

NATURAL SELECTION

CONCEPT CARTOONS
POWER POINT PRESENTATIONS

CLASSROOM ACTIVITIES
ASSESSMENTS

This collection of materials is designed to teach middle school or high school students the difficult subject of evolution by means of natural selection. The materials and lessons are based in science education research and have been shown to be effective tools for teaching this topic.

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Importance of Teaching Natural Selection

The topic of evolution is central to all fields of life science. It is the unifying theory of biology (Dobzhansky, 1973) and important in the construction scientific ideas about many concepts, from cell biology to ecosystems. Since natural selection appears to be the main mechanisms of evolution, it is an essential topic for students to learn. Even though natural selection is a fairly straight forward process, many students struggle with learning this foundational concept. Research shows that students often carry unscientific ideas with them into the course about what natural selection is and how it works (Bishop and Anderson, 1990; Smith, 2010). These alternative conceptions are well known and have been extensively studied (Anderson, Fisher & Norman, 2002).

This unit attempts to provide teachers with tools to help their students tackle these alternative conceptions and build up a scientific understanding of natural selection. One of the main tools in this unit is concept cartoons. A concept cartoon is a single-panel image that shows several characters explaining a situation. One of these characters provides a scientifically accurate answer, while the others make statements that are incorrect. The incorrect choices are explanations that are common unscientific ideas that the students often hold. This allows the teacher insight into what their students' conceptions are and how they change throughout the course.

Concept cartoons have been found to be successful in helping students learn complex physics concepts (Guzzetti, 1997) and are more recently being used to communicate biological concepts (Anderson, 2014). Concept cartoons are especially useful because they allow students to engage in argumentation about the alternative conceptions that are commonly held (Artırabiliriz , 2009 ; Jimenez-Aleixandre, 2000). Concept cartoons are also engaging and provide motivation for students to participate in classroom activities (Bandiera, 2006).

This unit will provide teachers with a way to teach the main concepts of natural selection and attempts to address the common alternative conceptions that students hold. The unit is broken into four sections. Each section contains concept cartoons, notes, and an activity. Formative and summative assessments are also included. When using this researched-based unit, teachers can be confident that they are helping their students to build a scientifically solid understanding of evolution by means of natural selection and setting a foundation for their students' future biological studies.

References

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Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. Science Education, 84, 757-792.

Smith, M.U. (2010). Current Status of Research in Teaching and Learning Evolution: I. Philosophical/Epistemological Issues. *Science Education*, 19, 523–538.

Smith, M.U. (2010). Current Status of Research in Teaching and Learning Evolution: II. Pedagogical Issues. *Science Education*, 19, 539–571.

SUGGESTED SEQUENCE OF LESSONS

The following is a suggested order for the lessons and activities that are included in this unit. However, each class has unique needs so the timing of the lessons should be altered as needed for your particular group of students. An estimate for the time needed to complete the activity is included. Other lessons (such as vocab or videos) can be added into the lesson sequence as seen fit by the instructor. Click on the assignment name to jump to the lesson.

- CINS Pretest Version A — *20-30 min*

Section #1- Biotic Potential and Stable Populations

- BP Cartoon #1- Grass (Click Here or see cartoon section for instructions) — *20 min*
- Biotic Potential Activity — *50 min*
- Biotic Potential Notes (Click here to go to power point) — *20- 30 min*
- BP Cartoon #2- Mice With class discussion (If time allows have students review the first cartoon to see if they would change their answer) — *30 min*

Section #2- Limited Resources and Survival

- Choose 1-3 cartoons: SP #1 Snakes, LR #1 Bighorn Sheep, LS #1 – Chicks — *20-30 min*
- Oh Deer Activity — *50 min*
- Limited Resources and Survival Notes (Click here to go to power point) — *20- 30 min*
- Choose 1-3 cartoons: SP #1 Trees, LR #2 Seedlings, LS #2 Dandelions — *20- 30 min*

Section #3 Variation

- Choose 1-3 cartoons: V #1 Owls, OV #2 Random Part, VI #1 Sport — *20-30 min*
- Sunflower Variation Activity — *50–70 min*
- Variation Notes (Click here to go to power point) — *20- 30 min*
- Choose 1-3 cartoons: V #2 Flamingo, OV #2 Sunflower, VI Dogs — *20-30 min*

Section #4 Change in Populations and Speciation

- Choose 1-3 cartoons: DS #1 Guppy, CP #1 Adaptation, OS #1 Squirrel — *20-30 min*
- Natural Selection Activity — *50-70 min*
- Speciation Notes (Click here to go to power point) — *20- 30 min*
- Choose 1-3 cartoons: DS #2 Sunflower, CP #2 Antibiotics, OS #2 Finches — *20- 30 min*
- Natural Selection Card Sort Activity — *40-50 min*

- CINS Post Test Version B — *20-30 min*

BIOTIC POTENTIAL & STABLE POPULATIONS

SECTION #1 INTRODUCTION

Key Points:

- Organisms produce more offspring than are needed to replace themselves.
- If populations of organisms have no limiting factors in their environments these populations will produce offspring exponentially.
- In a stable population experiencing limiting factors in the environment we see that population numbers stay about the same over time.

Common Student Unscientific Conceptions:

- Populations stay the same size even with unlimited resources.
- Most populations will grow slowly over time even with plentiful resources.
- Organisms tend to just have enough offspring in order to replace themselves.

Biotic potential activity

How many offspring could you possibly get?

Population #1: Dandelions

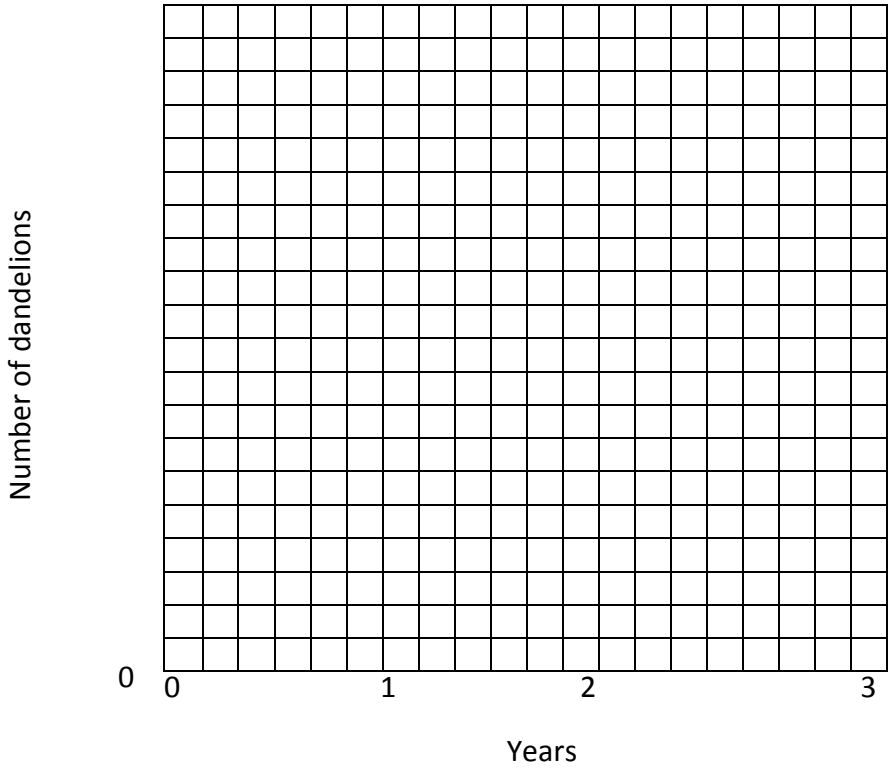
Suppose that dandelion plants produce 2 flowers with 100 seeds in each one every year. Starting with the original plant, determine the size of the population after each generation.

Assume:
- all individuals reproduce at the same time every year
- that individuals can reproduce each year
- that all seeds germinate to produce plants that survive to flower

Time	Number previously in population	Number Added	Total Number in Population
Start	--	--	1
1 year			
2 years			
3 years			

Now graph your results below:

Change in dandelion population size



D. Anderson, 2011 Point Loma Nazarene University

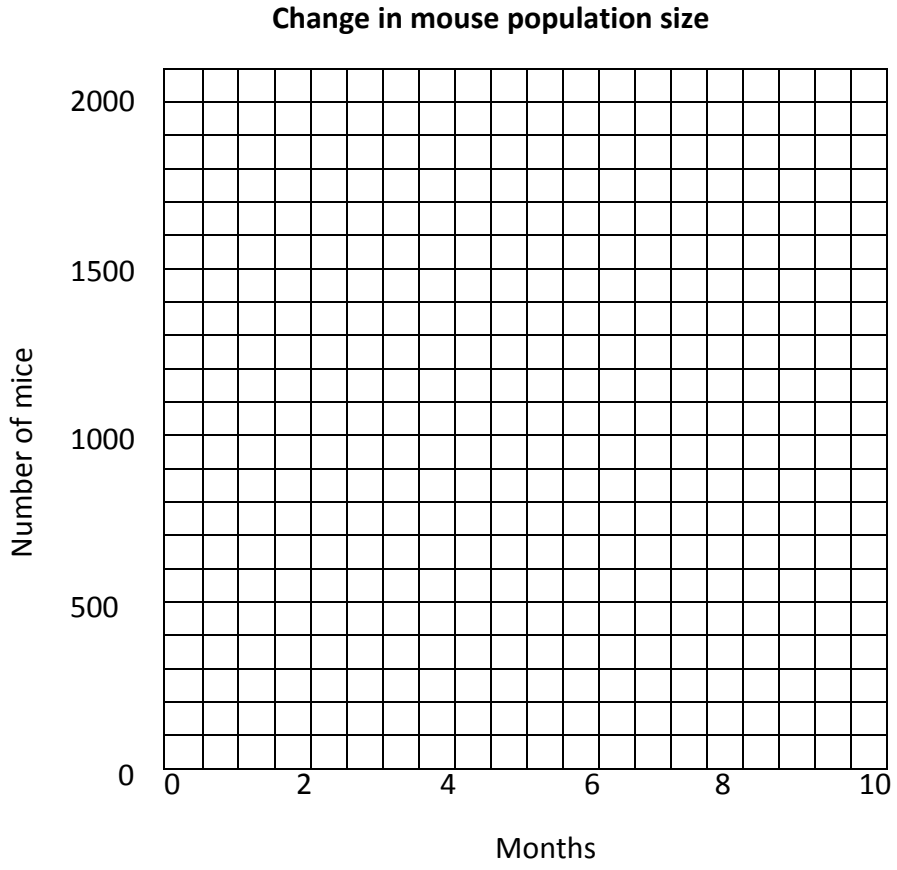
Population #2: Mice

Suppose a theoretical population of field mice bred for five generations. Starting with an initial pair, determine what the size of the population would be for each generation.

Assume:
- each female has 6 offspring each time
- litters of offspring are ½ male and ½ female
- all individuals reproduce at the same time every two months

Time	Number previously in population	Number Added	Total Number in Population
Start	--	--	2
2 months			
4 months			
6 months			
8 months			
10 months			

Now graph your results below:



Population #3: Bacteria

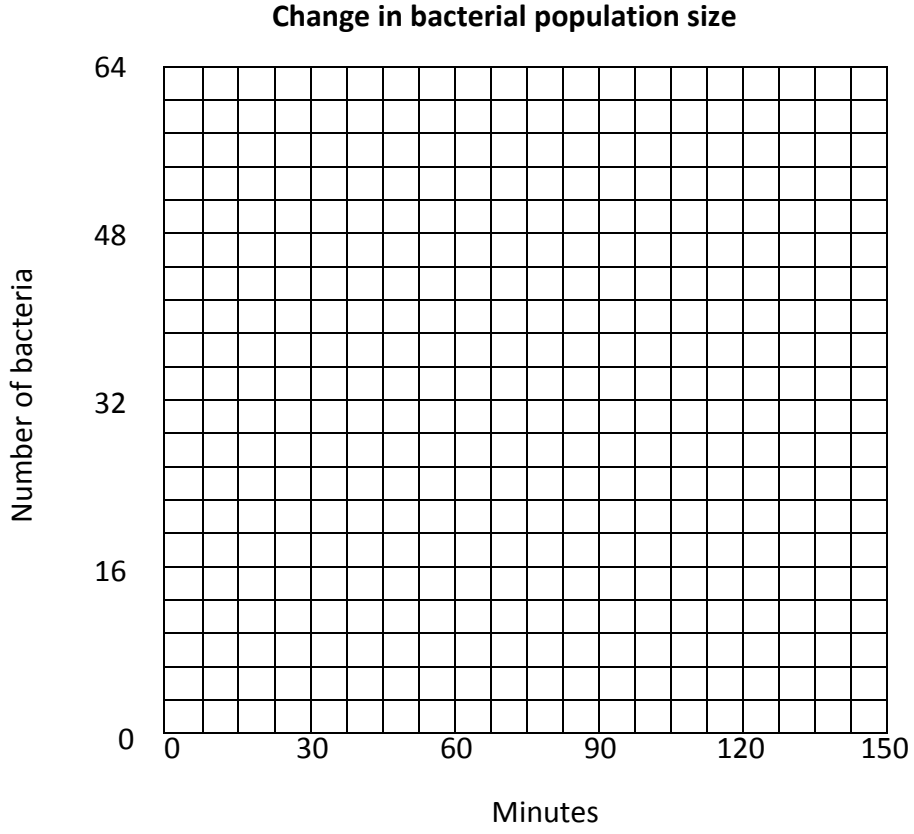
Suppose a theoretical population of bacteria reproduced for five generations. Starting with an initial pair, determine what the size of the population would be for each generation.

Assume:

- all individuals live to reproduce
- All individuals reproduce at the same time every 30 minutes

Time	Number previously in population	Number Added	Total Number in Population
Start	--	--	2
30 minutes			
60 minutes			
90 minutes			
120 minutes			
150 minutes			

Now graph your results below:



LIMITED RESOURCES AND SURVIVAL

SECTION #2 INTRODUCTION

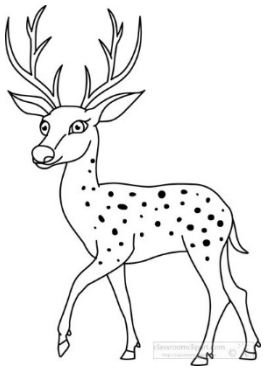
Key Points:

- Organisms are in competition with other organisms for resources such as sunlight, water, nutrients, and mates.
- Competition can occur between species and also between organisms of the same species.
- Competition rarely involves physical fighting between organisms.
- As a result of competition most offspring die before reaching sexual maturity.

Common Unscientific Conceptions Held by Students:

- Competition is a physical fight between organisms in which the biggest/strongest one typically wins.
- Only male organisms compete.
- There are always enough resources for organisms.
- Organisms of the same species do not compete with each other.
- Most (or all) offspring survive to reproductive age.

Oh Deer!!



A Game about Population Change

Teacher Instructions:

Objectives

1. Students will understand that organisms need certain resources in order to be able to survive and reproduce.
2. Students will understand that there are limiting factors that determine how large a population can become.
3. Students will be able to describe how and why a population changes as its ecosystem changes.

Materials

- Large area for running or walking (field or gym)
- "Resource" and "Necessity" cards. – Printed in color or copied onto colored cardstock
- Writing materials

Procedure

1. Before you begin the activity: Ask the students what organisms need to survive? What happens to the organisms if they do not get what they need? Have the students fill out the "Before You Begin Questions" on their worksheets.

2. Outside: Pick 3 students to be special helpers, 2 for passing out cards and 1 for a score keeper. Separate the class so that about ¼ of the class becomes "deer" and ¾ become "Resources". You could have students count off 1-4 and then all #1s become deer. Have the students line up in two parallel lines about 10 to 20 yards apart. (It might be easier to mark out where the lines will be ahead of time). The two lines should have their backs to each other.

3. Special Helper #1 will run down the line of deer and had each of them a "necessity" card. Each deer will get one of 3 things: food, shelter, or water. This is what the student will have to find in order to live into the next "year". Special Helper #2 will run down the "resource" line and give them each a card with a certain resource on it. Helper #3 will record the number of deer that are present in year #1.

4. Count "One, Two, Three, Go!!" and all the students turn toward the other line. The deer then run (or walk) to a person in the resource line that has a matching card. Only 1 deer can claim a resource. If a deer successfully finds the resources that they need then they are able to

"reproduce" and bring that student back to the deer line with them. They are now a deer for the next round. If they are not able to find the resource that they need then the "deer" dies and becomes a student in the "resource" line.

5. Special Helpers #1 and 2 should collect the cards. Student #3 records the number of deer at the start of year 2. Both lines should turn away from each other and the cards get passed back out.

6. Repeat the process for 8-10 rounds, making sure that the number of deer is being recorded at the beginning of each year.

7. Take the students back in the room. Have special helper #3 share the data with the class (by writing it on the board or showing it on an overhead projector). Students should copy the data onto their data table, graph the number of deer over time, and use that graph to answer the questions. Discuss the results as a class.

Credits: Adapted from "Oh, Deer!" Project WILD Activity Guide. Western Regional Environmental Education Council, 1992.

Printing Instruction for cards

Make 5 copies of each sheet of cards. Print off onto different colored card stock (ex: food = green, water = blue, shelter = yellow).

