organisms reproduce, they pass down copies of their genes to their offspring. However, the copies aren't always perfect: as genes are duplicated, changes can occur. These changes are called mutations, and they can be passed from parent to offspring when organisms reproduce. Most of the changes are minor and don't affect traits at all, but every once in a while, mutated genes give instructions to make a new protein molecule that leads to a new trait in the offspring.

The new traits that arise from mutations may be adaptive or non-adaptive, or they may have no effect on survival and reproduction. It all depends on the organisms' environment. If a new trait makes organisms less likely to survive and reproduce in their environment, the trait is non-adaptive. Organisms born with that trait don't have a very good chance of surviving long enough to reproduce and pass their mutated genes down to the next generation. If they don't pass the mutated genes down, they don't pass the new trait down either. Mutated traits that are non-adaptive usually remain uncommon in the population.



In movies and comic books, mutations make people into superheroes. In the real world, mutations often have no visible effect at all.

On the other hand, mutated genes sometimes result in a new trait that turns out to be adaptive. Adaptive traits help organisms survive and reproduce in their environments. If a mutation results in an adaptive trait, organisms with that trait are more likely to reproduce and pass on their mutated genes to the next generation.

Through natural selection, adaptive traits become more and more common in the population over time. A trait that is adaptive in one environment may be non-adaptive in another, and that's what makes mutations so important. Environments don't stay the same forever. Mutations can introduce new traits, increasing the chance that one of those traits might help make a population better able to adapt to a changing environment. To learn more about mutations, you can explore one or more of the following chapters.

Chapter 2: Revenge of the Bed Bugs

They creep into your bed at night and suck your blood, then crawl back to hide in their lairs… Bed bugs are seriously creepy! These tiny insects live in walls and furniture, and they survive by feeding on the blood of humans. Bed bugs have been a problem for humans for thousands of years. In the past, people didn't have any good way of attacking bed bugs—these insects hide during the day, only coming out at night when people are sleeping. People couldn't kill bed bugs by leaving poison for them to eat, because they won't eat anything but blood.

Then, in the 1940s, the situation changed: people invented new insecticides that were very effective at killing bed bugs. Like all insects, bed bugs have hard exoskeletons covering their bodies like suits of armor. However, the new insecticides penetrated the bed bugs' exoskeletons, killing bed bugs even if they just touched the insecticide. People sprayed these new insecticides wherever bed bugs were found, and killed huge numbers of bed bugs.

