7.3 - Mutations & Change Unit, Packet 3

Score
□ Above & Beyond
□ Meets Expectations
□ Near Expectations
□ Incomplete – *fix the following pages:*

First & Last Name: _____ Period/Hour:_____

NOTE: Packets are due after completing Part 5. Check each page to be sure all blanks are completed.

Driving Question: How can mutations create new traits & species?

Anchoring Phenomenon: Previously we have explored how amino acid properties determine protein shape & function, and how different kinds of mutations change proteins and traits. In this packet, we will explore how environmental conditions determine if traits from mutations are helpful or harmful, and how species change over time as a result.

Deeper Questions

1. What determines whether mutations are helpful, harmful, or neutral?
2. How and why do the traits of species sometimes change?
3. Why do some species' traits change faster than others?

Schedule

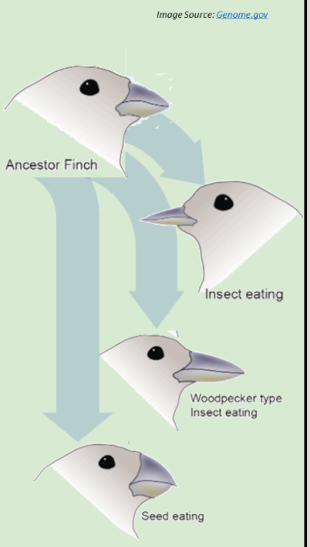
Part 1: Introduction
- Initial Ideas & Data Dive - Natural Selection
- Discussion & Developing Explanations

Part 2: Core Ideas
- Core Ideas
- Revisions of Part 1 Explanations

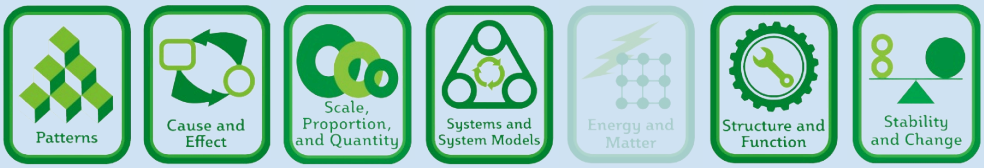
Part 3: Investigation
- Flap or Flop Bird Activity
- PhET Natural Selection

Part 4: Review & Assessment
- Ranking Your Readiness
- Formative Assessment & Mastery Check

Part 5: Life Connections
- Antibiotic Resistance Investigation Set-up



NGSS Standards (*PEs* & *CCCs are summarized below. SEPs are noted throughout the packet*).
HS-LS1-1 - How the structure of DNA determines the structure of proteins and function.
HS-LS1-2 - How inheritable variations result from 1) changes via meiosis; 2) errors during replication; 3) mutations via environmental factors. HS-LS4-3 – How organisms with advantageous traits increase in proportion in their populations. HS-LS1-4: How mitosis and differentiation enable complex organisms.



Semester Schedule

5. Traits & Genes
5.1: What determines the traits of an organism?
5.2: How are traits inherited from parents?
5.3: Can we predict traits?
5.4: Unit Assessment

6. DNA & Proteins
6.1: What is DNA and how does it work?
6.2: How does DNA affect protein assembly?
6.3: Unit Assessment
6.4: How are genes modified? *(mini-unit)*

7. Mutations & Change
7.1: How does a protein get its shape & function?
7.2: How do mutations change genes & proteins?
7.3: How can mutations create new traits & species?
7.4: Unit Assessment
7.5: How Does Antibiotic Resistance Occur?

8. Biodiversity
8.1: How does biodiversity affect ecosystems? Why is biodiversity being lost?

These materials were partly developed with assistance from artificial intelligence.

Resource Links: Class Website; Core Ideas; Practice Quiz; Video Quiz; Summary Video; Nat. Selection Video; PhET Nat. Selection Simulation; Summary Poster;

Part 1: Introduction – Natural Selection Lab (7.3.1)

Overview: Discuss your initial ideas about natural selection. Then use data to develop initial explanations.