Cut out and separate into two different stacks, one stack of "I need" cards and another of the "I am" resource cards. The necessity cards get passed out to the deer and the "I am" cards get passed out to the resource line.

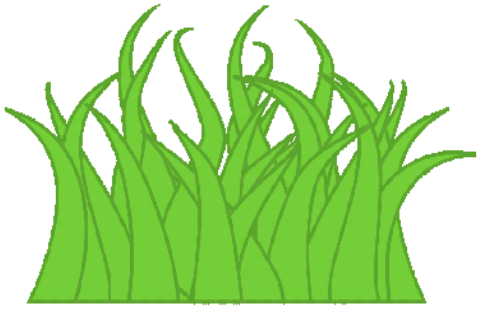
I need:

Food



I need:

Food



I need:

Food



I need:

Food



I need:

Water



I need:

Water



I need:

Water



I need:

Water



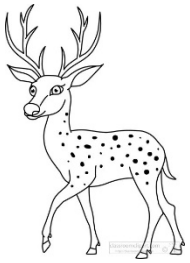
I Need: Shelter 	I Need: Shelter 
I Need: Shelter 	I Need: Shelter 

I Am: Food 	I Am: Food 
I Am: Food 	I Am: Food 

I Am: Water 	I Am: Water 
I Am: Water 	I Am: Water 

I Am: Shelter 	I Am: Shelter 
I Am: Shelter 	I Am: Shelter 

Name:
Period:



Oh Deer!!- A Game about Population Change

Student Handout

Before you start the game:

1. List some things you think organisms need in order to survive and reproduce.
   _____
   _____
   _____

2. What do you think will happen to a population of organisms over time if there is a limited amount of resources available to them in an environment?
   _____
   _____
   _____

Instructions:

Today the class is going to simulate a population of deer in an environment with a limited number of resources (food, water, and shelter). We will start off with ¼ of the class being "deer" and the rest of the class will be the resources that the deer need. In each round of the game the deer will have to find the resource that they need in order to survive. If they are successful then they get to reproduce (a "resource" student becomes a "deer). If they are unsuccessful then they die (a "deer" student becomes a "resource" student).

We will track the changes in the deer population over 8-10 rounds with 1 round representing 1 year. Make sure to follow all of the teacher's instructions and rules or the simulation will not work correctly.

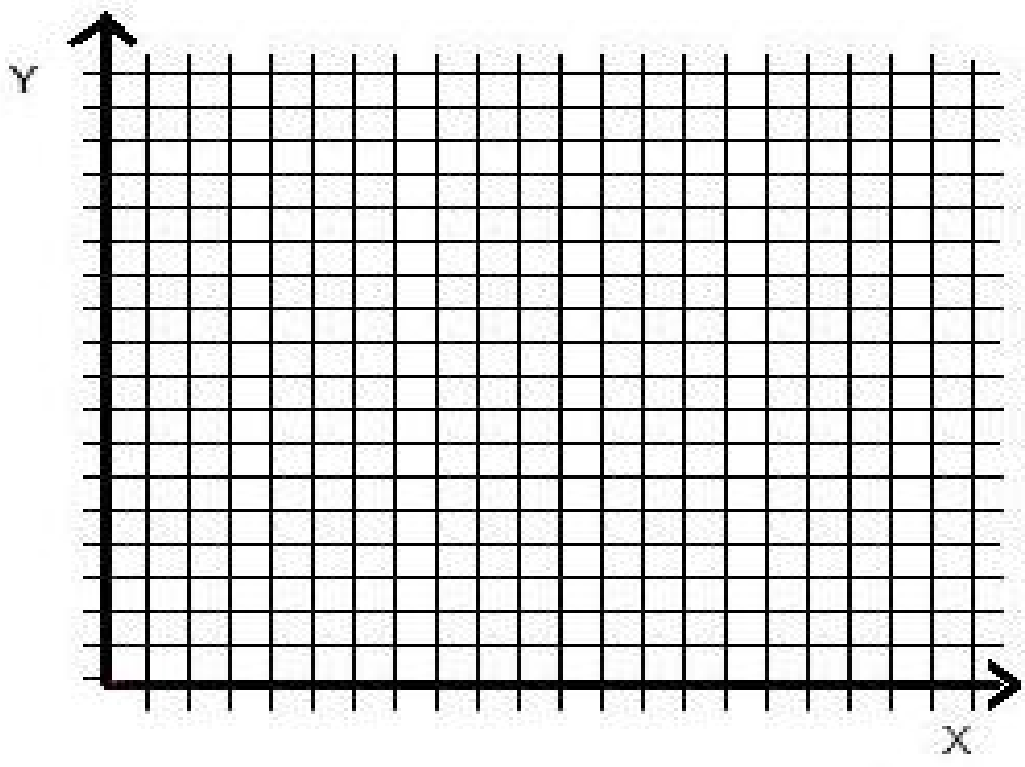
When the simulation is complete you will graph the data that has been collected and analyze the changes in the deer population that were observed.

After the game:

1. Fill in the data table showing the number of deer present at the start of each year (round)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
# of Deer								

2. Graph the change in the deer population over time



3. Describe how the population of deer changes between years 1-3. _____

_____

4. Describe what happened to the population of deer as the resources became more limited.

_____

_____

5. What is realistic about this simulation and what is not realistic. _____

_____

VARIATION

SECTION #3 INTRODUCTION

Key Points:

- Variation exists between organisms even if they look very similar.
- This variation originates from random mutations in DNA.
- These variations can be important in the survival of the organism and can be passed down to offspring.
- Traits that are learned or acquired during the lifetime of an organism are not encoded in the DNA and therefore are not passed down to offspring.
- As long as a trait is not harmful to the survival/reproduction of an organism it can get passed on through generations.

Common Unscientific Conceptions Held by Students:

- Organisms of the same species are identical or have no important differences.
- Origin of variation arises out of a need or want of the organism for that trait.
- Acquired traits can be genetically inherited.

Name:
Period:

Variation in Sunflower Seeds Worksheet

Introduction

One of the central ideas in Charles Darwin's theory of evolution by natural selection is that variations (differences) exist naturally within any population of organisms. These variations are the "raw materials" upon which natural selection works. Without variation evolution, indeed life itself, would be impossible. In this lab we examine the range of variation within a "population" of sunflower seeds. The number of stripes is a polygenetic characteristic – determined by multiple genes. Thus, the more "striped genes" the seed has inherited, the more stripes it will have. This has consequences for the future offspring of the plant that eventually grows from the seed.

Instructions

1. _____Check off each instruction as you complete it.
2. _____Secure the following materials from the indicated place:
    a. A baggie with sunflower seeds.
    b. CAUTION: THE SEEDS ARE COVERED IN FUNGICIDE -DO NOT EAT!
    c. Magnifying glass
3. _____Write a hypothesis that predicts the average number of (white) lines on a sunflower seed. Have your instructor check this off **before going on**!
4. _____Count the number of white stripes **on a minimum of 101** sunflower seeds and record the data in Table 1.
5. _____Count partial lines if they are longer than half the seed otherwise ignore them. **Count Both Sides**.
6. _____Construct a bar graph of your individual data as Graph 1.
7. _____Transfer your individual totals to the class data table



Part I ... Data Collection

Tally marks are to help you keep track of your counting. Simply make a mark in the appropriate box for each seed as you go through your bag. Total up the tallies and record in Column C. Columns E are for whole class data.

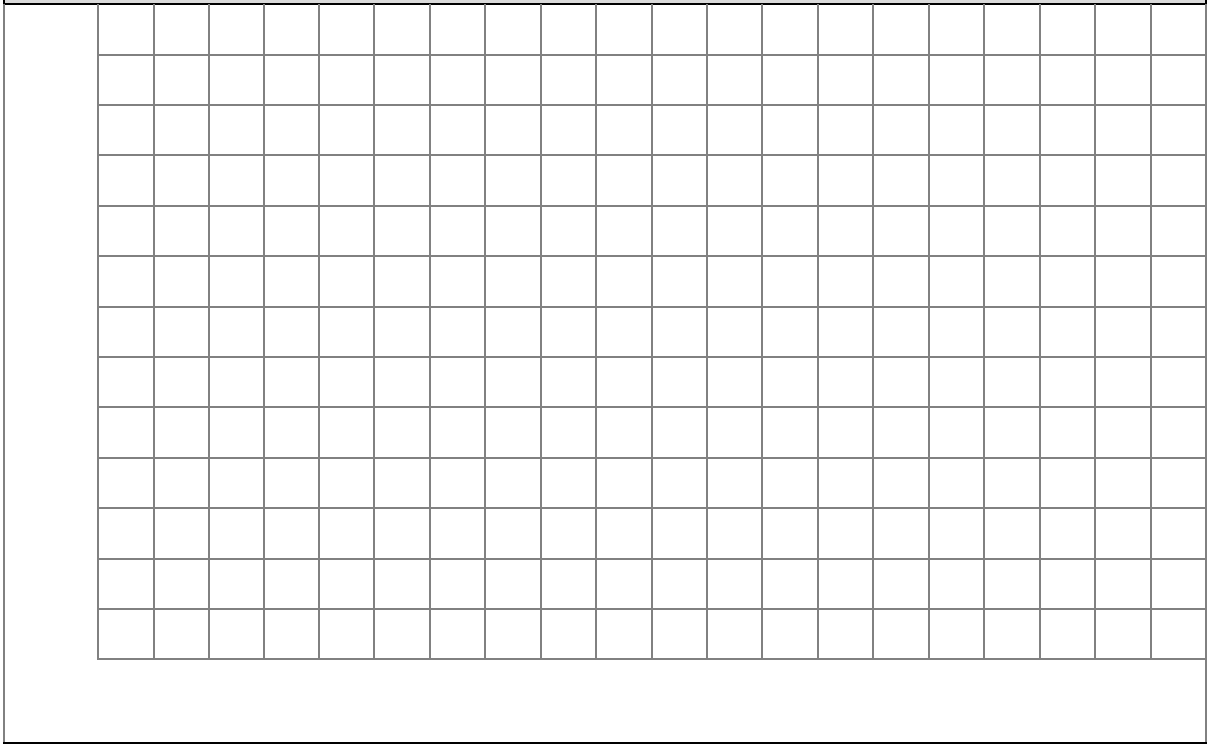
A	B	C	E
Number of Stripes per Seed	**Individual Totals**		**Class Totals**
	Tally Marks	**Seeds**	**Seeds**
0 - 1			
2 - 3			
4 - 5			
6 - 7			
8 - 9			
10 - 11			
12 - 13			
14 - 16			
Total # counted seeds =			

Instructions (Day 2)

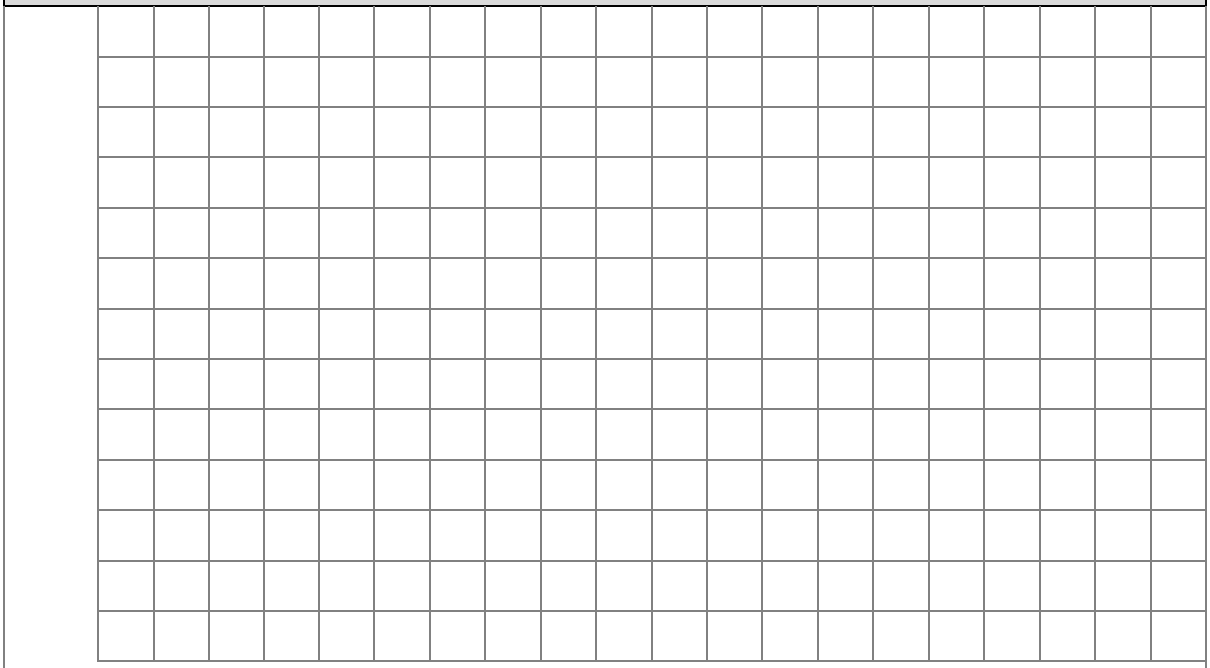
1. ___ When all the class data has been entered on the board or in the computer, complete Table 2.
2. ___ Construct a bar graph of the class data as Graph 2.

Graphing

Graph 1: Your group's Data



Graph 2: Whole Class Data



Part III ... Conclusions

1. Hypothesis:

_____

2. Was your hypothesis correct or incorrect? Explain why?

_____

_____

3. Describe the shape of the line form in the class data.

_____

4. How does the shape of your individual graph compare to that of the class data? (Hints: Is it shaped differently? Is it symmetrical?

_____

_____

5. List possible reasons why your graph is different?

_____

_____

6. If birds ate (selected) only seeds with 10 or more stripes, what would happen to the average number of stripes on sunflower seeds over several generations (time)?

_____

_____

CHANGE IN POPULATIONS & SPECIATION

SECTION #4 INTRODUCTION

Key Points:

- Adaptation is a change in allele frequency in a population over time in response to environmental pressures.
- Individual organisms cannot change their genes and therefore cannot adapt. Biologists say that individuals acclimate. Only populations can adapt over time.
- Acclimation are only physical changes that happen, not genetic. An example of acclimation is producing more red blood cells at higher elevation.
- When interbreeding between organisms is prevented changes can occur between the two populations over a long period of time.
- Reproductive isolation can eventually lead to the formation of a new species if given enough time.

Common Unscientific Conceptions Held by Students:

- Acquired traits can be genetically inherited.
- Individuals can adapt with time.
- Only certain organism can adapt and not others.
- If an organism needs or wants to change then they can.
- Different species come about out of the need for organism to access different resources to survive.



Name:

Period:

Natural Selection Lab

Objective: to demonstrate that natural selection results in populations different from the original population.

Background: Organisms that are best suited to their environment are going to survive and reproduce. Overtime these beneficial traits (adaptations) become more common in the population. You will be demonstrating natural selection acting on a model population of organisms (beans). Each different type of bean represents a variation in the population. The organisms that are best suited to escape their predator (2 Styrofoam bowels) will survive to pass on their genes to the next generation.

Materials:

* Cup full of 4 different types of beans (kidney, black, pinto, and split pea)

* 2 Styrofoam bowls (one with six different sized holes punched in it)

Procedure:

1. Select 4 beans of each type and place them in your bowl. Record your starting number on the data table.
2. Cover that bowl with the second bowl (so our organisms don't get thrown)
3. Shake the bowls back and forth gently a total of 10 times.
4. The organisms that make it through the bowl live! The ones that are still in the bowl have gotten eaten by a predator. Place the dead ones back in with the extra beans.
5. Every organism that lived reproduces and has two offspring. Add 2 extra beans for each organism that lived to the bowls.
6. Repeat these steps for 5 rounds (generations).