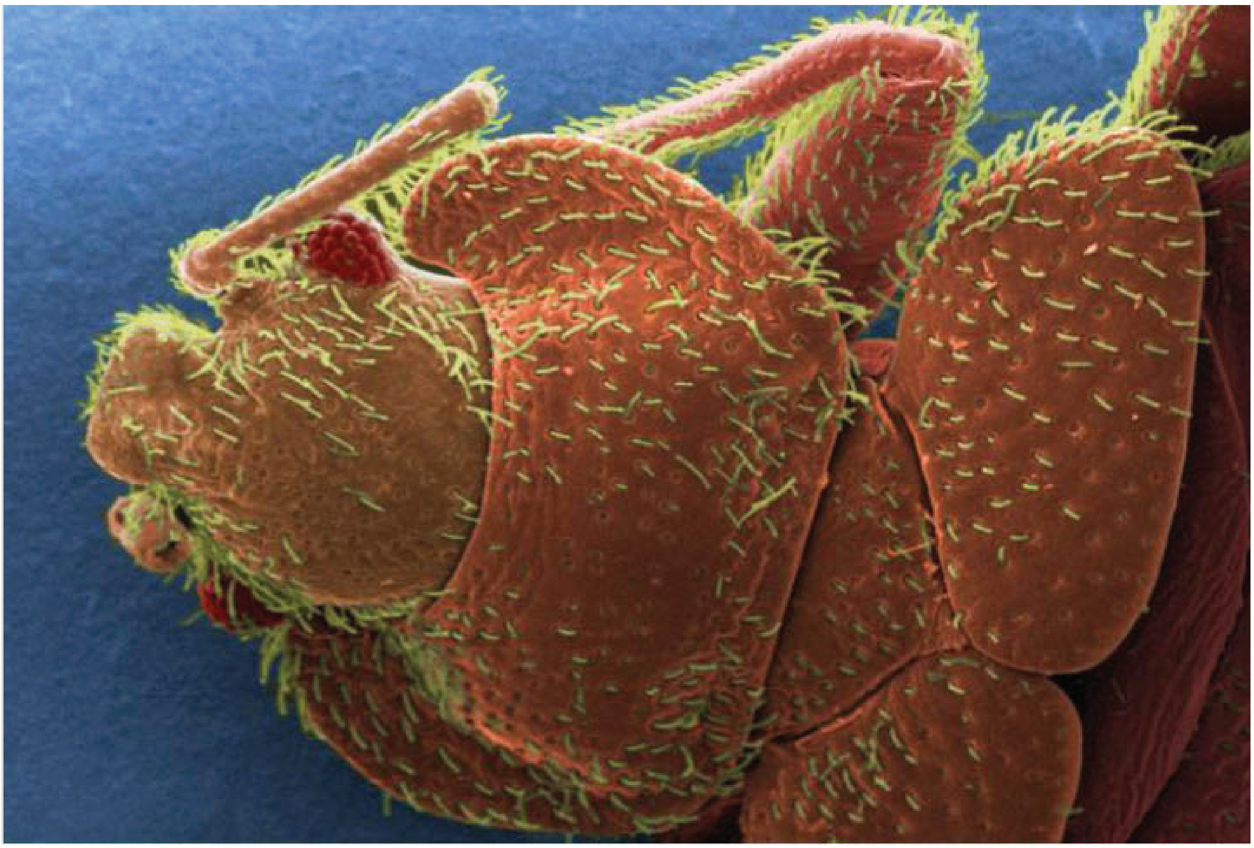
The insecticides didn't kill all of the bed bugs, however. In fact, they caused some effects that people hadn't predicted. Some bed bugs survived—mostly the individuals lucky enough to have extra-tough exoskeletons that were harder for insecticides to penetrate. These tough-skinned bed bugs began reproducing. Today, bed bugs with extra-tough exoskeletons are becoming more and more common in the bed bug population.

Scientists have studied the genes of tough-skinned bed bugs and compared them to the genes of ordinary bed bugs. They discovered mutations to several genes in the tough-skinned bed bugs. The mutations give the cells instructions to make protein molecules different from the protein molecules that other bed bugs can make. These new

Bed bugs live inside walls and furniture and survive by feeding on the blood of humans.

protein molecules all affect the exoskeleton in different ways, strengthening the bed bugs' armor. Before these mutations appeared in the bed bug population, there weren't any bed bugs with the trait of armor strong enough to resist insecticides.

The bed bugs' environment changed when people started using the new insecticides. However, a mutated trait in the bed bug population turned out to be adaptive in the bed bugs' new environment, so it helped the bed bugs with that trait survive. In the bed bugs' new insecticide-filled environment, stronger armor is an adaptive trait that helps them survive. Organisms with stronger armor are more likely to survive and reproduce, so they are more likely to pass on their mutated genes—and their adaptive traits. Through the process of natural selection, tough-skinned bed bugs are becoming more common with each new generation. Ironically, people's use of insecticide has produced a stronger bed bug population!



All bed bugs have exoskeletons, but some exoskeletons are thicker than others due to mutations.

Chapter 3: Cane Toad Invaders

Huge poisonous toads have invaded Australia! Humans brought cane toads from Asia to Australia in the 1930s, hoping the toads would eat beetles that were destroying crops. Unfortunately, the toads didn't eat many beetles. They ate almost anything else that could fit into their mouths, however. These big toads grow up to 22 centimeters (9 inches) long and weigh up to 1.8 kilograms (4 pounds). Cane toads are extremely poisonous, and no Australian predators can survive eating them. Without predators in their new environment, the cane toad population began growing and spreading. Today, cane toads are common in areas more than 1,500 kilometers (932 miles) from the place where they were first introduced to Australia.