Initial Ideas - *Record your ideas separately (scratch paper, etc).* *SEP: Engaging in Argument from Evidence*

1. As a result of differences in their genes, different kinds of tree frogs have different rates of survival and reproduction in different environments. Green tree frogs are more common in wetlands with lush green vegetation. Gray tree frogs are more common among hardwood trees with gray bark. Three students attempt to explain why this occurs. **Do you agree or disagree with each student's claim?**
   - Marisol: "I think that a frog turns green or gray depending on where it is found; for example, tree frogs turn green if they're born in a wetland or gray if they're born in a forest." *Agree / Disagree*
   - Daryll: "I disagree. I think that the frogs are already green or gray when they're born. Their DNA doesn't change, just their survival rate." *Agree / Disagree*
   - Nina: "I don't agree. DNA can definitely change from mutations. I just think the mutations happen regardless of what environment the frogs live in." *Agree / Disagree*

2. Discuss your group's ideas. How are your ideas similar or different? Be prepared to present your ideas.

Data Dive - *SEP: Analyzing & Interpreting Data*

In this activity, you will be modeling how the environment affects survival and reproduction. Your "environment" will be two pencil boxes filled with fabric. Your "organisms" are colored beads. There will be two rounds of predation and reproduction for each box. In each round, a student will represent a "predator" and remove 20 beads per round. This will be followed by a round of reproduction. You will then compare survival and reproductive rates among your beads and infer how each kind of environment affected these outcomes.

Directions:

1. Acquire the following: 2 pencil boxes lined with different colors and patterns of fabric; 50 beads of one color; 50 beads of another color. Record your initial data on the following page.
2. Select a group member to be the first predator. During this first round of predation…
   a. Predators must keep their eyes open.
   b. Predators must grab the first bead they see regardless of color preferences.
   c. Predators can only grab one bead at a time.
   d. After a bead is removed, the pencil box lid should be closed and the box should be shaken.
   e. Repeat until 20 beads have been removed.
3. During the first round of reproduction…
   a. Count the number of beads for each color that remain in the box and record your data.
   b. Calculate the survival rate for each color of beads (*remaining beads per color ÷ total beads*).
   c. Take the total number of remaining beads per color and divide by 2. Add this number of beads to your box. Round up for decimals. *E.g., If 31 beads remain □ 31 ÷ 2 = 15.5 □ Add 16*
   d. Record your data.
4. Choose a new group member to be a 'predator'. Repeat the steps above for a second round of predation.
5. Repeat the steps above for a second round of reproduction.
6. Repeat these steps for a pencil box with different colors and patterns.

Data:

Bead 1 Color: _____ Bead 2 Color: _____

Describe Environment 1: _____

Environment 1 Data	Bead 1	Bead 2	TOTAL
Total At Start			
% of Population (Bead X ÷ Total Beads)			
Remaining After First Predation			
% of Population (Bead X ÷ Total Beads)			
Population After First Reproduction			
% of Population (Bead X ÷ Total Beads)			
Remaining After Second Predation			
% of Population (Bead X ÷ Total Beads)			
Population After 2nd Reproduction			
% of Population (Bead X ÷ Total Beads)			

How did the rates of survival and reproduction of Bead 1 compare to that of Bead 2?

_____

How did this environment affect these outcomes?

_____

_____

Bead 1 Color: _____ Bead 2 Color: _____

Describe Environment 2: _____

Environment 2 Data	Bead 1	Bead 2	TOTAL
Total At Start			
% of Population (Bead X ÷ Total Beads)			
Remaining After First Predation			
% of Population (Bead X ÷ Total Beads)			
Population After First Reproduction			
% of Population (Bead X ÷ Total Beads)			
Remaining After Second Predation			
% of Population (Bead X ÷ Total Beads)			
Population After 2nd Reproduction			
% of Population (Bead X ÷ Total Beads)			

How did the rates of survival and reproduction of Bead 1 compare to that of Bead 2?

_____

How did this environment affect these outcomes?