Data table

Organism Type	Starting# Round 1	# left	Starting# Round 2	# left	Starting# Round 3	# left	Starting# Round 4	# left	Starting# Round 5	# left
Kidney										
Green										
Barley										
Black										

Questions:

1. How did your population of organisms change? Did they evolve?

2. List two genetic variations that are found in your starting population of beans.

3. What variation was most helpful to the organisms when it came to escaping the predator?

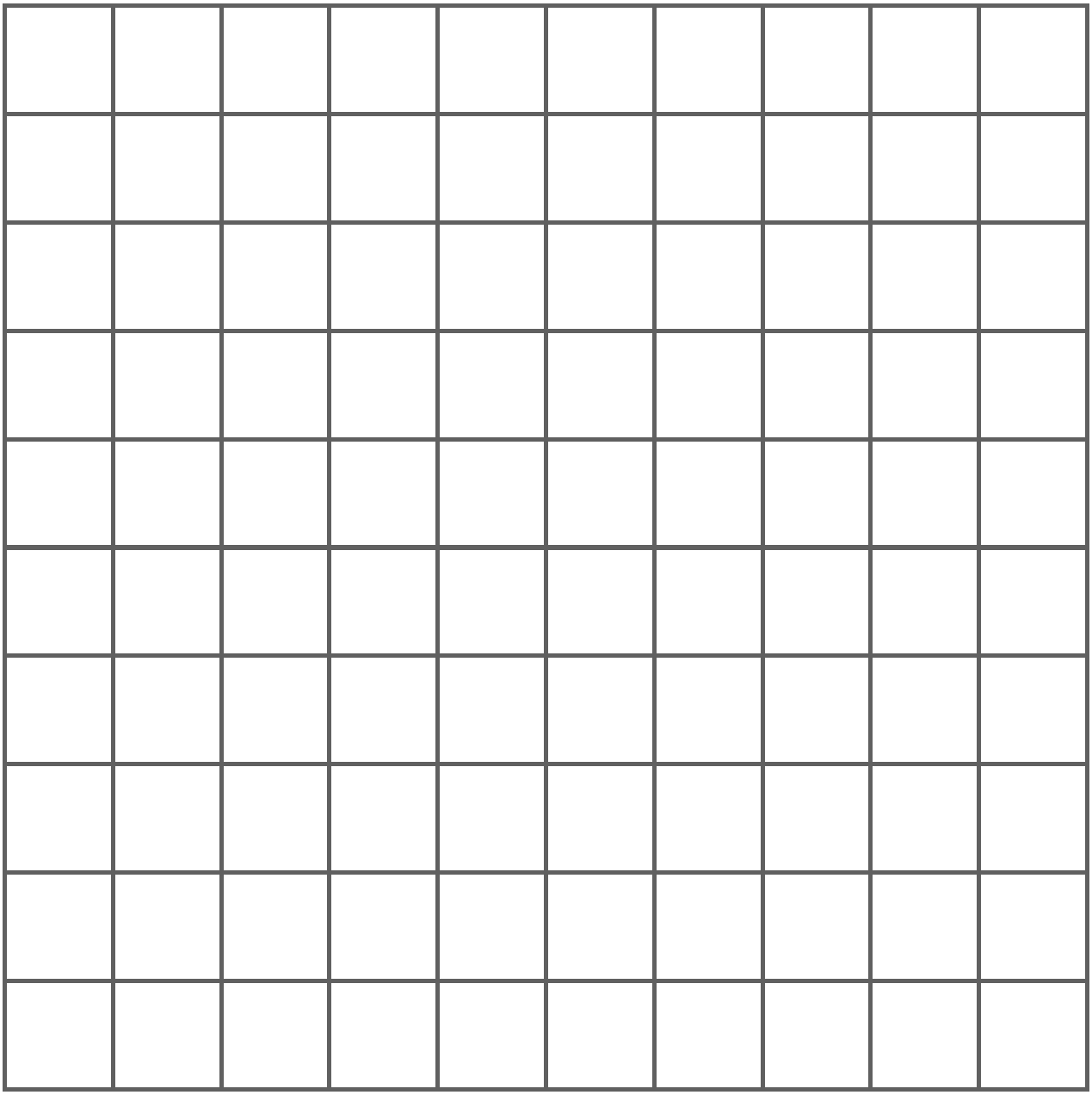
4. Did any variation die out completely?

5. What results do you think you would have seen if there had been larger holes in the bowl?

6. What results do you think you would have seen if there had been smaller holes in the bowl? Why?

7. You study a population of rabbits that are both light and dark. The surrounding grass is light. What color would you predict the population of rabbits to mostly be after thousands of years had passed? Why?

**Using a different color line for each variation, graph the results from this activity. Population size is on the y-axis and trial number on the x-axis. Please include a title and a key for your graph and label your axis.



Natural Selection Card Sort

Teacher Instructions

After teaching a unit on natural selection students should be able to explain how a population of organisms could change over time. Use this activity as a formative assessment to tell if students understand the concept or if more clarification and re-teaching is necessary.

Directions:

Print out a set of cards for each group (or pair) or students. Give them the following scenario

There is a population of rabbits and they are all brown (show the card with all brown rabbits). They were moved to a location that is all snowy. After sometime the rabbit population evolves and now looks like this (show card with white rabbits, one brown rabbit, and a fox)*. They are still living on a snowy background. I have other cards that you can use to explain what is happening here. You do not have to use them all if you do not want to. So…using these cards can you explain to me how the population of rabbits change from this* (show card with brown rabbits) *to this* (show card with white rabbits and one brown rabbit)*?*

Have the students fill in the student worksheet after they think they have a good explanation. Pick several groups to share their idea to the class. Discuss the good points and misunderstandings that come out as a class during this activity.

Example of a Good Explanation

1. 

2. 

3. 

4. 

5. 

6. 

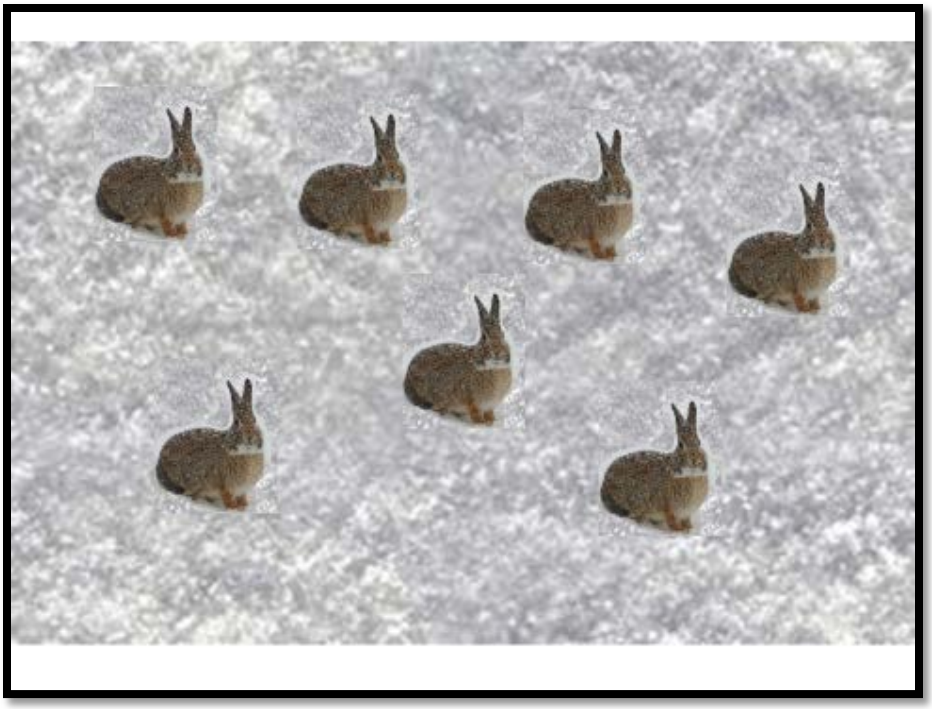
There is a population of brown rabbits living in a snowy environment. There was a **random mutation (change in the DNA)** that caused a white variation of fur color to be present in the rabbit population. The fox is a predator of the rabbit and can see the brown rabbits more easily against the snowy background. This gives the white rabbits an **advantage** in surviving and reproducing. **Over time** more of the brown rabbits get eaten by the fox before they can reproduce and the white rabbits live to reproduce and **pass on** their "white fur" genes to their offspring. Over **many generations** we are able to see a population of brown rabbits evolve to a population of mostly white rabbits.

Common unscientific ideas:

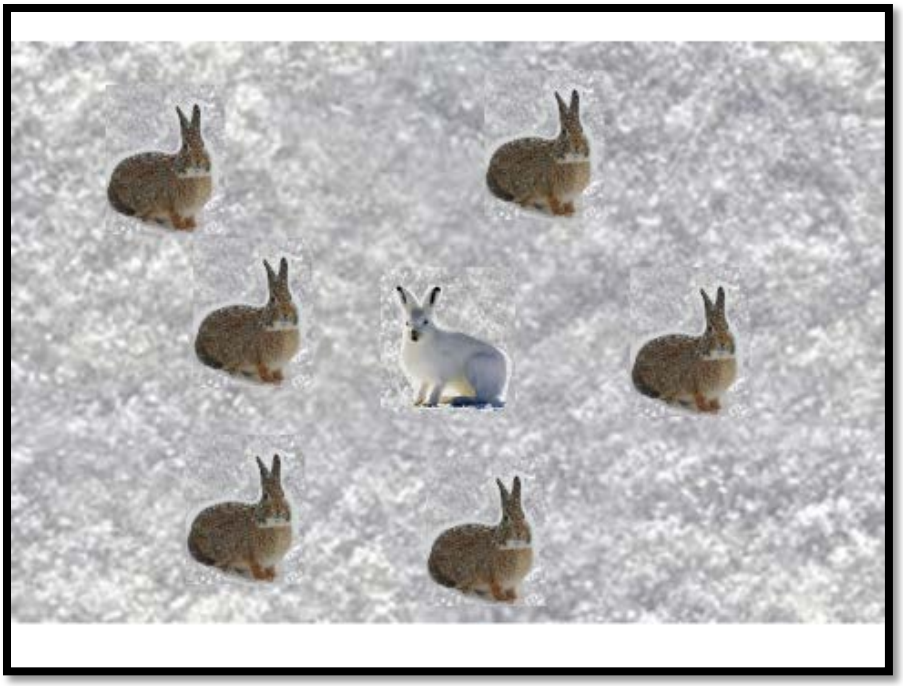
*When asked, students will often identify the rabbits on the first card as the same individuals as the rabbits on the last card. In reality, individuals can not adapt, only populations. This kind of change is usually only seen over many many generations.

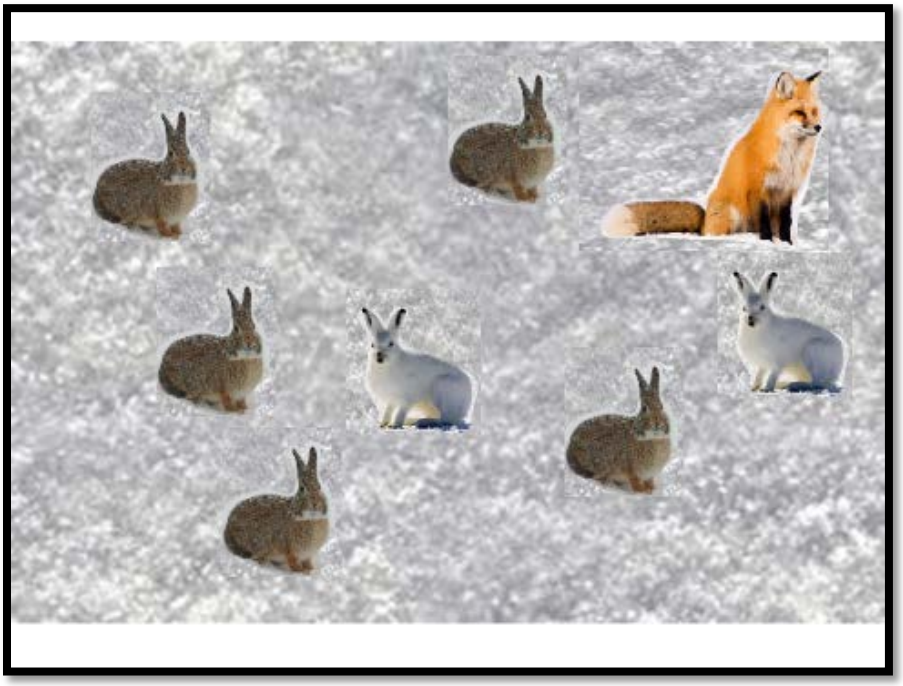
* Students sometimes will say that the rabbits NEEDED to change in order to hide from the fox. In reality organims can not change because they need to. If they are not born with the needed traits for survival then they simply die. Variations (like white fur) come about through RANDOM mutations in DNA.

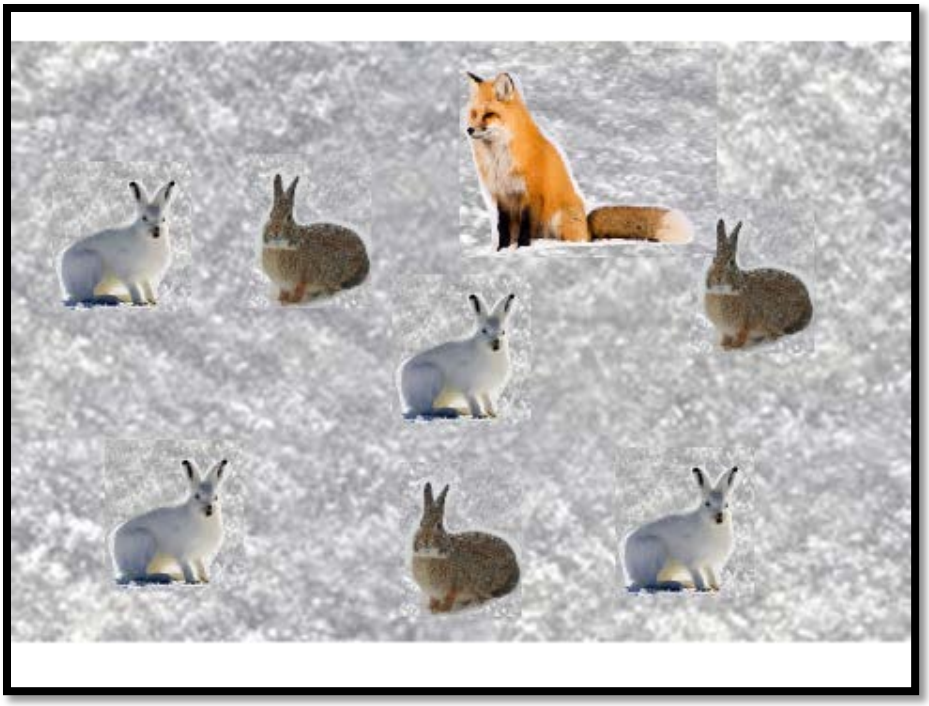
(adapted from Southerland et.al, 1999)

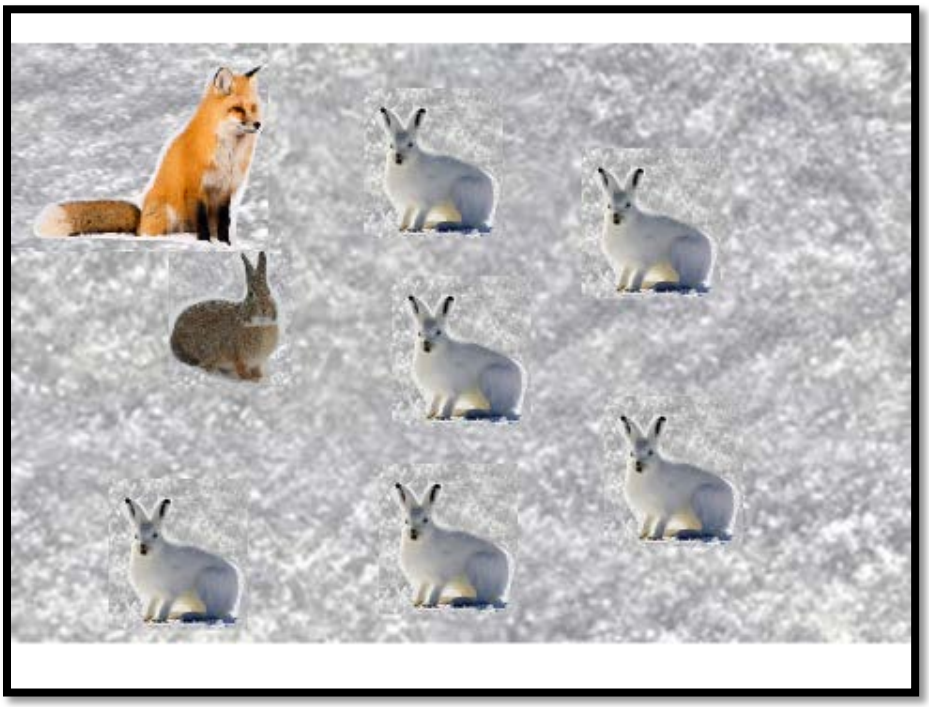


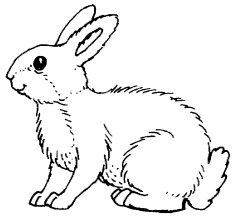












Name:_____

Period_____

Natural Selection Card Sort

Challenge: You and your group will need to use your knowledge about how natural selection works to explain the following scenario:

There is a population of rabbits and they are all brown. They were moved to a location that is all snowy. After sometime the rabbit population evolves and now is made up all most entirely of rabbits with white fur. They are still living on a snowy background. On your desk you have other cards that you can use to explain what is happening here. You do not have to use them all if you do not want to. So…using these cards can you explain how the population of rabbits changed from a population with brown fur to one with primarily white fur?

