Activity 14 - Bug Hunt Camouflage

Purpose:

What outcomes will result from both mutations and natural selection?

Procedure:

You will be working in teams of four people today. Each person on your team will be simulating the actions of a bird that is hunting bugs to eat.

Exploration 1:

Question

"What outcomes result from the combination of mutations, natural selection working together?"

Model Rules

Your teacher demonstrated and explained how bugs will reproduce in this model. Summarize what you understand to be the rules used in the model.

Genetic information for the color trait is a combination of three separate genes and three separate protein production levels. What colors do each of these of these proteins contribute to the overall phenotype of the bug?

a) Red pigment production, Green pigment production, and Blue pigment production
a) Black pigment production, White pigment production, and Blue pigment production

When a new bug is selected to have an offspring, how is that bug selected?

b) Randomly
c) Non-randomly

When a new bug is selected of have an offspring, how is the genetic information for protein production levels of the offspring bug related to the genetic information of its parent?

a) It inherits exactly the same information its parent had
b) It is close to the same information its parent had, but with a bit of random fluctuation
c) It is wholly random, unrelated to the information its parent had

When an offspring bug is placed on the screen, how is where that bug is placed determined?

a) It is placed in exactly the location of its parent had
b) It is close to the same location of its parent, but with a bit of random fluctuation
c) It is wholly random, unrelated to the location of its parent

Predict

In the first exploration, a snow covered glacier will be the background in which you will hunt a population of randomly colored bugs. As bugs are eaten by the players, and new bugs are produced as offspring with slight mutations in their color, what do you predict will happen to the overall appearance of the population over time?

_____

_____

_____

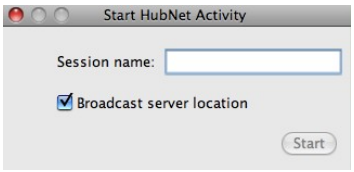
Procedure

Assign one member of your team to be the team leader. This will be the person who is responsible for launching the computer model that everyone joins into.

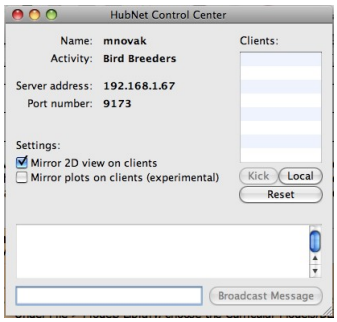
Below are two sets of instructions. The one on the left is for the team leader. The one on the right is for all the other players.

INSTRUCTIONS FOR THE GAME LEADER ONLY

1. *Find the BEAGLE pilot models folder on your computer. Double click on the "Bug Hunters Camouflage" model and open it.*
2. *The Interface tab will fill up with lots of buttons, switches, sliders, and monitors.*
3. Enter your name in the session name in the HubNet Activity box



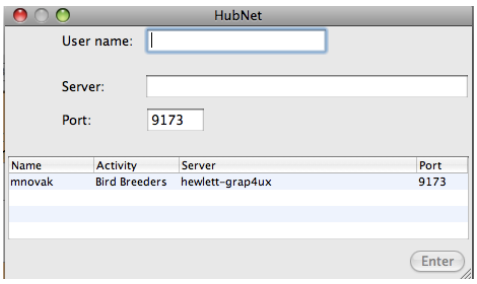
4. Click the mirror 2D view on clients check box so that it is checked.



INSTRUCTIONS FOR THE OTHER TEAM PLAYERS

a) Open HubNet on your computer.

b) A connection box will appear like the one below. In this box type your user name.



c) Click on the Server name in the list below which has the name of the Group Leader in it. Then press enter.

d) Check with the group leader to make sure you now appear in the client list of the HubNet Control Center.