Because there are so many cane toads in Australia, they compete with each other for food. The cane toads are eating everything in sight, so food becomes scarce in any area where they live. To survive, cane toads have to keep moving into new areas with more food sources. The first toads to reach new territory get to eat all the food they want. Slower toads are stuck with whatever is left.

Recently, Australian scientists have been finding cane toads with bigger, more muscular legs. These bigger legs can be traced back to mutations that changed the toads' genes. Scientists compared the big-legged toads to ordinary cane toads. They identified several gene mutations that gave the cells instructions to make protein molecules that were different from the protein molecules that other toads could make. These new protein molecules affected the cane toads' legs, increasing the leg size and strength. Having bigger legs is an adaptive trait that helps cane toads survive in an environment where there isn't much food to go around. Bigger, stronger legs help these toads outrun other cane toads and be the first ones to get to the food in new areas. With better chances of getting food, big-legged toads are more likely to survive and reproduce. Because of this, they are also

Cane toads like this one can grow up to 22 cm (9 in) long and weigh up to 1.8 kg (4 lbs).

more likely to pass on their mutated genes to their offspring. Along with these mutated genes, they pass on their adaptive traits.

When humans introduced cane toads to Australia, the cane toads' environment changed. With no predators hunting them in their new environment, there were more cane toads and therefore much less food was available. However, mutations led to a new trait in the population that turned out to be adaptive in the new environment. The mutated trait for bigger legs was adaptive for cane toads in an environment with scarce food because it helped them get more food and survive. Through the process of natural selection, big-legged cane toads are becoming more and more common in the cane toad population. These stronger, faster toads are spreading across Australia, invading new areas all the time.

Through the process of natural selection, cane toads with big, strong legs are becoming more and more common in the cane toad population.

Chapter 4: Red Lobster, Blue Lobster

What color are lobsters? In pictures, they're usually red. However, that's only after they've been caught and cooked. When they're alive and living in the ocean, lobsters are usually a greenish brown that blends into the ocean floor—except when a genetic mutation causes them to be bright blue! About one in every two million wild lobsters is blue in color. Why? A genetic mutation caused the lobster's body to produce more of a certain protein molecule than usual, which turned its shell blue instead of the normal brownish green. This mutation introduced a new trait into the lobster population: bright blue shells.

Having a blue shell may sound like the kind of trait that might make a lobster less likely to survive in its environment. After all, blue lobsters don't blend into their environment as well as greenish-brown ones do. However, research shows that being blue doesn't seem to make the blue lobsters any more or less likely to survive in their environments. In the 1990s, scientists studied blue lobsters: they mated a female blue lobster with a male blue lobster, producing all blue offspring. They released the offspring into the wild and studied them to see whether they survived at the same rates as lobsters with normal greenish-brown coloring. The scientists found no difference in the blue lobsters' survival rates compared with normal lobsters. The genetic mutation that results in blue shells appears to be a neutral mutation—that is, the trait is not adaptive in the environment, but it's not non-adaptive either. Blue shells seem to have no effect on survival and reproduction.

The trait for blue shells has not caused a big change in the lobster population. The mutated trait still passes from one lobster generation to the next, just like the traits for greenish-brown shells. Lobsters with blue

Most lobsters are greenish-brown.

About one in every two million lobsters has a mutation that causes its shell to be bright blue.

shells are just as likely to survive as lobsters with greenish-brown shells, so lobsters with these two color traits are likely to have about the same number of offspring. That means that the mutated trait has become neither more common nor less common in the population.

Lobsters also come in other colors: occasionally, people catch lobsters that are yellow, orange, red, or white! All of those other colors are also caused by genetic mutations. These rare lobsters' colors make them stand out in a crowd of living lobsters, but once cooked, colorful lobsters look just like their brownish-green relatives: like nearly all other lobsters, they turn bright red when boiled. (The only lobsters that don't turn color when they're cooked are extremely rare albino lobsters, which have no coloring at all.)