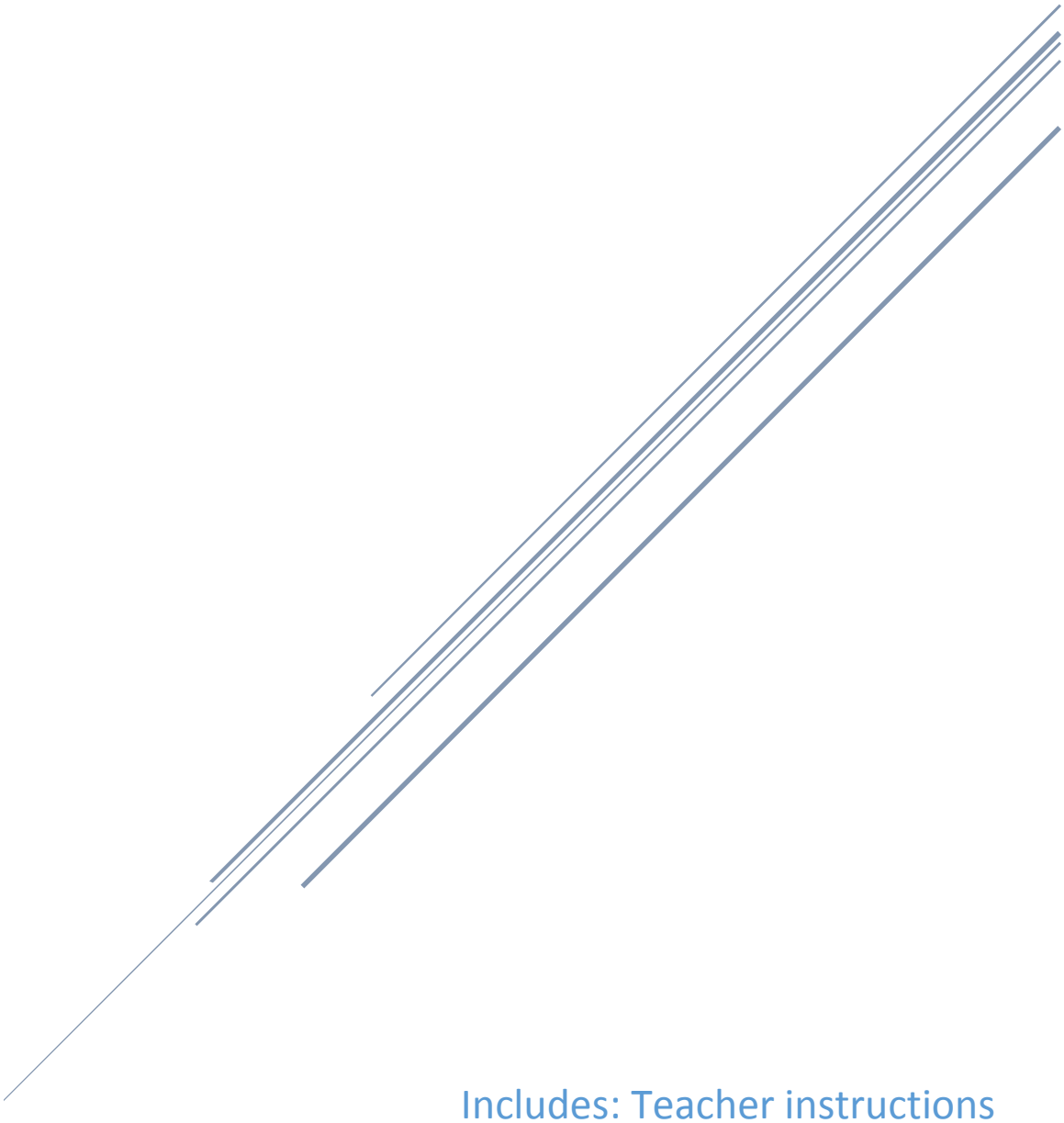
Fill in the boxes with pictures showing the final order of your cards:

1	2	3
4	5	6

Write a paragraph explaining the scenario:

NATURAL SELECTION CONCEPT CARTOONS

Student Handouts



Includes: Teacher instructions
Student handouts, Key/explanations

Teacher Instructions

This set of biology concept cartoons has been developed to correlate with the ten concepts assessed by the Conceptual Inventory of Natural Selection (CINS) – a multiple-choice diagnostic assessment instrument. The ten concepts include ecological concepts and genetic concepts, as well as concepts dealing with change over time. Explanations for the correct answers are located at the end of the packet.

Suggested classroom implementation:

Use these cartoons before you teacher the indicated concept (ie: biotic potential, competition, natural selection etc.)

Pass out the handout for a cartoon to each student and give them a few minutes to read it to themselves or read it together as a class. You can also project the cartoon on an overhead screen so that you can refer to it later.

Give the students some time to select and answer and fill out why they are choosing that answer and why they think the other answers are incorrect.

Have the students come together in groups of 3-4 and discuss their thoughts. Allow students to make changes to their answers. You could have the students write any changes on the back of the worksheet so you can see their thought process.

Come back together as a whole class. Randomly choose a few groups to discuss their thoughts about the cartoons. Lead the class in a discussion about why an answer is correct and the others are incorrect.

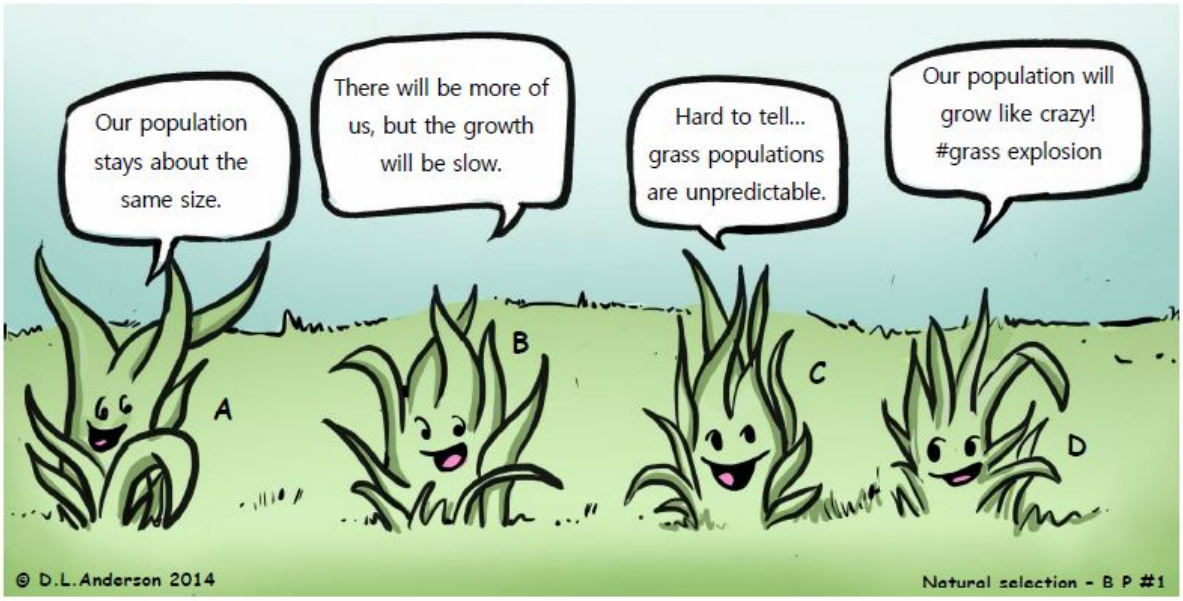
Other Options

- If there are multiple cartoons on a single topic and time allows, have the students complete more than one cartoon. It is not advised however, to go over large amounts in one sitting.
- If you are short on time only select one cartoon to go over per topic.
- If you have students that struggle with writing skip the individual writing time and start with the small group conversation.
- Go over one cartoon at the start of a topic and then go over a second cartoon after a particular topic has been formally taught.
- Paper shortage? Simply project the cartoon and have students write on their own paper or print out a class set of cartoons and put them in sheet protectors. Have the students write on them with dry erase markers or write their answers on separate white boards.

Concept cartoons on other biological concepts can be found at:
http://www.pointloma.edu/experience/academics/schools-departments/department-biology/faculty-staff/dianne-anderson-phd/concept-cartoons-0

Name:
Period:

What happens to the size of a grass population when there is plenty of water, sunlight and space, and no grass eaters (like cows)?



The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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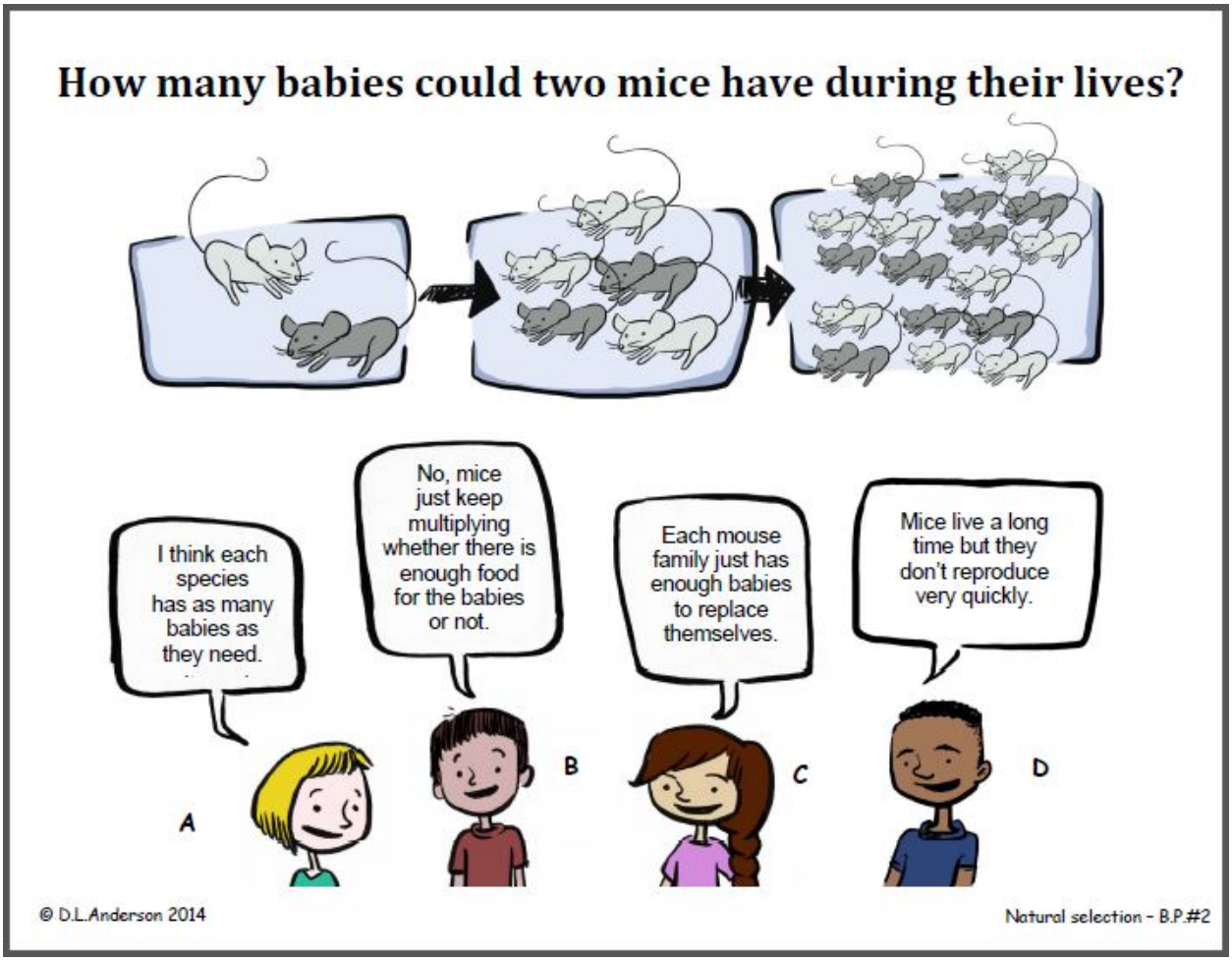
The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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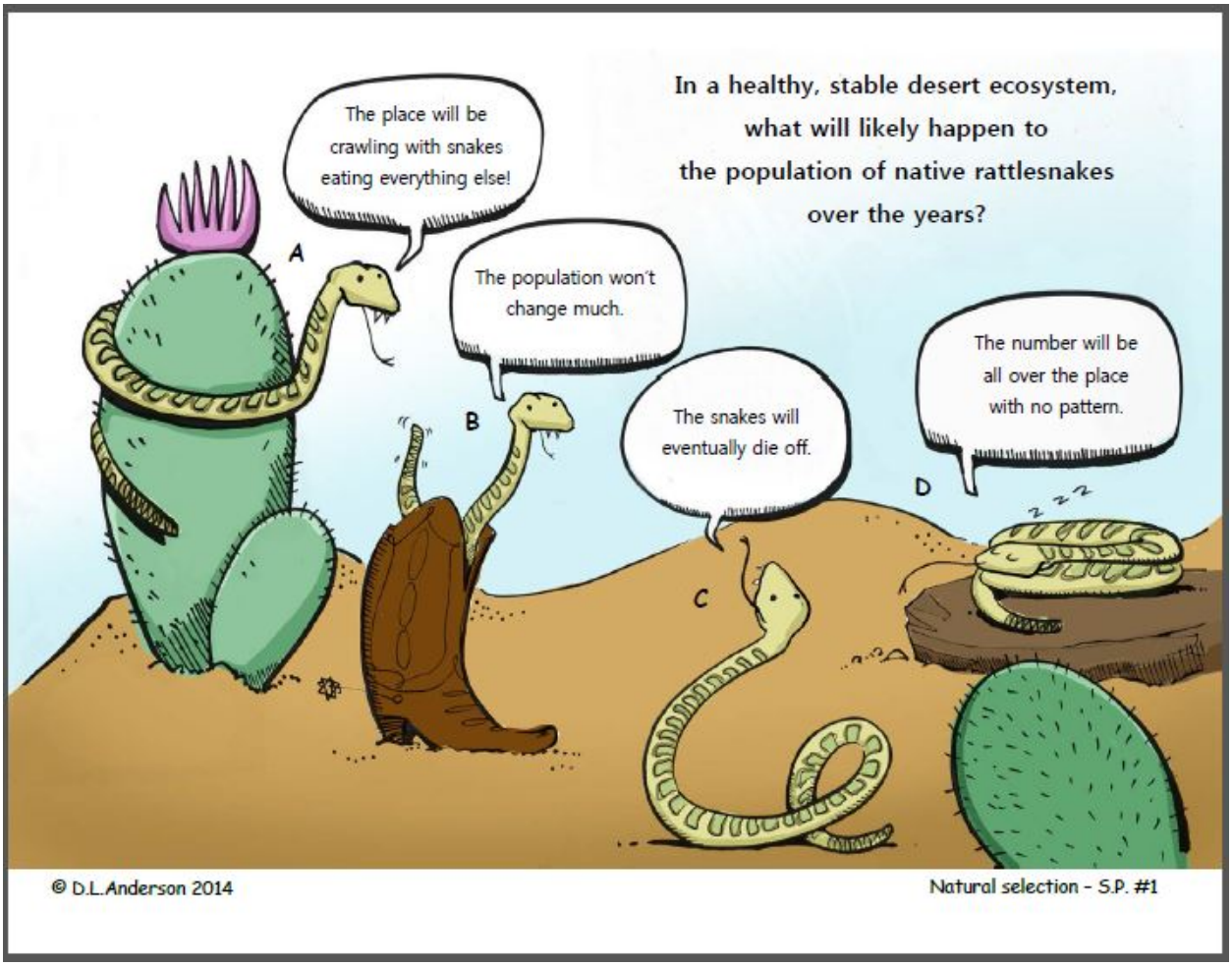
The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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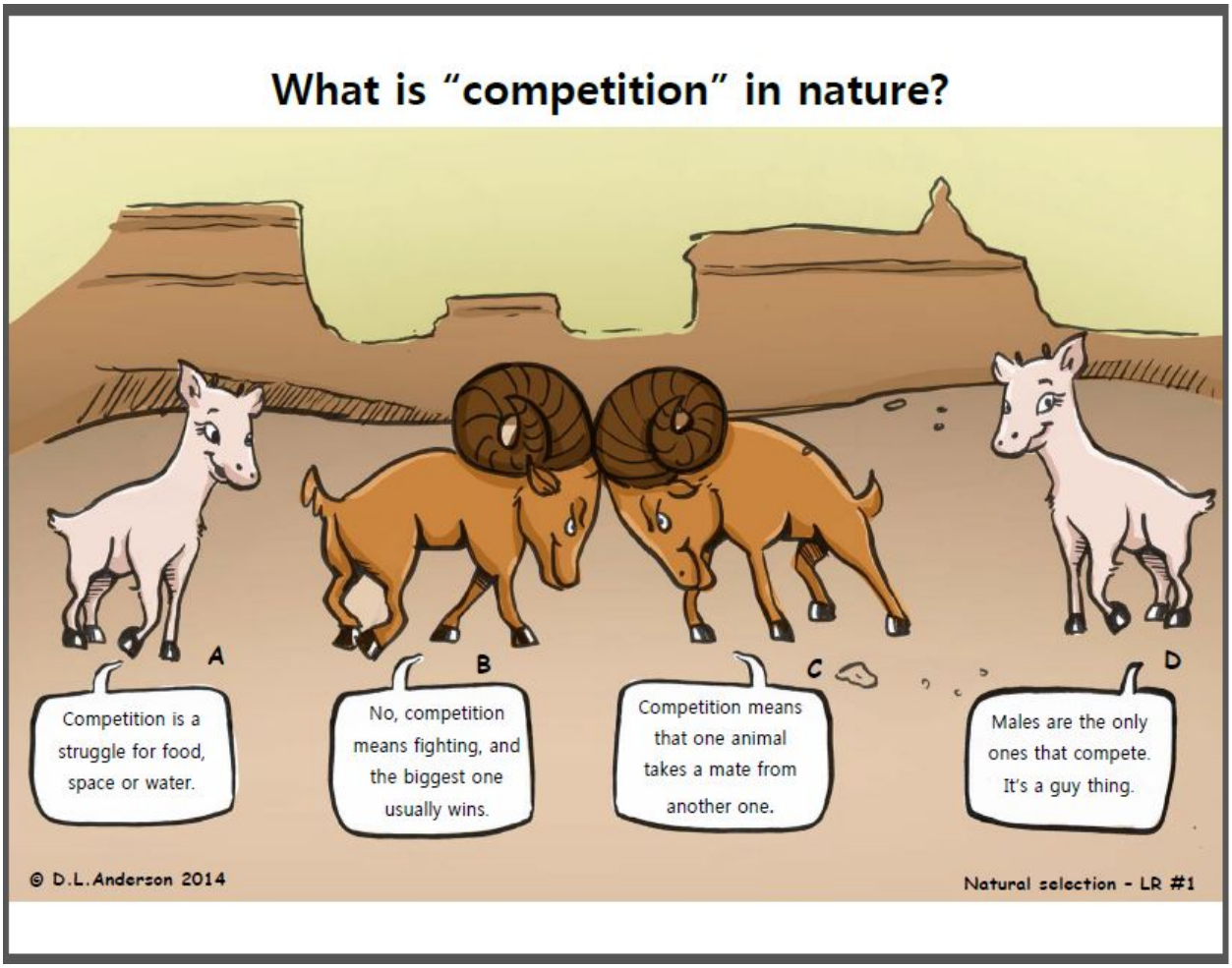
The other choices are wrong because: _____