5. *Now ask all the other players to follow the CLIENT directions below. Once you see all the players appear in the CLIENTS section of the HUBNET CONTROL CENTER, you may join the game yourself by pressing the LOCAL button. A client interface will be launched for you to join the simulation.*

6. *You now have two windows for the model open. The one on the left is the main model window. It is the model window. It is the one you will use to control the setup and running of the model. The one on the right is the client window that you can use to play in the competition too.*

7. *Tell your group members to get ready try to eat as many bugs as fast as you they can by clicking on the bugs by point at them with their mouse cursor and pressing their mouse button. Tell them that this is a competition to see if they can eat more bugs as a group of birds than other groups in class when you say go. At the end of 3 minutes you will record your group results.*

Setting	Value
MAX-MUTATION-STEP	10
SHOW-GENOTYPE	"Off"
ENVIRONMENT	"poppyfield.jpg"

8. *Press the SETUP button in the left model window. Then press GO/STOP button in run the model and say "go"!*

9. *After 3 minutes, tell everyone "stop!". Press GO/STOP to pause the model. Tell all participants to Record **Part 1 of their Data and Observations** now. Then after doing so, continue....*

10. *Press the FLASH button, and the bug locations will be revealed to all.*

11. *At the end of 3 minutes you will record your group results.*

e) Check with the group leader to make sure you now appear in the client list of the HubNet Control Center.

f) When you appear in that list, wait until your Group Leader says "go" before interacting with the model. Your group leader will give you instructions on what your goal is in this competition.

g) Play for 3 minutes and then record the results from the model below in the DATA & OBSERVATIONS section below.

Setting	Value
ENVIRONMENT	"black background"

12. *Press the CHANGE ENVIRONMENT button*

13. *Switch the SHOW-GENOTYPE? To "On" and press GO/STOP again.*

14. *Tell all participants to Record **Part 2 of their Data and Observations** now. Record your results as well. Then after doing so, continue....*

Data and Observations - Part 1:

How many total bugs did the group catch? _____

Take 1 minute to see how many total bugs you can find on the screen right now? _____

Do these bugs appear harder to find than when you first started hunting the population? _____

Data and Observations - Part 2:

Describe the type of color variations you observe in the phenotype of the bugs:

_____

_____

Describe the type of variations you observe in the genotype of the bugs (r-g-b values):

_____

_____

Making Sense of Your Data:

Did you predict that mutation in combination with natural selection would lead to an outcome of better camouflaged bugs? _____

The rest of the explorations will be done individually. So at this point say good bye to your team and get ready to start your own model

Exploration 2:

Question

How does changing the environmental conditions affect the outcomes of natural selection and mutation over time?

Predict

If you changed the background photograph of a field of red flowers to a photograph of a glacier, and you hunted the population of bugs again, what to you predict would happen to the colors of the bugs in the population over time?

_____

_____

_____

Procedure to Test Your Prediction

1. Quit HubNet if it is still open on your computer.
2. Open the "Bug Hunt Camouflague" model.
3. Set the initial values to:

Setting	Value
MAX-MUTATION-STEP	10
SHOW-GENOTYPE	"Off"
ENVIRONMENT	"Glacier.jpg"

4. Press SETUP and GO/STOP.
5. Try to eat the bugs as fast as you can using your mouse to point at them and click on them for about 2 minutes.

6. Remove the background image by changing this setting:

Setting	Value
ENVIRONMENT	"Black Background"

7. press the CHANGE ENVIRONMENT button.

8. Study the color distribution of the population. Record your observations below:

Data and Observations:

Making Sense of your Data:

How is this outcome different than the outcome in the poppy field?

_____

_____

How is this outcome similar to the outcome in the poppy field?

_____

_____

Exploration 3:

Question

"How does changing the environmental conditions affect the outcomes of natural selection and mutation over time?"

Predict

If you kept the existing population of bugs on the screen, but now changed the background photograph from an ice glacier to a seashore covered in shells, what to you predict would happen to the colors of the bugs in the population over time if you continued to hunt them?

_____

_____

_____

Procedure to Test Your Prediction

Keep the same population of bugs that is currently on the screen from the last exploration (the ones that tended to blend into the poppy field background), then change the background image by doing the following:

1. Change this value to:

Setting	Value
ENVIRONMENT	"Seashore.jpg"

2. Press GO/STOP *only*
3. Try to eat the bugs as fast as you can using your mouse to point at them and click on them for about 2 minutes.
4. Remove the background image by changing this setting:

Setting	Value
ENVIRONMENT	"Black Background"

5. press the CHANGE ENVIRONMENT button.
6. Study the color distribution of the population. Record your observations below:

Data and Observations:

Making Sense of your Data:

Which of the following best explains the mechanisms responsible for the causing the change in the colors of the bug population?