_____

_____

Initial Explanations - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Developing Solutions*

How do environmental factors determine whether a mutation is helpful, harmful, or neutral?

_____

_____

Part 2: Core Ideas (7.3.2)

Overview: In this activity, you will use an intro video and a short presentation to provide you with information that will help you improve and revise your initial ideas. Your instructor will decide on how to implement this portion. You will then work in small teams to address the questions listed below.

Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing & Using Models

1. What determines whether mutations are beneficial, harmful, or neutral?
2. What is a silent mutation? What is an adaptation? How are these terms similar & different?
3. Why do vultures and ostriches lack head feathers? How did this happen, and why is it common in some birds but not others?
4. Whales changed significantly while sharks have changed very little during the same time despite sharing the same habitat. Why?
5. What is natural selection? How does natural selection relate to mutations?
6. How are green and gray tree frogs an example of natural selection?
7. What is evolution? How is evolution similar but different from natural selection?
8. Summarize and explain the four factors that are necessary for evolution to occur.
9. What is a species? How does evolution by natural selection result in new species?
10. What is the difference between natural selection and artificial selection?
11. "*Mutations occur randomly and independently from the environment.*" What does this mean?
12. What evidence indicates that evolution by natural selection occurs? Address each of the following: *homologous structures; analogous structures; vestigial structures; DNA; fossils; and measurable evolution*.

Revising Explanations - *Record your ideas in the spaces below.* *SEP: Constructing Explanations & Developing Solutions*

How can mutations create new traits & species?

_____

_____

_____

Use this space for notes if needed.

Part 3A Investigation: Flap or Flop Birds (7.3.3a)

Overview: you will use models to explore how new species emerge through mutations and natural selection.

Background: A scientific model is a substitute for the actual thing we are studying that is similar to what it represents. It follows the same rules as the actual object, but it provides a simpler version of a complex concept. You'll model how mutations and natural selection can lead to changes in species' traits over time. Each "baby bird" will have an assigned genotype. Determine its traits and create your bird with provided materials. Once each group member creates their bird, compete for food, survival, and mates.

Materials Needed (per group of 4): 8 foam balls; toothpicks; 2 plastic spoons; craft feathers; beads or dried beans; packing peanuts; petri dish. *Optional: tape; googly eyes; thumbtacks; plastic containers; felt squares.*

Creating Your Birds *SEP: Planning and Conducting an Investigation*

1. ☐ Before starting, predict how the birds in your class will differ by the end. Note that each group will have a slightly different environment, but all birds will inherit genes from parents with the same traits. Will survival outcomes be similar across groups or vary at each table?

   I predict the following: _____

   _____

2. Next, determine your bird's genotype and phenotype for beak shape and feather color.
   B = spoonbill; b = spikebill. F = green feathers; f = red feathers.

   The parents of your birds are heterozygous for both traits. They mated and had 4 babies in your group's habitat. The genotypes are summarized below. Record the phenotype in the blank for each.

   a. ☐ Oldest Group Member: BB & FF _____
   b. ☐ 2nd Oldest Group Member: Bb & ff _____
   c. ☐ 3rd Oldest Group Member: bb & Ff _____
   d. ☐ 4th Oldest Group Member: bb & ff _____

3. Once you have determined your bird's phenotype, you can create your bird based on these steps:
   a. ☐ Insert a toothpick into the foam ball for a spikebill or break the handle off a plastic spoon for a spoonbill. Use 2-3 toothpicks as the neck to connect the head to another foam ball.
   b. ☐ Attach feathers: Add either green or red feathers for wings and tail based on genotype.
   c. ☐ Attach feet: Use toothpicks or thumbtacks as the bird's feet.