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Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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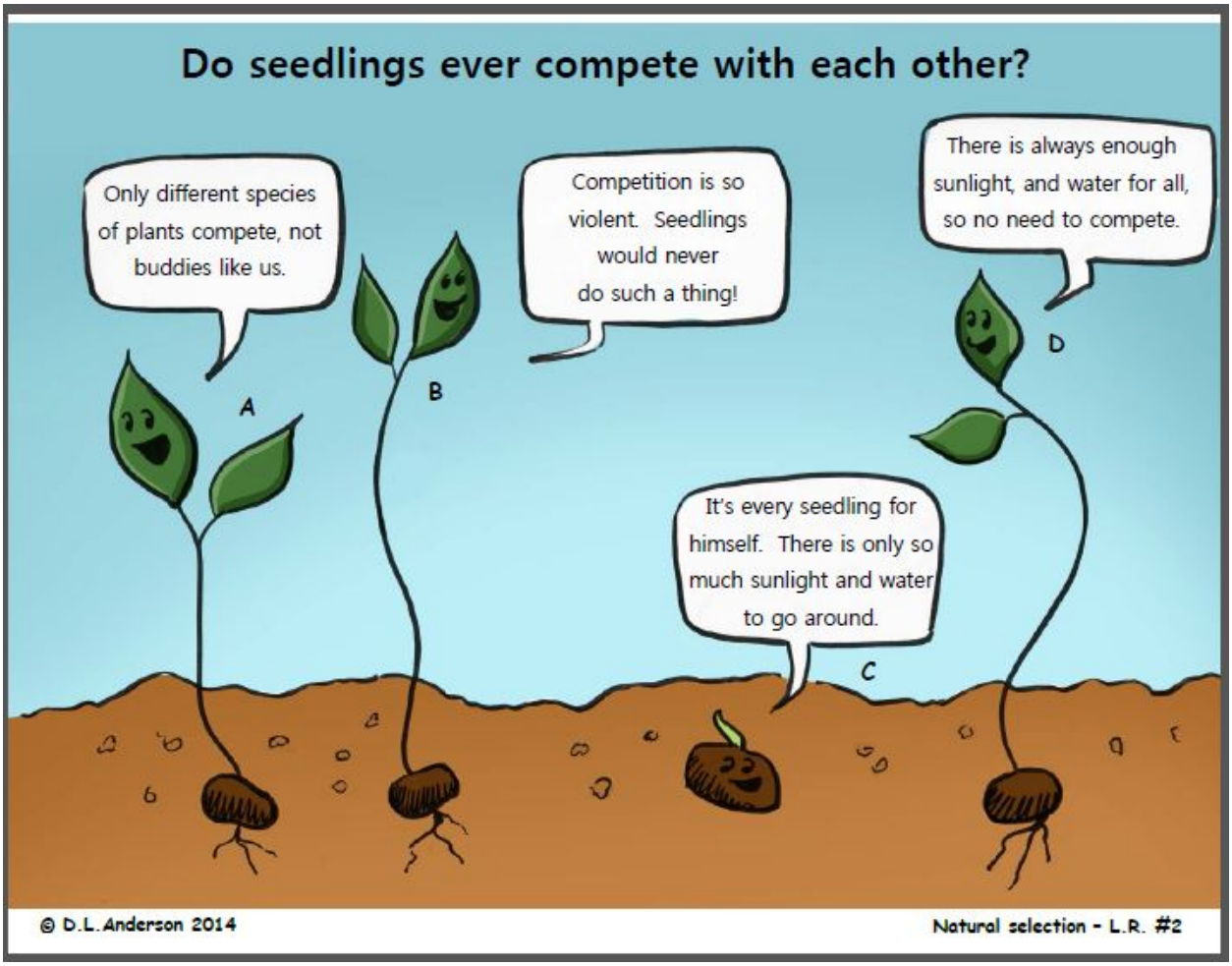
The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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The other choices are wrong because: _____

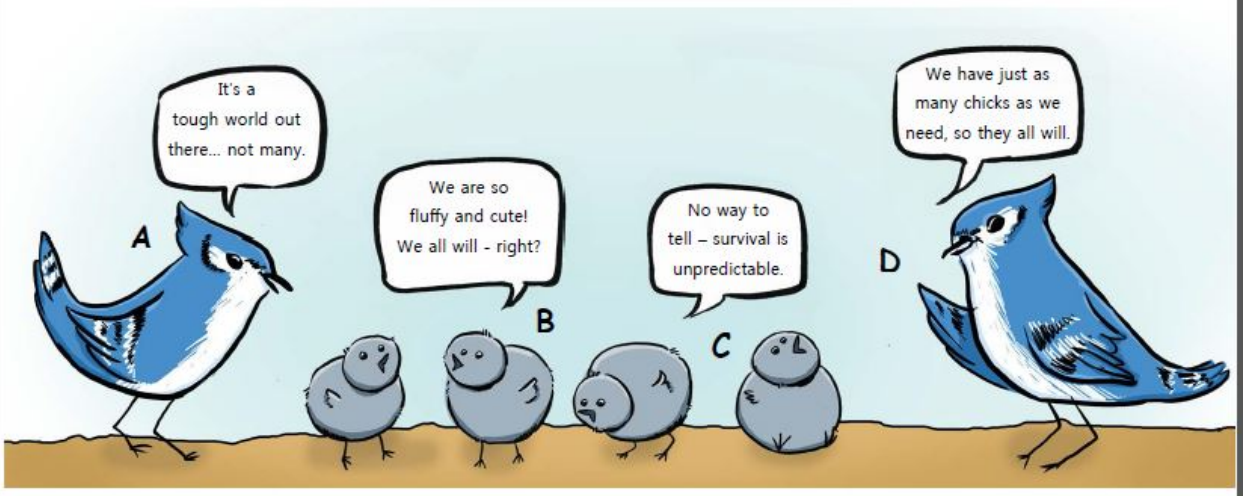
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Name:
Period:

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How many of the four chicks will be likely to survive and then have chicks of their own?



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Natural selection - L.S. #1

The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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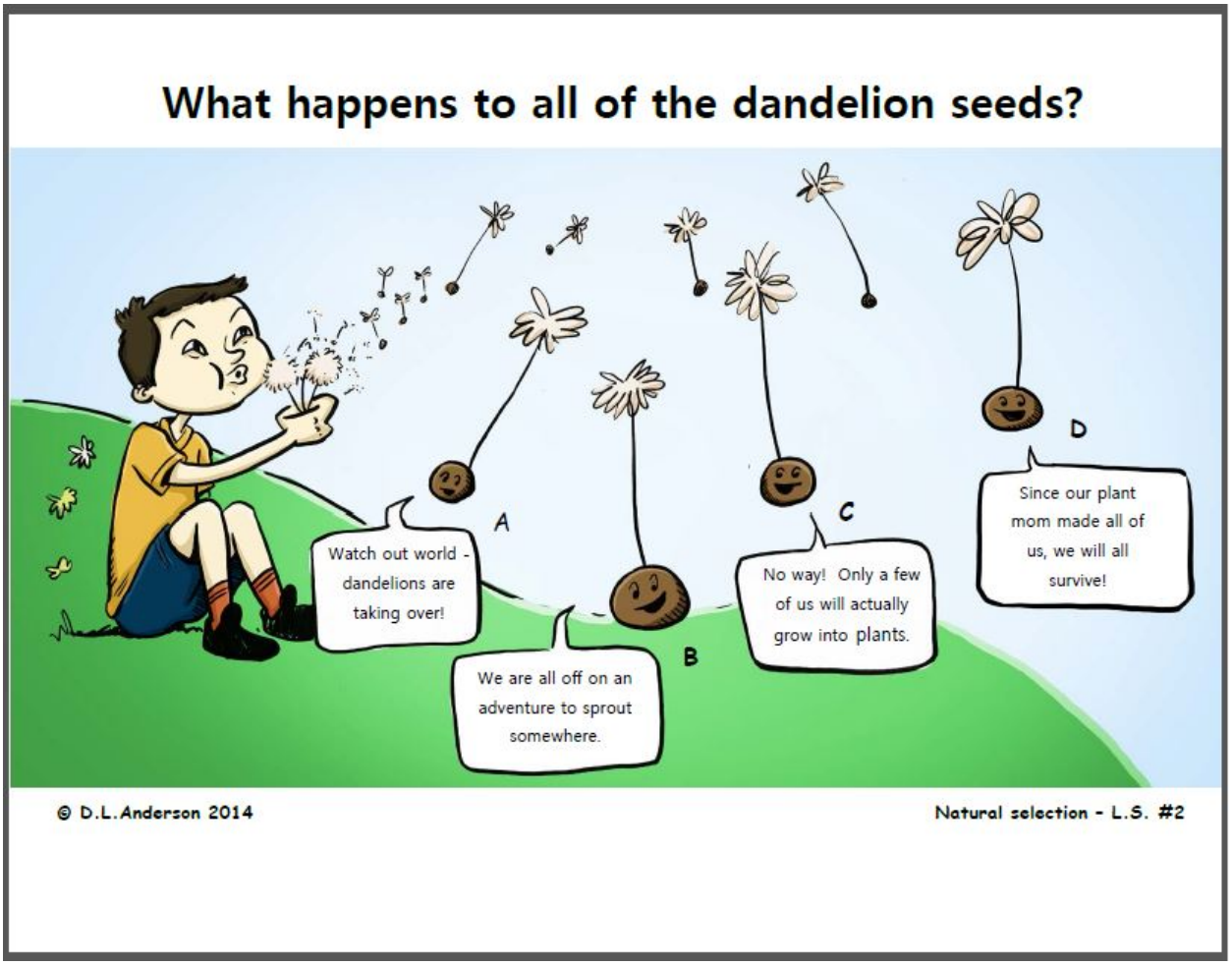
The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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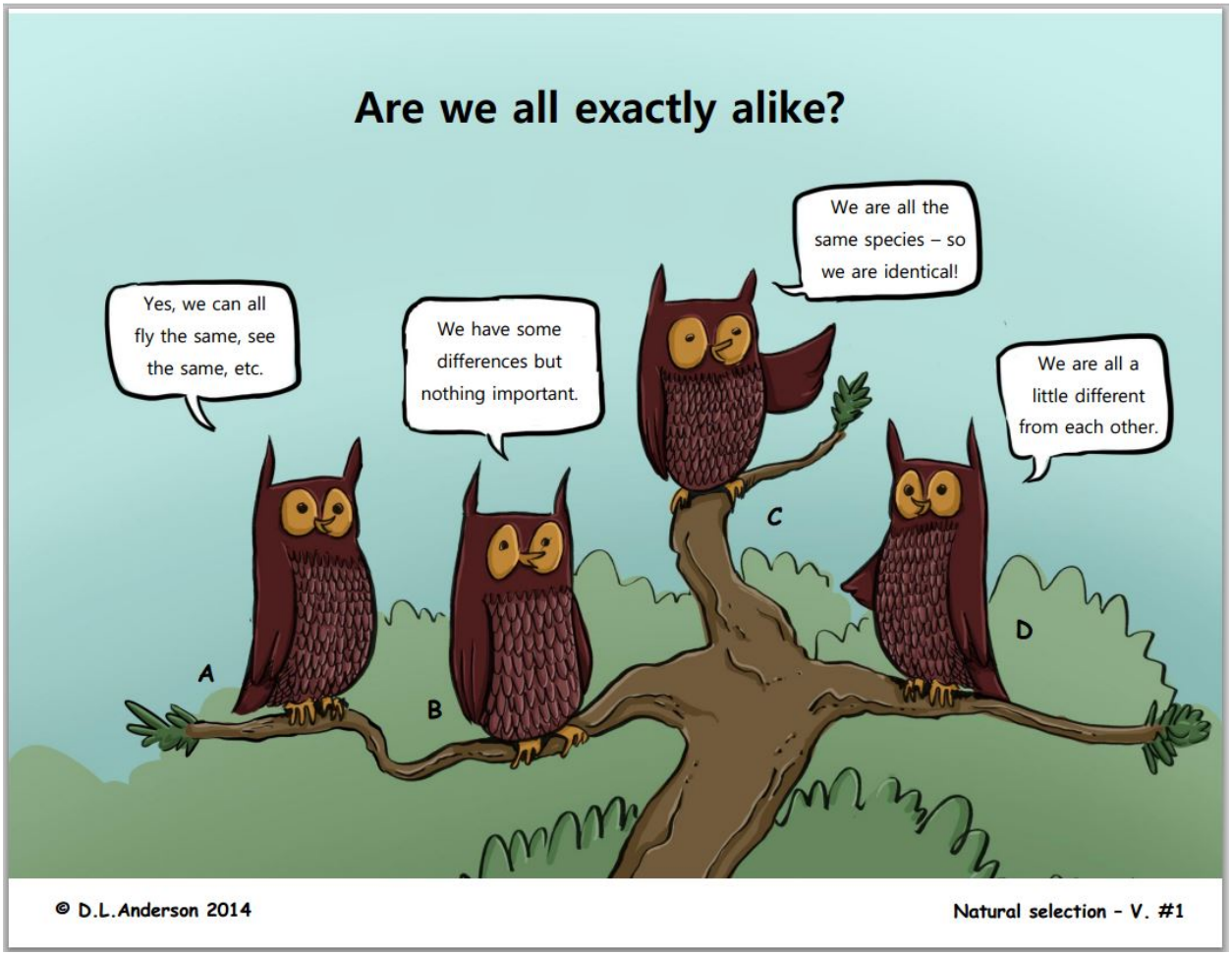
The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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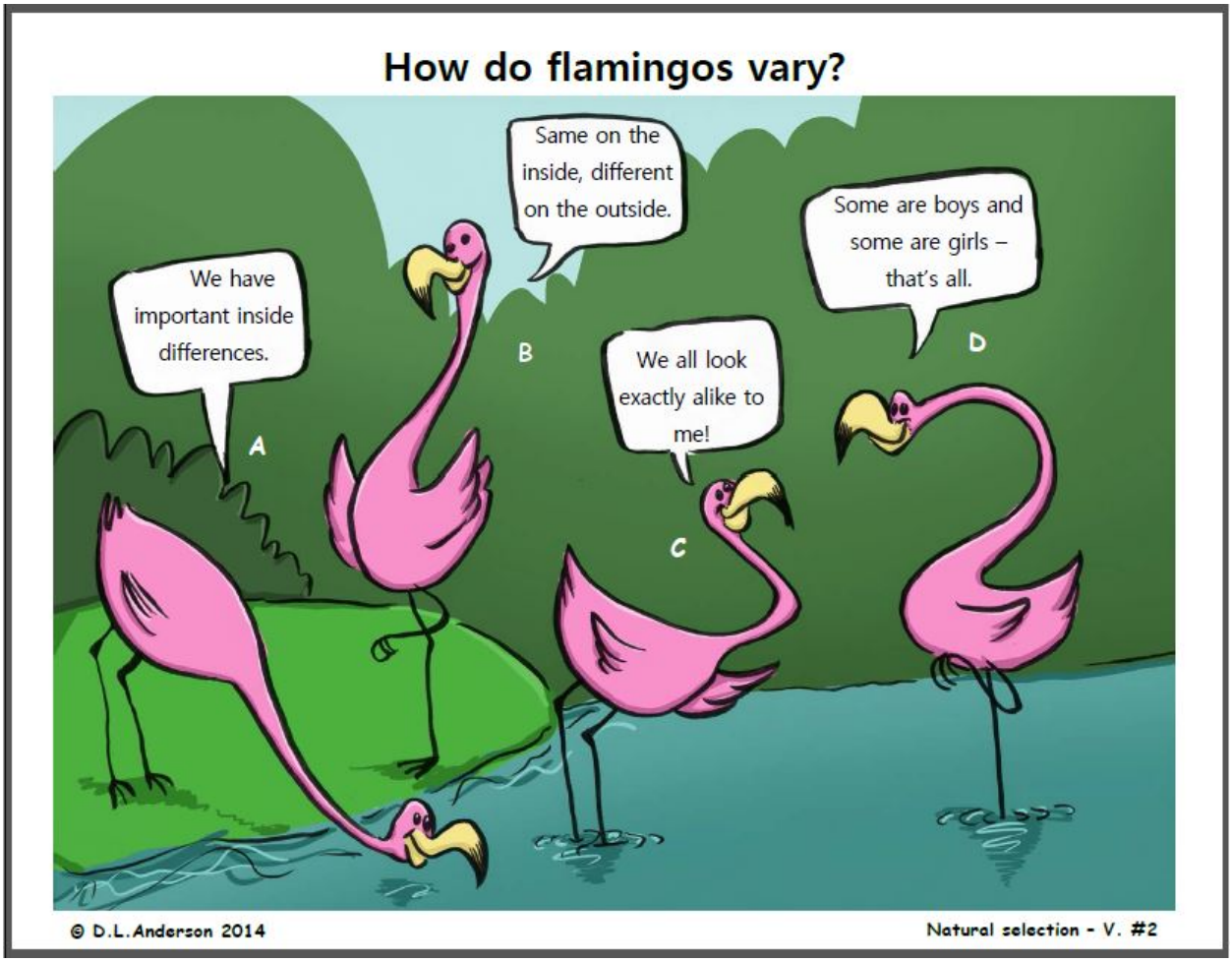
The other choices are wrong because: _____