- Each bug chooses a form of camouflage to help them survive. The bugs choose best, then that survive to pas that choice on to their offspring. Which helps their offspring know what the environment around them looks like. These bugs have a competitive advantage in that environment.
- Birds unintentionally eat the easiest bug to find more often than hard to find bugs. Random mutations in the color of the bugs leads to slight variations in the offspring, some of which are harder to find and some of which are easier to find. As birds leave behind bugs that are more difficult to find, each new generation becomes progressively better camouflaged.
- Birds choose which bugs they want to survive. Each new bug that is born with mutations in its genotype. These mutations give more choices for the birds gives the birds. Since the bird prefers to leave behind the hard to find bugs to find bugs, it intentionally selects for camouflaged bugs in this environment.
- Every bug is programmed to adapt and evolve in its genotype. Each bug can develop any color necessary survival in any environment. Once a bug recognizes the environment it is in, it changes the genetic information in all of it cells to create a new protein that will lead to a trait variation to better help its offspring survive.

In a real world ecosystem, if the environmental condition changed, what do you expect would happen to the populations in that ecosystem?

_____

_____

_____

Discoveries and Insights:

What discoveries did you make regarding the question of this lesson - "What outcomes will result from the both mutation and natural selection?"

How does understanding these mechanisms or outcomes help you answer the driving question for the unit?

Homework 14 – Adaptation for Survival

Jumpstart: Why are polar bears white? Why are bears that live in other environments brown? You investigations on the computer and the discoveries you made might help you explain such observations in nature. As you read about other examples of camouflaging of animals in the every day world think about what selective pressures from the type of environment the animals are in and the type of predators or prey they interact with that might have led to these adaptations.

In the everyday world, there are many examples of animals that appear camouflaged in their environment. In arctic ecosystems, many species of mammals have white fur to blend in with the snow. Polar bears and snowshoe rabbits are two examples.

Question 1: Camouflaging can also help predators as well as prey. Why do you think sharks are typically gray or blue-gray colored?

In heavily forested ecosystems, brownish "earth tone" colors of deer, squirrels, hedgehogs, and other animals help give these animals a competitive advantage.

Color is not the only trait that grants a competitive advantage for helping animals hide. Many types of insects, not only have a green or brown color, some also have body structures that look very similar to the leaves, the twigs, or the bark they live on.

http://en.wikipedia.org/wiki/Phasmatodea

Question 2: How might the shape of the legs and appendages on this bug give it a competitive advantage for survival in a forest ecosystem?

Question 3: Tigers and leopards in jungles have dark vertical stripes on their coats and leopards have dark spots**.** In these environments their coats are often yellowish colored. Imagine that the surrounding environment of the tiger and leopard changed to cooler. It begins to accumulate snow more and more each winter. A thousand years from now the environment changes so much, that during most of the year, snow covers the ground. If the tiger or leopard could still hunt prey in this ecosystem, how do you think its appearance might change in those thousand years?

_____

_____

_____

Question 4. - List some other examples of animals that you think are well camouflaged for their environment.

_____

_____

_____

Camouflage is just one example of an **adaptation** that emerges in populations from natural selection and mutation. Populations can also adapt to become more successful at finding food, finding mates, fending off predators, or resisting the effects of drought, as well as countless other examples.

When thinking about **adaptation** of a population to its environment, it is important to realize that the adaptations are the result of both natural selection and mutation. Think back to the activities you did related to mutation. You learned that mutation is a random process. It results in random reordering of nucleotides in DNA which in turn leads to the emergence of new proteins or the disappearance of old proteins in an individual's cells. Natural selection, though not random, is the result of unintentional selection events that occur between individuals and the environment.

The word, adaptation, in the scientific sense, is the way that a population changes.

Individuals often change or alter their behavior or their environment to better suit their needs. For example, you might alter an area of land to support farming by clearing trees or irrigating it. Or you might change the way they interact with a friend based on how their friend is feeling. Likewise, animals can change the way they interact with their surroundings. A wolf might change where it hunts if it finds no food in a given area. A bird might inspect different trees for a nesting sight before it choose one. And plants too can respond to their environment. A plant that is not getting enough sun might grow taller and leaner. A plant that is not getting enough water might alter its pattern of

root growth by growing longer roots or branching its roots more.