Many cabbage farmers have problems with caterpillars eating their cabbages before they're ready to be picked and sold.

How to Make a Venomous Cabbage

What do you get if you cross a cabbage with a scorpion? That may sound like the beginning of a joke, but it isn't. Scientists have been exploring ways to use scorpion DNA to keep cabbages from being eaten before they're ready for harvest.

Cabbages have the traits they do because humans have selected for those traits. For thousands of years, farmers have been engaging in a practice known as "artificial selection." Unlike natural selection, artificial selection happens when humans, not nature, choose for or against traits in organisms. Through artificial selection, farmers choose plants that have desirable traits and breed them so that the resulting populations have those traits. For example, 2,500 years ago farmers found a wild plant with tasty leaves and began growing it as a crop. (Scientists call this plant *Brassica oleracea*—say it BRASS-ick-ah oh-luh-RAY-see-ah.) Over time, farmers chose to replant the seeds of certain individual *Brassica oleracea* plants with a trait that was desirable, such as large leaves. By breeding the offspring of wild plants over and over and selecting for certain traits, farmers caused the traits of the plants to shift. Over many generations, the *Brassica oleracea* plants developed into new types of plants with new traits, including cabbages and other vegetables like kale and broccoli. Farmers can use artificial selection to choose traits that make their crops easier to grow in certain conditions, such as rocky soil or a particularly dry climate. They can also choose traits that make their crops more appealing to customers.

Today, cabbage is an important food for humans—but cabbages also make tasty meals for caterpillars and other organisms. To keep their cabbages from being eaten in the fields

Scientists use the genes that produce venom in *Androctonus Australis* scorpions to make cabbages less appealing to caterpillars.

before they're ready to be picked, farmers use chemicals called pesticides that kill the caterpillars. However, pesticides can have negative effects on the environment when they get into soil and water nearby. One way to keep the cabbages safe from caterpillars without spraying pesticides on the fields is to change the plants themselves.

To change an organism, scientists can use genetic engineering—they can change the organism's genes so the organism has different traits than it normally would. One type of genetic engineering uses genes from one organism that have been inserted into the cells of another organism. The genes are instructions for the organism to produce certain proteins, and the proteins give the organism its traits. Through genetic engineering, scientists can give an organism traits that it wouldn't normally be able to have.

To engineer insect-proof cabbages, scientists in China inserted genes from scorpions into the cells of the cabbage plants. Scorpions have genes that instruct their cells to make venom, which they use to paralyze and kill their prey. The scientists added the genes for making venom to the cabbage plants. The cabbages began to produce scorpion venom and store it inside their leaves, so that any bugs that ate the cabbages would be paralyzed and die.

In the wild, scorpion venom doesn't just work on insects; scorpion stings can also be very painful and cause paralysis in humans. However, the scientists changed the scorpion venom so that it kills insects but has no effect on people. Otherwise, nobody would be able to eat the cabbages. So far, cabbages modified with genes for scorpion venom have been just an experiment, and haven't been grown or sold to the public. Although scientists have found no negative effects of eating the modified cabbages, many people are concerned that they may be dangerous. For now, the cabbages you eat will be just plain cabbages.

Scientists can alter the genes in plants and animals to change their traits, but should scientists do this? This question has led to many ethical debates. When people talk about ethics, they are thinking about the moral issues related to a behavior or activity.

Some people think genetic engineering is a good way to grow more food to feed our rapidly growing population. This is commonly referred to as genetically modified food. Food crops can be given genes that make them resistant to diseases, pests, or the chemicals that farmers use to kill weeds. Crops can also be engineered to grow in places where they wouldn't have been able to grow, like places that are too cold or have salty soil. All of these changes make it easier to grow more food. Crops can even be engineered to contain more vitamins or vaccines! Supporters of genetically modified food argue that changing the DNA of an organism that humans eat is not harmful for humans, and that the benefits outweigh the potential drawbacks.