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Name:
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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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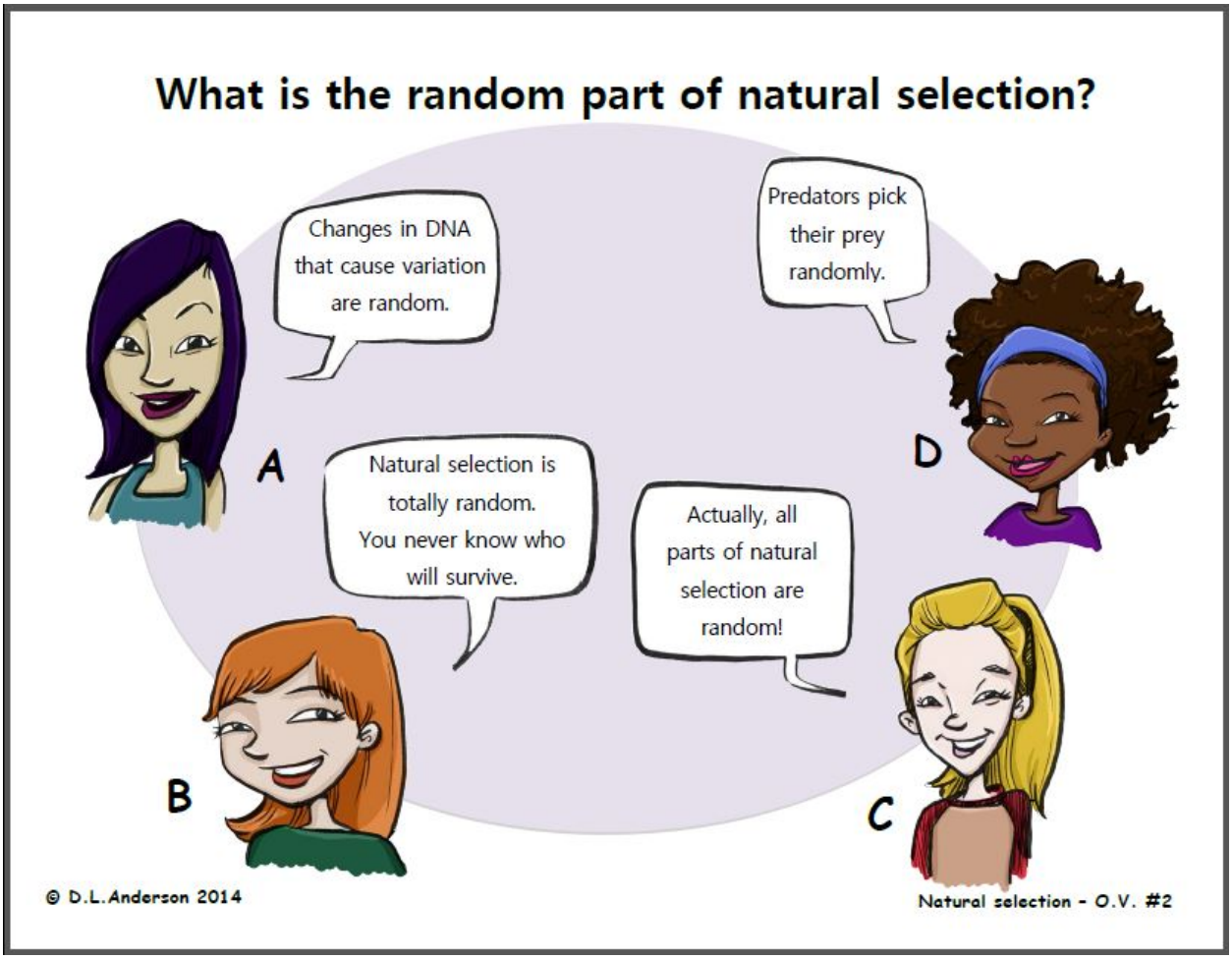
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Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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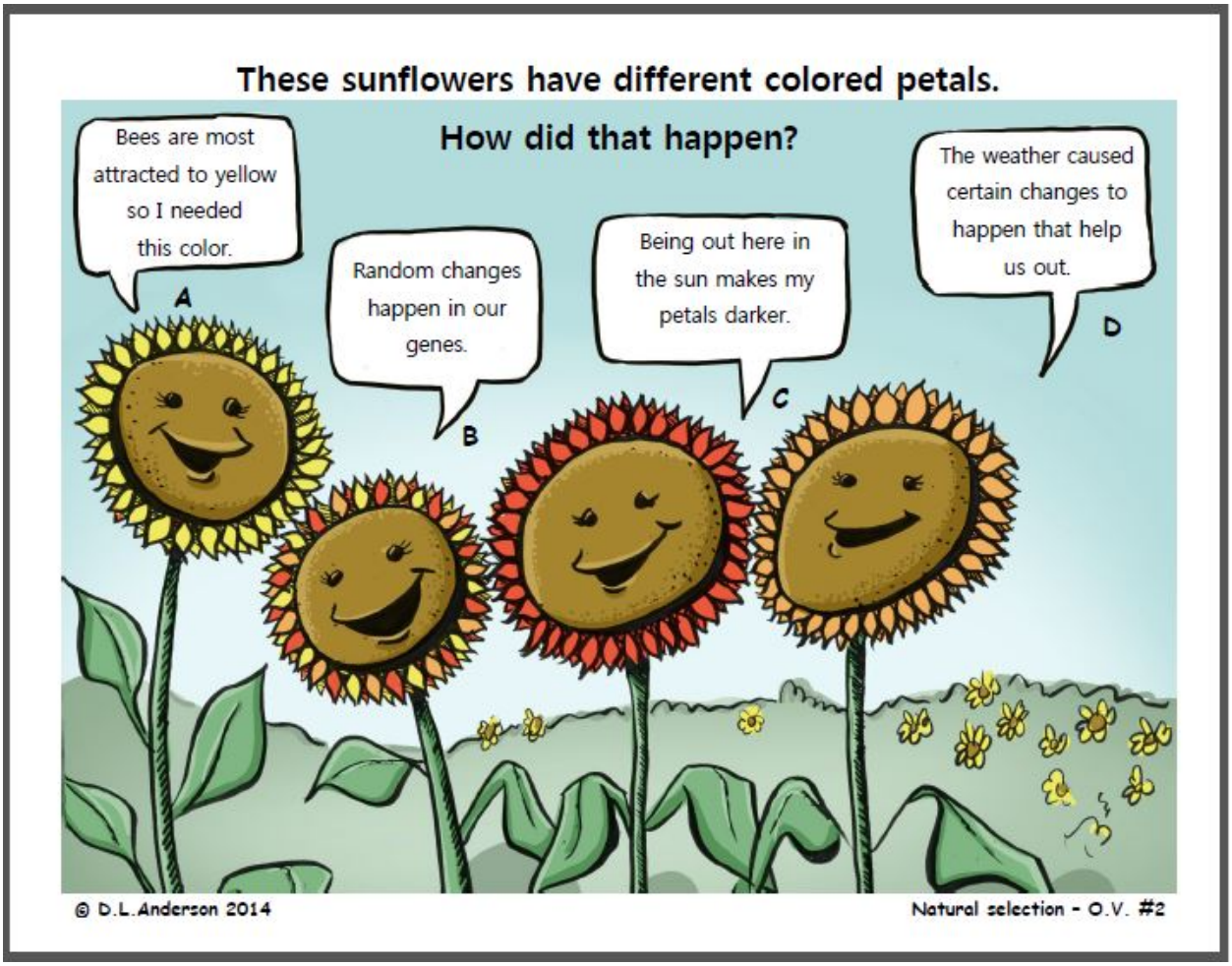
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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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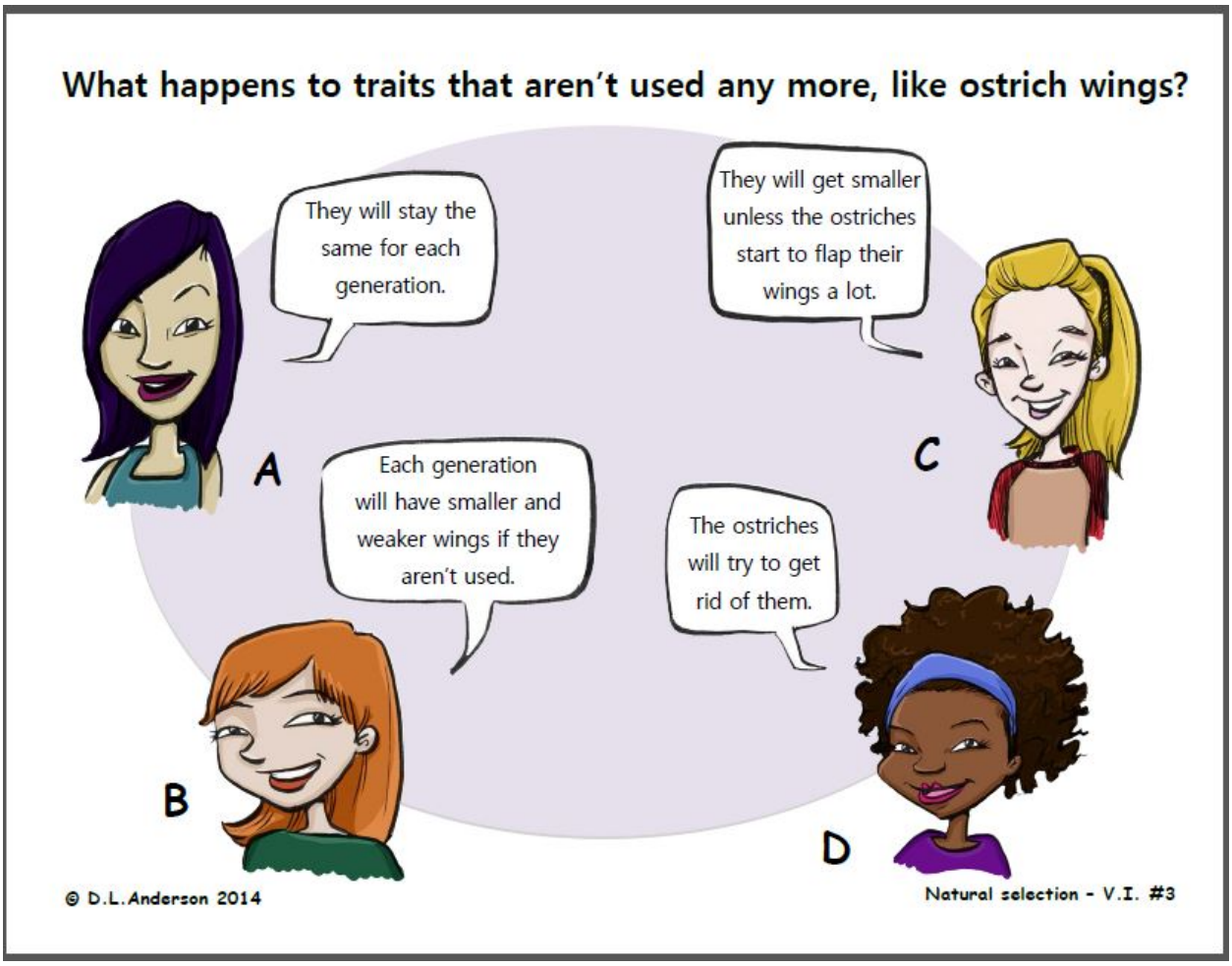
The other choices are wrong because: _____

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Name:
Period:

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The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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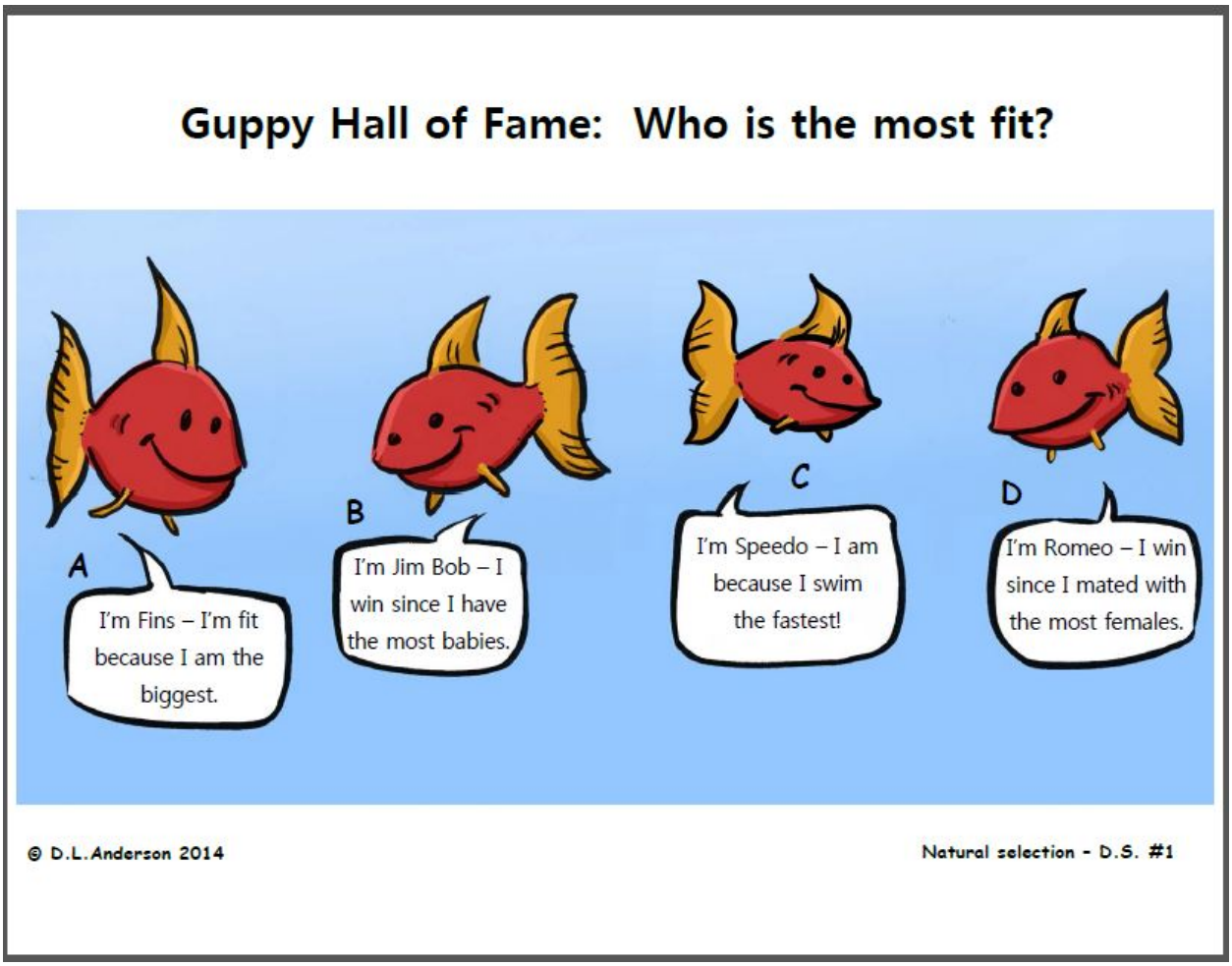
The other choices are wrong because: _____

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Name:
Period:



The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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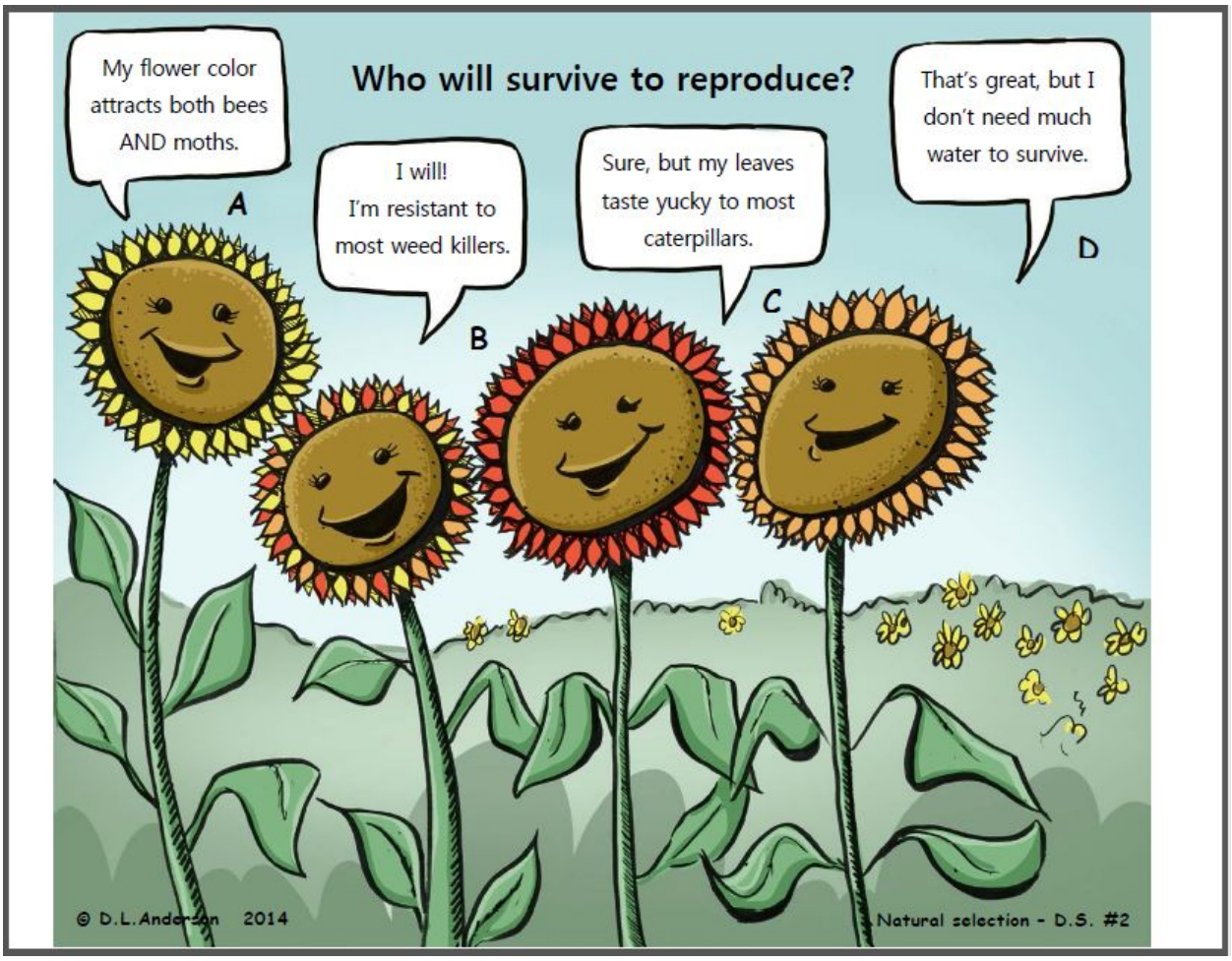
The other choices are wrong because: _____

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Name:
Period:



The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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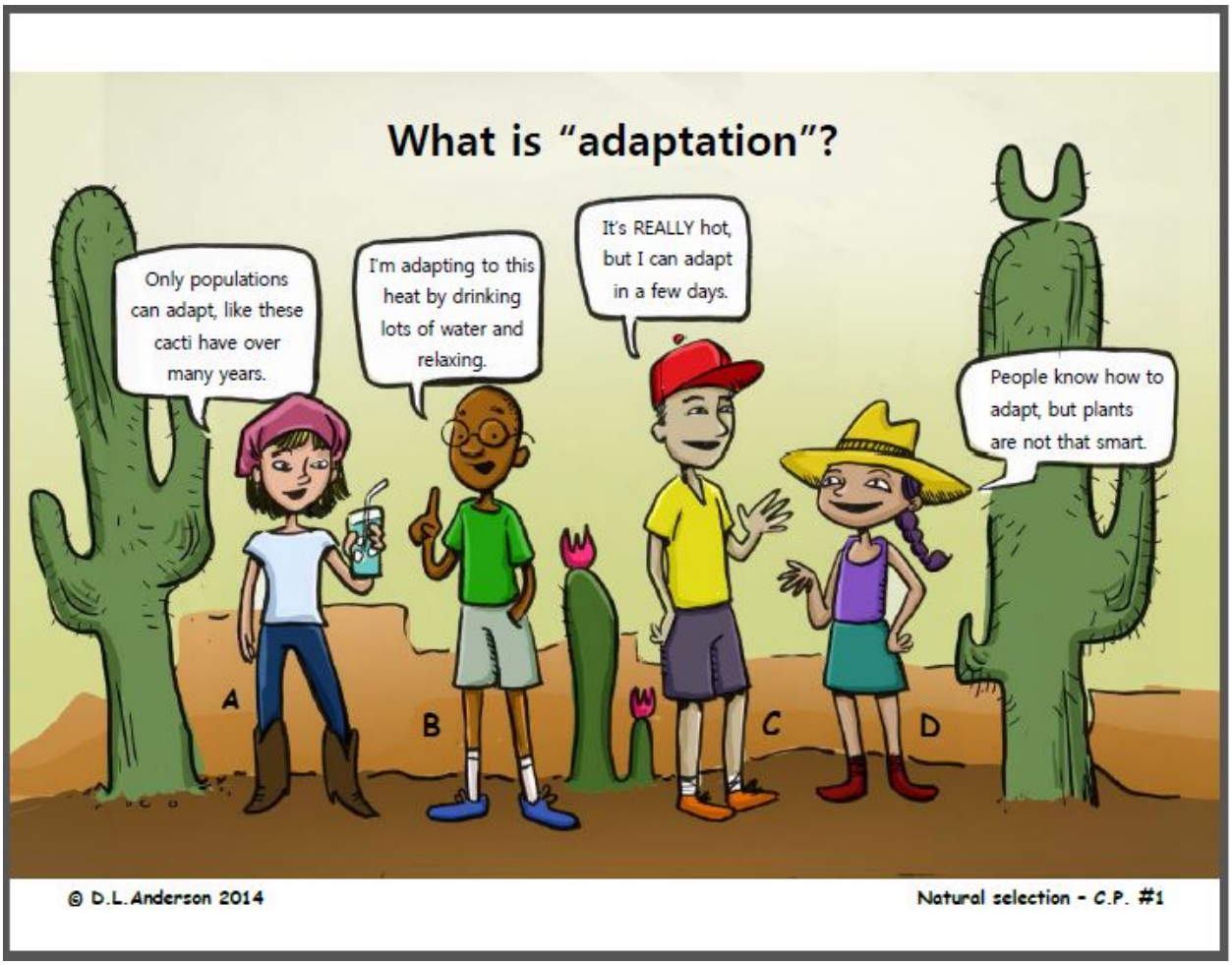
The other choices are wrong because: _____

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Name:
Period:



The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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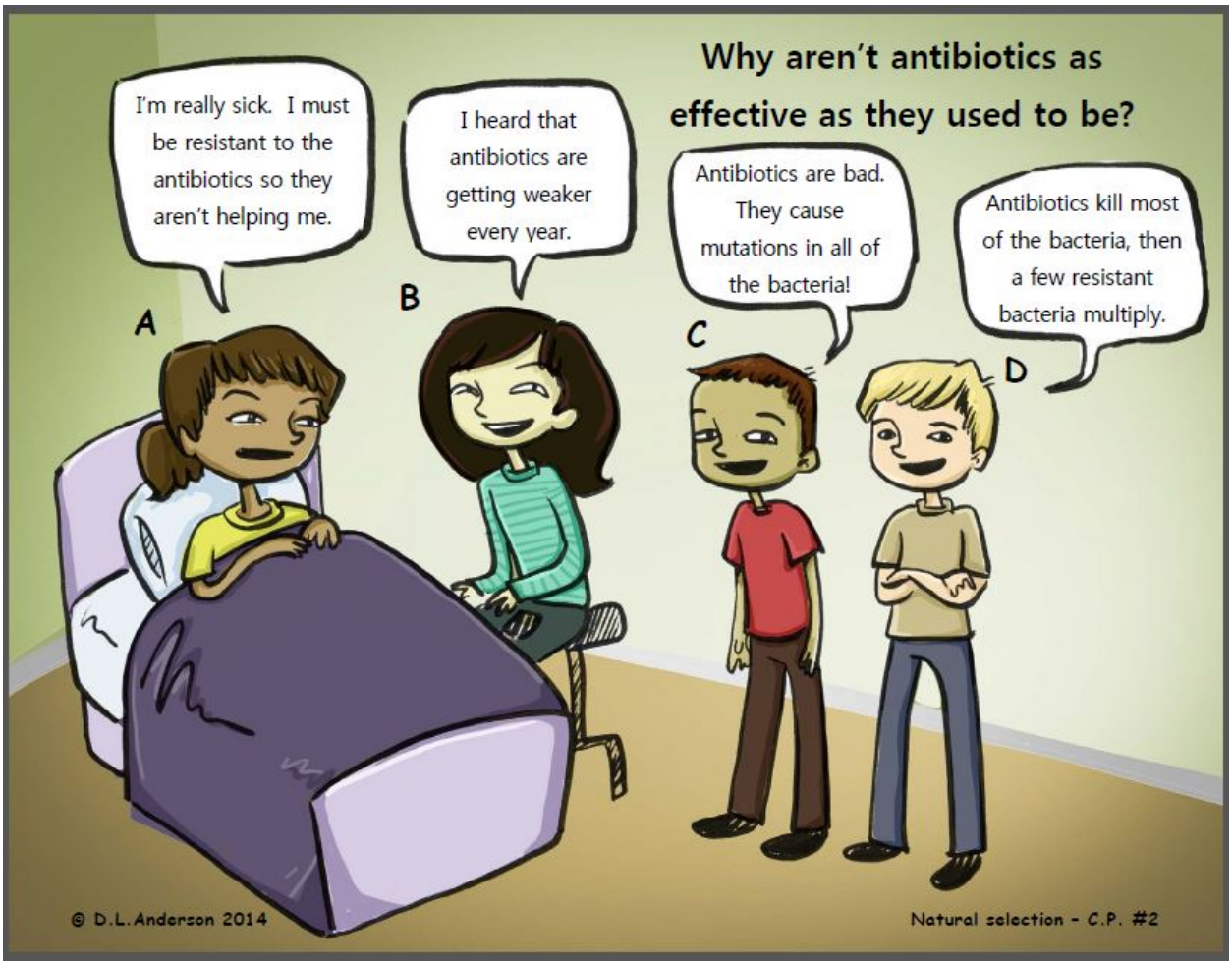
The other choices are wrong because: _____

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Name:
Period:



The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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The other choices are wrong because: _____

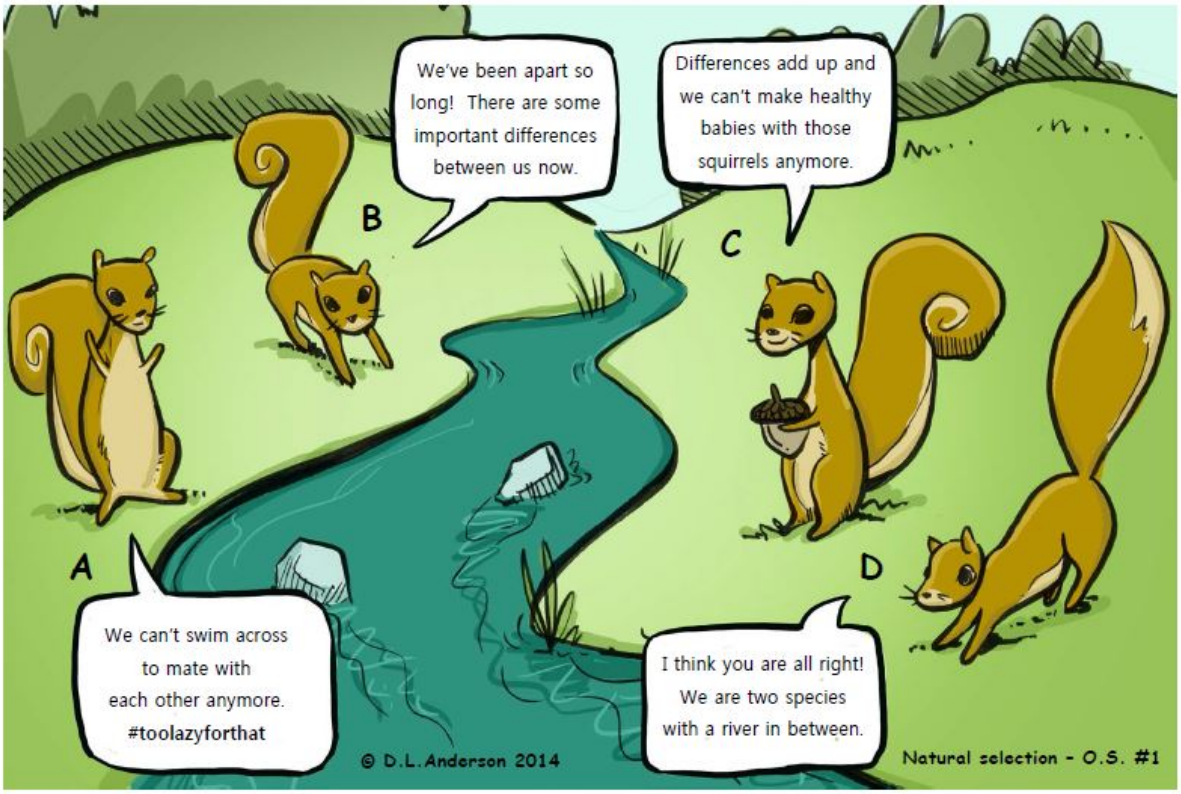
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Name:
Period:

How can two populations of the same squirrel species become two different species?



The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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The other choices are wrong because: _____

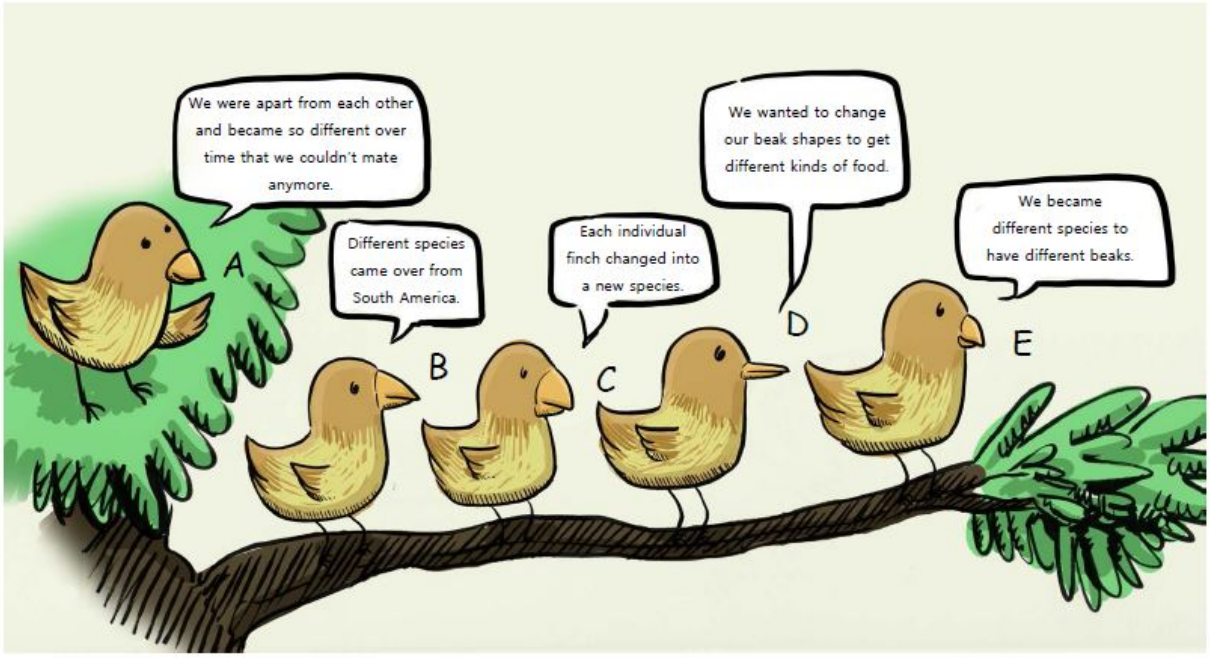
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Name:
Period:

Darwin learned a lot about natural selection by studying finches in the Galapagos Islands. How did several species of finches develop there?