In each of these cases, the organism is interacting and responding to its environment. But in none of these cases is it doing anything to change its DNA. Therefore nothing it does will influence the genetic instructions that its offspring could inherit from it. And none of these would be considered part of the mechanisms that is responsible for **adaptation** of a population.

Question 5. - Give an example of a type of change that people commonly refer to as an "adaptation", but is not actually an adaptation of a population in the scientific sense.

Before people understood how genes and DNA worked, they suggested alternate mechanisms for what might be causing populations to evolve. One model was called **Lamarkianism**. In this model, it was proposed was that the actions of the individuals was what influenced what was inherited by the offspring. For example, a person who worked hard to learn a new language would then have changed the traits that his or her offspring would inherit. Their offspring would inherited a trait for learning language better, even those offspring grew up in a different environment than the parents.

Another example would be that a plant that grew taller and slimmer in response to limited sunlight. This taller growing plant would then have changed the traits it would pass on to its offspring. All offspring of that plant would then be taller and slimmer, even if there was plenty of sunlight in the environment. In this way, it was believed that intentional efforts by organisms to respond to the environment were what caused adaptation of a population.

After DNA and genes were discovered and understood, this idea was seen as a poor model for how adaptation occurred. And subsequent experiments showed that the only way that an individual would alter their own DNA would be through very indirect means, such as intentionally exposing themselves to radiation or mutation causing chemicals. But though such intentional exposure would increase the chance of random mutations, it wouldn't lead to intentional "adaptation" to gain a competitive advantage. The model of evolution that explains how natural selection, genetic drift, DNA, and mutations are interconnected together is called the **Modern Synthesis**.

Question 6: In your own words explain the difference between the Lamarkian model and the Modern Synthesis model:

Even today, people use the word adaptation to refer to the outcome of evolution, but often mistakenly attribute the mechanisms to 1) natural selection and 2) intentional efforts of individuals to change the traits they pass on to their offspring. No intentional efforts by individuals to purposefully change their DNA are part of what causes adaption. Instead, the mechanisms that lead to adaptation are 1) natural selection and 2) random mutations in genetic information amongst individuals in a population. By repeated cycles of random mutations in each generation (generating new traits) and natural selection (traits that give a competitive advantage for survival tend to have more offspring), populations become progressively better adapted to their environments over time.

In this next question you will compare two alternate models to explain why giraffes have long necks. If you observe giraffes in their natural ecosystem, you will see that their long necks give them a competitive advantage for reaching leaves (a food source) on trees that other consumers can't reach.

Question 7. In the spaces below, provide two alternate explanations for why a giraffe population would adapt to have progressively longer necks, if trees started growing taller in their environment	
Use the old rejected Lamarkian model in this explanation:	Use the Modern Synthesis model in this explanation:

Activity 15 – Fish Spotters

Purpose:

How Do Mates Influence Adaptations?

Procedure:

You will be working in teams of four to six people today. Each person on your team will be simulating the actions of either a predator of a fish or a another fish seeking a mate.

Exploration 1:

Question

"How do mates affect adaptations?"

Model Rules

Keep track of your team members and team leader in the chart below:

Team Leader Player 1	Player 2	Player 3	Player 4	Optional: Player 5	Optional: Player 6

Design Your Experiment as a Group

In this experiment will be able to set up the environmental conditions in two fish tanks. And you may assign the type of initial color variations in each colored fish population. For each tank, circle or fill in the values you wish to assign.

Top Tank			
TOP-WATER	TOP-FLOW	TOP-GROUND	TOP-INITIAL-FISH
The water conditions	How fast plant debris or ripples flow	The background	The initial variations in the colors of the fish population
• Clear • Ripples • Debris	Any value between 0 and 0.25 _____	• Clear • Plants • Rocks • Sand	• Multi-colored • All gray • Black or white

Bottom Tank			
BOTTOM-WATER	BOTTOM-FLOW	BOTTOM-GROUND	BOTTOM-INITIAL-FISH
The water conditions	How fast plant debris or ripples flow	The background	The initial variations in the colors of the fish population
• Clear • Ripples • Plants	Any value between 0 and 0.25 _____	• Clear • Plants • Rocks • Sand	• Multi-colored • All gray • Black or white

Predict

Each fish population will start with the individuals of the same adult body size and the same visibility for spots on their body (not visible) and the same amount of movement. Through mutations, these four attributes may change slightly in each new offspring:

- Color
- Movement
- Adult Body Size
- Visibility of Spots

If you were try to mate with bugs as fast as possible, how do you predict the population in each tank will adapt over time?