A few countries have decided to ban genetically modified foods. People who are against these foods argue that genetic engineering is a new technique that hasn't been sufficiently studied. There are also environmental consequences to using these foods. For example, a genetically modified type of corn that was designed to be resistant to pests ended up also harming monarch butterflies. People worry that if plants are engineered to be resistant to weed killer, that will encourage farmers to use more and more chemicals on their crops. Those chemicals end up in the air and water. In addition, the new genes could spread to other organisms, leading to effects that are hard to predict and that may be negative. Opponents of genetically modified foods worry that we don't know whether this food could have negative effects on our health and environment far into the future.

For the moment, the Food and Drug Administration has decided that genetically modified foods are safe to consume. However, genetically modified foods are required to have a label so that consumers can decide for themselves. You can take a look at the labels next time you are in the grocery store. Will you choose to purchase genetically modified foods? Why or why not?

The Stickleback Fish in Its Environment

Sticklebacks are small fish—a full-grown stickleback is usually only about 5 centimeters (2 inches) long. These little fish live in two very different environments: the quiet lakes and ponds of Oregon and the huge Pacific Ocean. As you might guess from their name, stickleback fish have sharp spines sticking up from their backs. Unlike many other fish, sticklebacks don’t have scales: instead, they have bony plates of armor protecting their bodies. Sticklebacks can have just a few plates of armor for protection, or they can have many—and the less armor a stickleback has, the faster it swims.

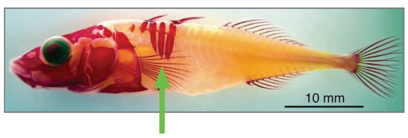
Sticklebacks are small fish with sharp spines that stick up from their backs.

This is what three-spined sticklebacks look like.

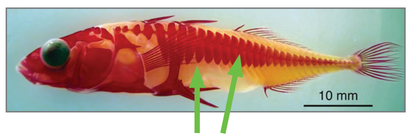
less armor, faster

more armor, slower

These are three-spined sticklebacks that have been stained to show their plates of armor.



plates of armor



plates of armor

These sticklebacks look identical from the outside, but take a closer look: the fish skeletons on the bottom have been stained to show their plates of armor.

What Do Sticklebacks Eat?

Stickleback fish may be small, but they are fierce predators. Sticklebacks catch and eat small animals such as worms, small shrimp, insect larvae, fish eggs, and young fish—including young sticklebacks.

Sticklebacks eat tiny water animals like these.

What Eats Sticklebacks?

Predators that eat sticklebacks include other fish, birds, and a predator you might not expect: dragonflies! As adults, green darner dragonflies have thin green bodies, large eyes, and four transparent wings. However, these insects actually spend most of their lives underwater! They first hatch as wingless nymphs, with gills for breathing underwater. Green darner dragonfly nymphs often catch and eat sticklebacks.

Green darner dragonfly nymphs have big jaws that allow them to eat fish.

How can an insect eat a fish? Green darners are large—the nymphs can grow to 5 cm (2 in) long, which is bigger than some fish. They are fast, too—green darner nymphs shoot jets of water out of their bodies to move quickly underwater. They also have big jaws, which they use to catch young fish, insects, and tadpoles. Sticklebacks are so small that dragonfly nymphs are one of their main predators in lakes and ponds.

Another important predator of sticklebacks is the Chinook salmon. Chinook salmon hatch in rivers, but they swim out to the ocean and live most of their lives there. When they are ready to reproduce, the salmon travel back to the rivers where they first hatched. Because they live in both rivers and the ocean, Chinook salmon are comfortable in both salt water and freshwater—just like sticklebacks.

Chinook salmon are big fish that can live in both salt water and freshwater.

Chinook salmon are big, strong fish. They are the largest species of salmon in the western United States, weighing up to 55 kilograms (120 pounds)! These big fish eat mostly smaller fish, including little sticklebacks.

Natural Selection:
Poisonous Newts

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