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Natural selection - O.S. #2

The correct answer is: _____

List at least one reason why this answer is the correct one: _____

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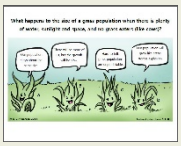
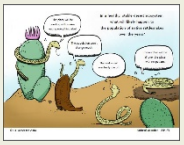
The other choices are wrong because: _____

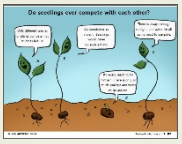
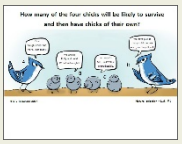
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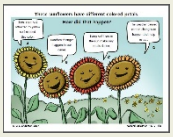
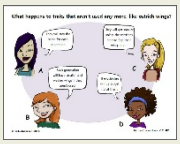
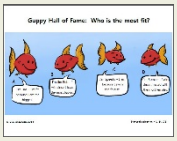
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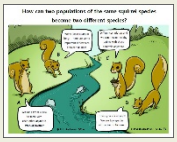
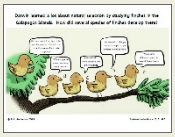
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Natural Selection Concept Cartoons
Teacher Explanations/Key

Concept	# and Context	Format (Cartoon/Photo)	Answer	Explanation
Biotic Potential (BP)	#1 - Grass		D	With no limiting factors, any population will produce offspring in large numbers. Some species may take longer than others (elephants vs. flies), but they can do so over time.
Biotic Potential (BP)	#2 - Mice		B	Any species has the potential to reproduce exponentially. Organisms produce far more offspring than are needed to replace themselves.
Stable Population (SP)	#1 - Snakes		B	In a <u>stable</u> ecosystem, populations tend to stay about the same size even though there may be some changes.
Stable Population (SP)	#2 - Trees		B	Trees usually produce MANY seeds, but the chances that any of those seeds will actually sprout and grow to become mature, are very small.
Limited Resources (LR)	#1 - Bighorn Sheep		A	All living organisms compete for resources, including: food, water, mates, sunlight, space, etc., both with members of their own species as well as other species. Competition only rarely involves actual fighting between animals.

Limited Resources (LR)	#2 - Seedlings		C	Seedlings compete for the limited water, sunlight, carbon dioxide, and soil nutrients. Once the nutrition in the seed is used up, there is fierce competition between seedlings and they won't all make it.
Limited Survival (LS)	#1 - Blue Jays		A	The reality is that most offspring (chicks, seedlings, etc.) die before reaching sexual maturity and producing their own offspring.
Limited Survival (LS)	#2 - Dandelions		C	Most seeds will land in areas without enough soil, or water, or sunlight to sprout and live very long.
Variation (V)	#1 - Owls		D	While owls may look all the same, they actually have differences on both the inside and the outside, and some of those differences are important in terms of survival or reproduction. For example, owls may vary in flying ability, or in ability to care for chicks.
Variation (V)	#2 - Flamingos		A	While flamingos may look all the same, they actually have differences on both the inside and the outside, and some of those differences are important in terms of survival or reproduction. For example, some may be resistant to certain diseases or can digest certain foods more effectively.
Origin of Variation (OV)	#1 - Random Part		A	The appearance of variation is due to random changes (mutation) in DNA. Natural selection REQUIRES the existence of variation in order for there to be something for nature to select.

Origin of Variation (OV)	#2 - Sunflowers		B	Random changes in genes allow for various colors, shapes, sizes, etc. Certain traits do not appear because they would help an organism to survive.
Variation Inherited (VI)	#1 - Fitness		C	Training can certainly affect the health of a person, but it will not cause related genetic changes in future offspring, so the kids will still need to work out to match their parents' fitness level!
Variation Inherited (VI)	#2 - Dog Training		D	The puppies of these trained dogs will still need to be trained. Many behaviors ARE controlled by genes (such as animal instincts), so "C" is not correct.
Variation Inherited (VI)	#3 - Ostrich Wings		A	Traits that no longer have an important function may "hang around" if there is no disadvantage to having them. They don't just gradually disappear unless organisms that have them are less likely to survive and reproduce.
Differential Survival (DS)	#1 - Most Fit Guppy		B	In biology, it is all about reproduction! Organisms that leave the most offspring are considered to have the greatest fitness in the population.
Differential Survival (DS)	#2 - Sunflowers		It Depends!	It all depends on what happens. Advantageous traits in one setting may not be helpful in another.
Change in Population (CP)	#1 - Cacti		A	Adaptation is a change in allele frequency in a population over time in response to environmental pressures. Individual

				organisms can't change their genes so they do not adapt. Biologists use the term "acclimatization" to refer to physiological (not genetic) changes that CAN take place in an individual, such as producing more red blood cells at higher altitude. Acclimatization is NOT adaptation.
Change in Population (CP)	#2 - Antibiotic Resistance		D	Bacterial populations can develop resistance to antibiotics if almost all of the bacteria are killed by the antibiotic, but a few survivors, or even one, have random genetic mutations that protect them from the action of the drug. Those survivors reproduce, resulting in entire populations that are not killed by that particular antibiotic. In contrast to popular thought, humans do not become immune or resistant to antibiotics.
Origin of Species (OS)	#1 - Squirrels		D	All of the answers reflect changes that can lead to speciation when interbreeding is prevented over a long period of time.
Origin of Species (OS)	#2 - Finches		A	The Galapagos finches resulted from an ancestral bird that arrived, then as variation increased and birds became dispersed on various islands and/ or different habitats, local adaptation took place. Reproductive isolation prevented interbreeding and the birds eventually became different species.

Power Points

The notes for the natural selection unit have been broken into 4 sections. This allows students to approach the information in small chunks. Links to the power points are provided below. Have students take notes in whatever way they are used to doing in your class (Cornell Style, in a notebook, etc). Instructor notes are written on the slides in the "notes sections" for further clarification. Once you follow the link there is an option to download the file under the options icon  at the bottom of the screen. From here you can also open up the speaker notes.

Section #1 Biotic Potential: Link to Section #1 Powerpoint

Section #2 Limited Resources and Survival: Link to Section #2 Power Point

Section #3 Variation: Link to Section #3 Power Point

Section #4 Speciation : Link to Section #4 Power Point

Conceptual Inventory of Natural Selection

2013 Middle School Version A

Developed by D.L. Anderson and P.L. Evans as a modification of the original CINS published in
Fisher, K.M., Anderson, D.L. & Norman, G. (2002). Development and evaluation of the Conceptual Inventory of Natural Selection. Journal of Research in Science Teaching, 39(10), 952-978.

List of concepts and answer key

Concept name	Concept description	CINS 2013 version items	Answer key
Biotic potential	All species have such great potential fertility that their population size would increase exponentially if all individuals that are born would again reproduce successfully.	1	C
Stable populations	Except for minor annual fluctuations and occasional major fluctuations, populations normally display stability.	2	B
Limited resources	Natural resources are limited. In a stable environment, they remain relatively constant.	3	A
Limited survival	Since more individuals are produced than can be supported by the available resources, but population size remains stable, it means that there must be a fierce struggle for existence among the individuals of a population, resulting in the survival of only a part, often a very small part, of the progeny of each generation.	4	D
Variation	No two individuals are exactly the same; rather, every population shows enormous variability.	5	D
Origin of variation	New variation appears randomly through mutation and sexual reproduction.*	6	B
Variation inherited	Much of this variation is heritable.	7	C
Differential survival	Survival in the struggle for existence is <u>not random</u>, but depends in part on the hereditary constitution of the surviving individuals. This unequal survival constitutes a process of natural selection.	8	B
Change in population/ Origin of species	Over the generations this process of natural selection will lead to a continuing gradual change of populations, that is, to evolution and to the production of new species.	9 (change in population) 10 (origin of species)	B A

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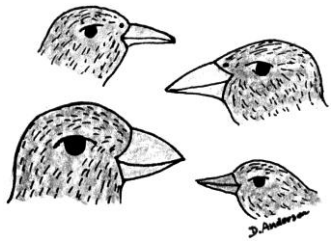
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Your answers will test your understanding of the Theory of Natural Selection. Please choose the answer that best shows how a **biologist** would answer each question.

Introduction to Galapagos finches



- These birds were studied on the Galapagos Islands by many scientists.
- The original finches most likely came to the islands one to five million years ago.
- Scientists think that 14 species of finches on the Islands evolved from a single species.
- Species found on the islands have different beak sizes and shapes.

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1. What will probably happen if a breeding pair of finches is placed on an island with no predators and plenty of food so that all the birds live?

   a. The population of finches would stay small because finches only have enough babies to take their place when they die.
   b. The population of finches would double and then stay about the same.
   c. The population of finches would grow to a large number and would keep growing.
   d. The population of finches would grow slowly and then stay the same.

2. A population of finches lives on an island for many years where there are predators and limited food. What will probably happen to the population if everything on the island stays the same?

   a. The population will grow rapidly each year.
   b. The population will remain stable, with few changes each year.
   c. The population will get larger, and then smaller each year.
   d. The population will get smaller, then get larger each year.

3. Finches on the Galapagos Islands require food to eat and water to drink. Which statement is true about the finches and the available resources?

   a. Sometimes there is enough food and water, but at other times there is not enough food for all of the finches.
   b. When food and water are limited, the finches will find other kinds of food so there is always enough.
   c. When food and water are limited, the finches all eat and drink less so there is always enough
   d. There is always plenty of food and water to meet the finches' needs.

4. Depending on the size and shape of the beak, some finches get nectar from flowers, some eat insects in the bark, some eat small seeds, and some eat large nuts. Which sentence best describes how the finches will interact with each other?

   a. Many of the finches on an island cooperate to find food and share what they find so that they all live.
   b. Many of the finches on an island fight with one another and the physically strongest ones win.
   c. There is more than enough food to meet all the finches' needs, so they don't need to compete for food.
   d. Finches compete with other finches that eat the same kinds of food, and some die because they do not get enough to live.

5. A population of finches has hundreds of birds of a single species. Which sentence best describes the group of birds?

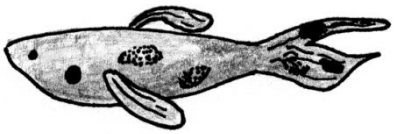
   a. The finches share all the same traits and are identical to each other.
   b. The finches share all of the most important traits, and the small differences between them do not affect how well they reproduce or how long they live.
   c. The finches are all identical on the inside, but have many differences in appearance.
   d. The finches share all of the most important traits, but also have differences that may affect how well they reproduce or how long they live.

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6. How did the different types of beaks first appear in the finches?

   a. Changes in the finches' beak size and shape happened because of their need to be able to eat different kinds of food to survive.
   b. Changes in the size and shape of the beaks of the finches happened because of random changes in the DNA.
   c. Changes in the beaks of the birds happened because the environment caused helpful changes in the DNA.
   d. The beaks of the birds changed a little bit in size and shape during each bird's life, with some getting larger and some getting smaller.

Indroduction to South American guppies



- These are small, colorful fish found in streams in Venezuela.
- Scientists have studied guppies in both natural streams and in lab experiments.
- Males have black, red, blue and reflective spots.
- Brightly colored males are easily seen and eaten by predators.
- However, females tend to choose more brightly colored males.
- In a stream with no predators, the number of males that are bright and flashy increases in the population.
- If predators are added, the number of brightly-colored males gets smaller within about five months (3-4 generations).

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7. What kind of variation in the traits of the guppies is passed on to their babies?

   a. Only behaviors that were learned during a guppy's life.
   b. Only traits that were helpful during a guppy's life.
   c. Only traits that were coded for by the guppy's DNA.
   d. Only traits that were affected by the environment in a helpful way during a guppy's life.

8. Fitness is a term often used by biologists to explain the evolutionary success of certain organisms. Which trait would someone who studies these fish think is the most important in deciding which fish are the "most fit"?

   a. Large body size and able to swim quickly away from predators.
   b. High number of babies that live to reproductive age.
   c. Excellent at being able to compete for food.
   d. High number of matings with many different females.

9. What is the best way to describe the evolutionary changes that happen in the guppy population over time?

   a. The traits of each guppy in the population change slowly.
   b. Guppies with certain traits reproduce and become more common.
   c. Behaviors learned by certain guppies are passed on to their offspring and become more common.
   d. Mutations happen in the guppy population to meet the needs of the fish as the environment changes.

10. What could cause populations of guppies in different streams to become different species?

    a. Groups of guppies could accumulate so many differences that they would not be able to breed with each other, and this would make them different species.
    b. All guppies are alike and there are not really different species.
    c. Guppies that need to attract mates could change their spots in many ways, and this would make them different species.
    d. Guppies that want to avoid predators in the different streams could change their patterns so they are not so bright, and this would make them different species.

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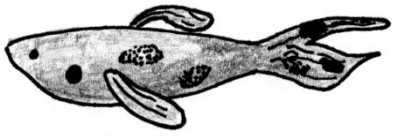
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1. If food and space are abundant, and there are no predators, what will likely happen if a mating pair of guppies is placed in a large pond?

   a. The guppy population will grow slowly. The guppies will have only the number of babies that are needed to replace those that have died.
   b. The guppy population will never become very large, because only organisms such as insects and bacteria reproduce that way.
   c. The guppy population will grow slowly at first, then will grow to a large number, and thousands of guppies will fill the pond.
   d. The guppy population will keep growing slowly over time.

2. A population of guppies lives for a number of years in a pond with other organisms and predators. What will probably happen to the population if everything in the pond remains the same?

   a. The guppy population will keep growing in size.
   b. The guppy population will stay about the same size.
   c. The guppy population will slowly get smaller until no more guppies are left.
   d. It is impossible to tell because populations do not follow patterns.

3. Guppies eat a variety of insects and plants. Which statement describes the availability of food for guppies?

   a. Sometimes there is enough food, but at other times there is not enough food for all of the guppies.
   b. Guppies can eat a variety of foods, so there will always be enough food for all of the fish.
   c. Guppies can get by on very little food, so the food supply does not matter.
   d. Finding food is not a problem since there is always plenty of food.

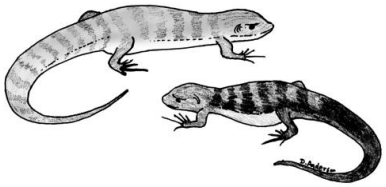
4. What will probably happen in a guppy population when the amount of food is low?

   a. The guppies cooperate to find food and will probably share what they find.
   b. The guppies fight for the available food, and the stronger guppies will kill the weaker ones.
   c. Genetic changes that allow guppies to eat new types of food will appear.
   d. The guppies that cannot compete for food well will die from a lack of food.

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Introduction to Canary Island Lizards

- The Canary Islands are seven islands just west of the African continent.
- The islands gradually became colonized with life: plants, lizards, birds, etc.
- Three different species of lizards are found on the islands.
- These three species are similar to one species found on the African continent.
- Scientists think that the lizards traveled from Africa to the Canary Islands by floating on tree trunks washed out to sea.



5. A population of lizards is made up of hundreds of individuals. How similar are they to other lizards in the population?

   a. All lizards are the same.
   b. All lizards are the same on the outside, but have differences in their internal traits.
   c. All lizards are the same on the inside, but have differences in their external traits.
   d. All lizards share many similarities, but have some important differences in their traits.

6. Where did the variation in body size of the three species probably <u>first</u> come from?

   a. The lizards needed to change in order to survive, so new helpful traits formed.
   b. Random changes in the DNA created new traits.
   c. The environment of the island caused certain changes in the DNA of the lizards.
   d. The lizards wanted to become different in size, so helpful new traits slowly appeared in the population.

7. How are traits in lizards inherited by their young?

   a. When a parent lizard learns to catch certain insects, its young can inherit the ability to catch those insects.
   b. When a parent lizard gets stronger claws through repeated use in catching prey, its young can inherit the stronger claw trait.
   c. When a parent lizard is born with an extra claw on each limb, its offspring can inherit the extra claw.
   d. When a parent lizard's claws are weak because the available prey is easy to catch, its young can inherit the weakened claws.

8. Fitness is a term often used by biologists to explain the success of certain organisms. Below are descriptions of four lizards. According to a biologist, which lizard is the most fit?

	Lizard A	Lizard B	Lizard C	Lizard D
Body length	20 cm	12 cm	10 cm	15 cm
Offspring surviving to adulthood	19	32	22	21
Age at death	4 years	3 years	4 years	6 years
Other information	Lizard A is very healthy, strong, clever	Lizard B is dark-colored and very quick	Lizard C has the largest territory	Lizard D has mated with many males

   a. Lizard A b. Lizard B c. Lizard C d. Lizard D

9. What is the best way to describe the evolutionary changes that happen in the lizard population over time?

   a. The traits of each lizard in the population change slowly.
   b. Lizards with certain traits reproduce and become more common.
   c. Behaviors learned by certain lizards are passed on to their offspring and become more common.
   d. Mutations happen in the lizard population to meet the needs of the lizards as the environment changes.

10. What could have caused one species to change into three species over time?

    a. Groups of lizards lived on different islands. Over time, many genetic changes may have happened in each group so they could no longer breed with each other, and this made them different species.
    b. There are small variations between the lizards, but all the lizards are mostly alike, and are all members of a single species.
    c. Groups of lizards needed to adapt to the different islands, so the lizards in each group slowly changed over time to become a new lizard species.
    d. Groups of lizards found different island environments, so the lizards needed to become new species with different traits in order to survive over time.