4. Your instructor will assign your group's habitat conditions, including seeds (*beans or beads*) or fruits (*foam packing peanuts*) for food, and for predators such as foxes, hawks, or none.
   a. **Habitat 1:** Food: seeds. Predator: Fox.
   b. **Habitat 3:** Food: seeds. Predator: None
   c. **Habitat 5:** Food: fruits. Predator: Hawk
   Habitat 2: Food: seeds. Predator: Hawk
   Habitat 4: Food: fruits. Predator: Fox
   Habitat 6: Food: fruits. Predator: None

5. Once your environmental conditions have been assigned, your instructor will provide you with your food supply. Your birds within your assigned group will compete for this food using these steps:
    a. ☐ Place the food in a petri dish; position it so that its is equidistant from each group member.
    b. ☐ Within your groups, determine a starting signal (e.g., "ready, set, go" or "3, 2, 1").
    c. ☐ Upon the signal, hold your birds head and use only the bird's beak to transfer food onto your felt square (i.e., you cannot use your hands or any other objects).
    d. ☐ Once all of the food is consumed, determine which two birds acquired the most food. Only these birds will survive (if there is a tie, make sure you have an odd amount of food & repeat).
    e. ☐ Record which bird survived in the Results section. Put away your food as instructed.
6. Next, determine which bird will survive predation and successfully reproduce in your habitat:
    a. If your habitat has predators, only green birds survive and reproduce.
    Without predators, red birds reproduce more as their bright feathers attract more mates.
    b. Record your outcomes in the Results section.

Results *SEP: Engaging in an Argument from Evidence. Analyzing & Interpreting Data*

1. **What type of food did you have?** Seeds (*beads or beans*) Fruits (*foam peanuts*) *circle one*
2. **Which two birds acquired the most food in your habitat**? *circle two*
   Green Spoonbill *Green Spikebill* *Red Spoonbill* *Red Spikebill*
3. **Of the surviving birds, which was most likely to survive and reproduce**? *circle one*
   Green Spoonbill *Green Spikebill* *Red Spoonbill* *Red Spikebill*
4. **Record the bird that was most likely to survive and reproduce in each habitat:**

   Habitat 1: _____ Habitat 2: _____

   Habitat 3: _____ Habitat 4: _____

   Habitat 5: _____ Habitat 6: _____
5. Both red feathers and spikebills are mutations. Were these mutations helpful or harmful? Explain:

   _____

   _____
6. Evolution by natural selection requires four factors. Summarize how each was present in this activity:

   Sexual Reproduction: _____

   Hereditary Mutations: _____

   Competition: _____

   Varied Repro/Survival: _____

Part 3B: PhET Natural Selection (7.3.3b)

Pre-Investigation Questions - *Work as a group to prepare verbal responses for these questions. When you think you are <u>all</u> ready to provide responses, raise your hand. Your instructor will listen to your explanations, provide feedback, and determine if you are ready to move on to the investigation.*
SEP: Developing & Using Models

1. What factors most affect whether a mutation is helpful, harmful, or neutral?
2. Why do some species change more rapidly than others?
3. What is the difference between natural selection and evolution? How are they both similar & different?
4. What are the four key factors that determine whether species change in response to natural selection?

This activity was completed _____ (*instructor signature*)

Overview: In this investigation, you will use a computer simulation to investigate how species change in response to natural selection.

Methods: Check each box as you complete each step.

First Simulation

1. ☐ First, use an approved devise and visit https://phet.colorado.edu/en/simulations/natural-selection/ (or use an internet search engine and search "PhET Natural Selection"). Your screen should resemble this☐
2. ☐ Second, click the Play arrow button. Then click "Intro".
    a. In the "Add Mutation" box in the upper right, click the brown fur button under "Dominant".
    b. Click "Limited Food" in the "Environmental Factors" box. Leave "Wolves" unclicked for now.
    c. In the box in the bottom left, click "Data Probe".
    d. Click the sun icon in the upper right (next to the snowflake).
    e. Complete your predictions on the next page.
3. ☐ Next, click the yellow "Add Mate" button. Let the program run until it reaches the 3rd generation.
4. Click "Pause" once it reaches Generation 3 (do not go past 3.5). Record your data on the next page.
    a. Be sure to drag the gray line to the appropriate generation when recording data; e.g., if the gray line is not between 3 and 4, it will not show the data for the third generation of rabbits.
5. ☐ Next, click "Wolves" under "Environmental Factors". Record your predictions on the next page. Click "Play". Pause the simulation after Generation 6. Record your data on the next page.
6. ☐ Click the "Snow" icon (upper right). Keep the wolves box clicked. Record your predictions on the next page. Click "Play". Pause the simulation after Generation 10. Record your data on the next page.