In tank 1, what, if any, adaptations will appear in….

in color?_____

in how much they move?_____

in body size?_____

in spot visibility _____

In tank 2, what, if any, adaptations will appear in….

in color?_____

in how much they move?_____

in body size?_____

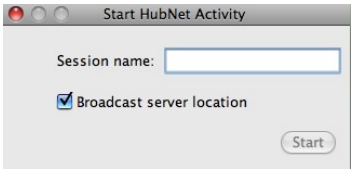
in spot visibility _____

Procedure for Joining Your Team

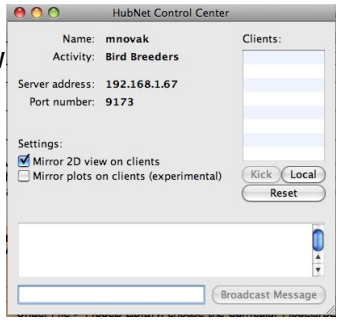
Below are two sets of instructions. The one on the left is for the game leader. The one on the right is for all the other players.

INSTRUCTIONS FOR THE GAME LEADER ONLY

1. *Open the Fish Spotters model.*
2. *Enter your name in the session name*



3. Click the mirror 2D view on clients check box so that it is checked.

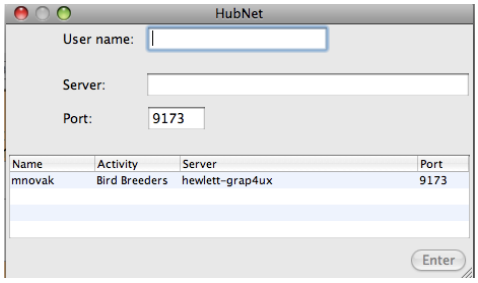


4. *Now ask all the other players to follow the CLIENT directions for steps 1-4 shown on the right.*
5. *Once you see all the players appear in the CLIENTS section of the HUBNET CONTROL CENTER, you may join the game yourself by pressing the LOCAL button.*

   When you do this a client interface will be launched for you to also join the simulation. *You will use this interface to interact the model.*

INSTRUCTIONS FOR THE OTHER 3 to 5 TEAM PLAYERS

1. Open HubNet on your computer.
2. A connection box will appear like the one below. In this box type your user name (8 characters or less).

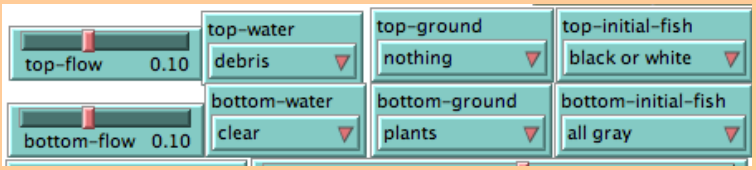


3. Click on the Server name in the list below which has the **name of the Group Leader** in it. Then press enter.
4. Check with the group leader to make sure you now appear in the client list of the HubNet Control Center.

Procedure for Playing the Game

1. Set the CLIENT-ROLES chooser to "all mates":

2. Adjust all the environmental conditions for the top tank and bottom tank to the values you chose for your experiment. For example:



3. Press the SETUP, and then GO/PAUSE in to run the model.

4. Play for about 5 minutes, then pause the model run and record your results.

Data and Observations:

Making Sense of Your Data

Which if any, predictions were correct for the adaptations you saw in tank 1?

_____

_____

Which if any, predictions were correct for the adaptations you saw in tank 2?

_____

Now that you have seen the adaptations that did occur, how could you explain at least one of these adaptions?

Exploration 2:

Question

"How does mating and predation affect adaptations?"

Design Your Experiment as a Group

In this experiment will be able to design a new experiment of your choice. Again you can assign the type of environmental conditions or initial color variations in the two tanks. This time however, you can also have some of the participants play the part of predators and others play the part of mates. So another part of what you will have to decide is what type of participant on your team will "hunt" or mate in which tank.