Predictions & Data – First Simulation:

1. Prediction 1: There are two traits for rabbits in this simulation – brown vs. white fur. Brown fur is dominant to white. Which trait do you think will be more prevalent by the end of the simulation? Why?

2. Prediction 2: Do you think that the addition of wolves will affect the percentage of rabbits with brown vs. white fur? Explain.

3. Prediction 3: Do you think that the transition from warm to snowy conditions will affect the percentage of rabbits with brown vs. white fur? Explain.

4. Use the table below to record your data after each round of the simulation.

	Total Population of Rabbits	White Fur Total Population	% White Fur (White Fur/Total)	Brown Fur Total Population	% Brown Fur (Brown Fur/Total)
Initial					
Start of Generation 3 (limited food)					
Start of Generation 6 (wolves added)					
Start of Generation 10 (transition to snow)					

5. Were your predictions accurate? Explain.

Second Simulation

1. ☐ Click the "Lab" button at the center bottom of the screen.
   a. Click all of the boxes in the white box in the lower left.
   b. In the white box in the upper right, click all of the boxes in the "Dominant" column for fur, ears, and teeth. Complete your predictions on the next page.

2. ☐ Next, click the yellow "Add Mate" button. Let the program run until it reaches the 3rd generation.
3. ☐ Click "Pause" once it reaches Generation 3 (do not go past 3.5). Record your data on the next page.
4. ☐ Next, click "Tough Food" under "Environmental Factors" to simulate the transition to more woody plants. Click "Play". Pause the simulation after Generation 6. Record your data on the next page.
5. ☐ Click the "Snow" icon (upper right). Record your predictions on the next page. Click "Play". Pause the simulation after Generation 9. Record your data on the next page.
6. ☐ Click "Wolves" under "Environmental Factors". Click "Play". Pause the simulation after Generation 12. Record your data on the next page.
7. ☐ Complete the remaining questions. Be prepared to discuss and defend your ideas for the class.

Predictions & Data – Second Simulation:

1. Predictions: White fur, floppy ears, and long teeth are dominant traits. You will slowly change the environment by adding woody vegetation, snowy conditions, and wolves. For each option, circle the traits you expect to be most prevalent in this population by the final generation and explain why.

Brown / White Fur because ...

Floppy / Upright Ears because ...

Long / Short Teeth because ...

2. Use the table below to record your data after each round of the simulation.

	Total Population of Rabbits	% White Fur (White Fur/Total)	% Brown Fur (Brown Fur/Total)	% Floppy Ears (Flop Ears/Total)	% Upright Ears (Up Ears/Total)	% Long Teeth (LT/Total)	% Short Teeth (ST/Total)
Initial							
Start of Generation 3 (limited food)							
Start of Generation 6 (tough food)							
Start of Generation 9 (transition to snow)							
Start of Generation 12 (wolves added)							

3. Based on the data you recorded, which had a greater impact on fur color, a) whether the trait was dominant or recessive, or b) the environmental conditions? Explain and justify with data.

4. Did the rabbit color change more drastically when the snow was introduced, or when the wolves were introduced? Why do you think this was the case? Support your argument with data (Gen. 9 vs. 12).

Class Discussion Questions: discuss within your groups; then be prepared to defend your ideas to the class.

1. Briefly summarize how changes from mutations affected a) the rabbits' DNA, b) their proteins & cells, c) the bodies of the rabbits, and d) the rabbit populations.
2. Three different mutations resulted in new traits (brown fur, floppy ears, and long teeth). Were these acquired or hereditary mutations? Explain what these terms mean and justify your ideas with evidence.
3. Two traits (fur color, teeth size) were directly affected by environmental conditions. One trait (floppy ears) was not. How did this affect evolution by natural selection?
4. What affected the rabbit color more, a) whether or not the conditions were snowy, or b) whether or not there were predators? Why? Explain and support your claims and ideas with evidence.
5. Did these mutations happen because of changes to environmental conditions, or did these mutations occur independently of environmental conditions?
6. Which would result in a faster rate of change, a) an environment with plentiful vegetation and minimal predators, or b) an environment with limited vegetation and more predation? Explain.
7. Four factors are necessary for evolution by natural selection to occur: 1) sexual reproduction, 2) heritable genetic variation, 3) competition, and 4) differences in survival & reproduction. Determine whether each of these factors were present in this simulation and justify your claims with evidence.

Part 4: Review & Assessment (7.3.4)

Step 1: Rank each Driving Question in Part 2 based on your comprehension (you can rank them as *1,2,3* or *green/yellow/red*, or any other method). Then work in teams to review anything that is still unclear.
Step 2: Identify any remaining areas of confusion or concern. Then review these topics with your instructor.
Step 3: Complete the Formative Assessment (*last page of the packet*). Your instructor will determine if you will work individually, in pairs, or in small groups. Then compare and evaluate your responses as a class.
Step 4: Individually complete a Mastery Check. If your performance indicates that additional support is needed, your instructor will determine how to help you move forward.

Part 5: Life Connections – Antibiotic Resistance

Overview: This activity involves the initial stages of a multi-day investigation. You will be investigating how populations of bacteria change in response to antibiotics. You will use this activity to model and observe how evolution by natural selection occurs among species. You will be starting these steps today because it will take time for bacteria to grow on your petri dishes.

Needed Materials: petri dishes with agar; bacterial samples; sterile cotton swabs; micro-centrifuge tubes; permanent markers; incubator; paper disks (cut from filter paper w/ a hole punch); tweezers; samples of antibiotics (antibacterial soaps and antibiotic creams work well).

Intro Video: https://ed.ted.com/lessons/how-antibiotics-become-resistant-over-time-kevin-wu

Methods:

1. At an earlier time, your instructor should acquire laboratory-grown samples of bacteria and add them to samples of sterile water in microcentrifuge tubes. They should also prepare your paper disks and pre-determine which antibiotic samples will go in each quadrant (1-4) of the petri dish.
2. Sanitize your lab bench or work area using either a) alcohol wipes or b) by spraying a disinfectant (e.g., Lysol) and wiping with a clean paper towel.
3. Sanitize your hands by washing with soap or using hand sanitizer.
4. Acquire a petri dish, vial of bacteria, a sterile cotton swab, and samples of antibiotics (such as antibiotic ointment or antibiotic soaps). Do NOT open these items
5. Use a permanent marker to divide the bottom of your petri dish into quadrants and number them 1-4.
6. Label the *bottom* of the Petri dish (not the lid!) with your last names, class period, and the date. Keep the writing very small and only on the very edges of the petri dish.
7. Open the cotton swab; be careful not to allow the cotton tip to touch any surfaces.
8. Grab a microcentrifuge tube of bacteria. Dip the swab into the vial and fully soak the whole swab.
9. Partially open the lid of the petri dish with the opening facing away from you (this will reduce the likelihood of accidental contamination).
10. Gently spread the soaked cotton swab across the surface of the agar gel so that it is evenly distributed across the entire surface. Rotate the swab as you do so. Close the lid of the petri dish when finished.
11. Acquire four paper disks. Soak three of the disks in different samples of antibiotics provided by your instructor. Soak the fourth disk in sterile water (this will be the control). After you soak each disk, place it on the petri dish – your instructor will determine which quadrant will contain each disk. Make sure to use the tweezers to place each disk into the petri dish.
12. Place the plates on their lids and keep in an incubator at 37°C for at least 24 hours (petri dishes should be stored upside down so that the agar nutrient gel is on top and the lid is on the bottom to reduce the risk of accidental contamination).