Top Tank Environment				
TOP-WATER	TOP-FLOW	TOP-GROUND	TOP-INITIAL-FISH	Team Participants
The water conditions	How fast plant debris or ripples flow	The background	The initial variations in the colors of the fish population	Who will interact with the fish in this tank
• Clear • Ripples • Debris	Any value between 0 and 0.25 _____	• Clear • Plants • Rocks • Sand	• Multi-colored • All gray • Black or white	• Only predators • Only mates • A mix of predators & mates

Bottom Tank Environment				
BOTTOM-WATER	BOTTOM-FLOW	BOTTOM-GROUND	BOTTOM-INITIAL-FISH	Team Participants
The water conditions	How fast plant debris or ripples flow	The background	The initial variations in the colors of the fish population	Who will interact with the fish in this tank
• Clear • Ripples • Debris	Any value between 0 and 0.25 _____	• Clear • Plants • Rocks • Sand	• Multi-colored • All gray • Black or white	• Only predators • Only mates • A mix of predators & mates

Predict

In tank 1, what, if any, adaptations will appear in….

in color?_____

in how much they move?_____

in body size?_____

in spot visibility _____

In tank 2, what, if any, adaptations will appear in….

in color?_____

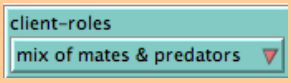
in how much they move?_____

in body size?_____

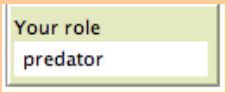
in spot visibility _____

Procedure for Playing the Game

1. Set the CLIENT-ROLES chooser to "mix of predators and mates":



2. Adjust all the environmental conditions for the top tank and bottom tank to the values you chose for your experiment.



3. Press the SETUP. Each player should make note of what role they have been assigned (a mate or a predator). This should show up in the Your Role monitor.

4. Assign players to the tanks that you decided on to create the experimental conditions you intended. Are all the predators going to hunt in one tank or both? Are all the mates going to hunt in one tank or both?

5. Press Go-STOP to start and play for about 5 minutes, then pause the model run and record your results.

Data and Observations:

Making Sense of Your Data

How did adaptations appear to change when there were only predators compared to having only mates compared to having a combination of both?

Discoveries and Insights:

What discoveries did you make regarding the question of this lesson - How Do Mates Influence Adaptations?

How does understanding these mechanisms or outcomes help you answer the driving question for the unit?

Homework 15 – Adaptation and Sexual Selection

Jumpstart: Have you ever the type of bird in the picture on the right? Its a peacock. Peacocks are male birds that have larger, more colorful, and more striking feathers than females of the same species. The female (peafowl) has a mixture of dull green, brown and gray feathers that are relatively short compared to the male. A female is shown at the bottom of the picture on the right.

The male, on the other hand, has a set of feathers on its tail that are iridescent blue and green. The male normally keeps these feathers folded up and hidden from view. But the male will flare out his feathers when he is trying to get the female's attention during mating season. A male peacock demonstrating this behavior is shown on the top of the picture on the right. In addition to showing these startling feathers, male peacocks also emit a very loud high pitched cry.

Need image permission
http://upload.wikimedia.org/wikipedia/commons/thumb/a/a9/Peacock_courting_peahen.jpg/250px-Peacock_courting_peahen.jpg

Question 1: If two males birds trying to attract a mate, circle which variation of each of these traits would lead to greater competitive advantage for reproduction.

Trait	Variations		
Color of Feathers	Bright and garish	OR	Dull and earth colored
Size and direction of feathers	Small feathers kept tucked away	OR	Large feathers displayed prominently
Amount of movement	Fast movement and lots of motion	OR	Slow movement and very little motion
Song	No song	OR	Loud song

Question 2: If a female bird is trying to avoid a predator, circle which variation of each of these traits would lead to greater competitive advantage for survival.

Trait	Variations		
Color of Feathers	Bright and garish	OR	Dull and earth colored
Size and direction of feathers	Small feathers kept tucked away	OR	Large feathers displayed prominently
Amount of movement	Fast movement and lots of motion	OR	Slow movement and very little motion
Song	No song	OR	Loud song

Question 3: The male only shows its tail and sings its song during mating season. If a male was born with mutations that caused it to show its tail and to sing its song all year long, why would this probably give it a competitive disadvantage for survival?