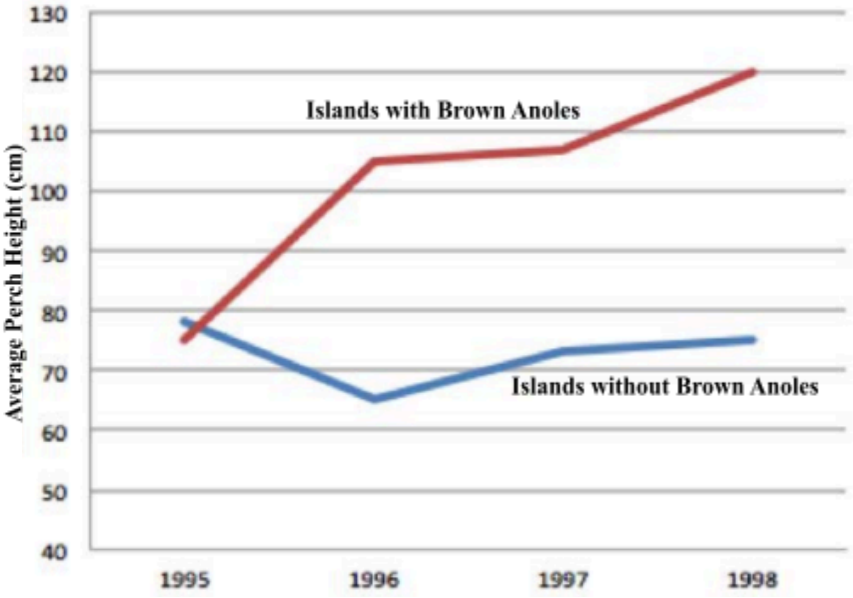
Mutations & Change Unit - Packet 7.3 Formative Assessment

Adapted from STEM Teaching Tools

Name: _____ Hour_____ Date:_____ Score:_____ /_____

Directions: A 3x5 notecard with handwritten notes can be used to guide your answers. Your instructor may allow you to work in assigned groups. If so, have a different person write each response while others assist.

Background Info: Green anoles are a lizard that lives in trees in Florida. A similar species called brown anoles invaded Florida from Cuba. Brown anoles eat similar food as the green anoles. Brown anoles also eat the newly hatched babies of green anoles.



Scientists measured the average height at which green anoles were found in trees (perch height) before and after the invasive brown anoles arrived. This graph shows the data they collected on perch height.

Next, scientists knew that living higher in the trees required larger footpads and more sticky scales on the anoles' feet. Scientists collected data to investigate whether or not the traits of green anoles changed because of the invasion of the brown anoles. Their data is below.

	Green Anoles on an Island WITHOUT Brown Anoles	Green Anoles on an Island WITH Brown Anoles
Average Perch Height in Trees	70 cm	120 cm
Average Size of the Toe pads	1.27 cm	1.33 cm (4.5% increase)
Avg. Number of Sticky Scales on Feet	51 sticky scales	54 sticky scales (6.5% increase)

1. **What was the hypothesis, rationale, and control in this experiment?**

_____

_____

_____

2. **What patterns do you see in the data above? How do the traits of the green anoles differ between populations on islands with brown anoles compared to islands without brown anoles?**

_____

_____

3. When the brown anoles invaded, scientists noted that they ate similar food and lived in similar habitats as the green anoles. **Why does this matter for the survival of the green anoles? How might this affect the rate of change in the adaptations of this species?**

4. **How did the changes to sticky scales & footpads occur? What caused these changes to these traits?**

5. **Four factors are necessary for evolution to occur. Explain whether or not each of the following four factors are present in the example of the green anoles. Justify your claims with evidence.**

   Sexual Reproduction:

   Heritable Genetic Variation:

   Competition:

   Repro/Survival Rates:

   Writer's Name:

6. **If green anoles were affected by a new predator, would the rate of change in their traits increase, decrease, or stay constant? Make a prediction and justify it with evidence.**