Question 4: If a male was born with a mutation that caused it have tail feathers that are twice as long as other males, what are the competitive advantages and disadvantages of this mutation?

Question 5: What are some examples of mating rituals of other animals that are designed to attract attention of mates?

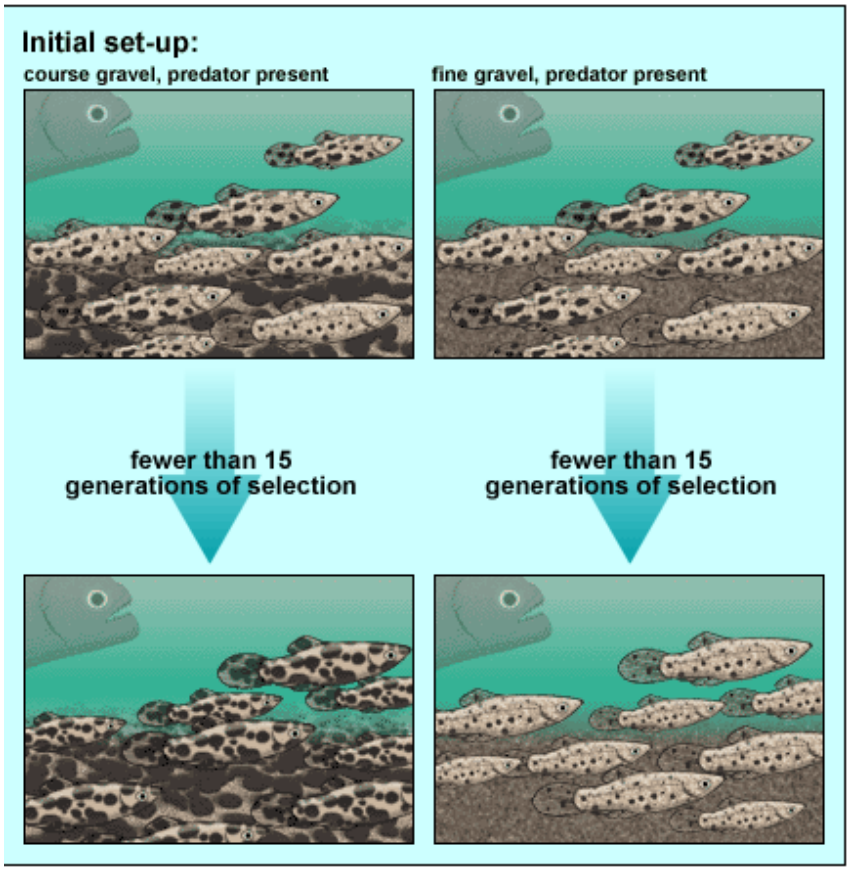
John Endler was an evolutionary biologist who studied guppies, a type of fish, found in Trinidad (an island in the Caribbean) during the 1970s. He was surprised to find a wide variation in the color, size, and spots that appeared on the tails of the guppies in different streams. He found similar variation among guppies even in different parts of the same stream

Images and text are from:
http://evolution.berkeley.edu/evosite/evo101/IVB1bInthelab.shtml

Endler photographed the guppies and recorded the color, size, and location of spots on their bodies. He noticed that upstream fish tended to be larger and more brightly colored than downstream fish. in some parts of stream the guppies were brightly colored and in other streams they were drab. He wondered if this difference in appearance was due to the presence of predators, since downstream guppies typically encountered more predators than upstream fish.

Using fish tanks, he designed an experiment to test what would happen to these traits in a fish population if he could watch natural selection at work.

John Endler performed experiments in microevolution, allowing artificial selection to manipulate the spots on guppies[1]. Guppy spots are largely genetically controlled. Spots that help the guppy blend in with its surroundings protect it from predation—but spots that make it stand out help it attract mates. Endler set up similar populations of guppies in artificial ponds in the laboratory. Ponds varied in the coarseness of gravel on the bottom and all ponds had predators. Below is a simplified representation of Endler's first experiment. After fewer than 15 generations of selection, the markings of guppies in different ponds had substantially diverged. The picture below summarizes his results from this experiment.



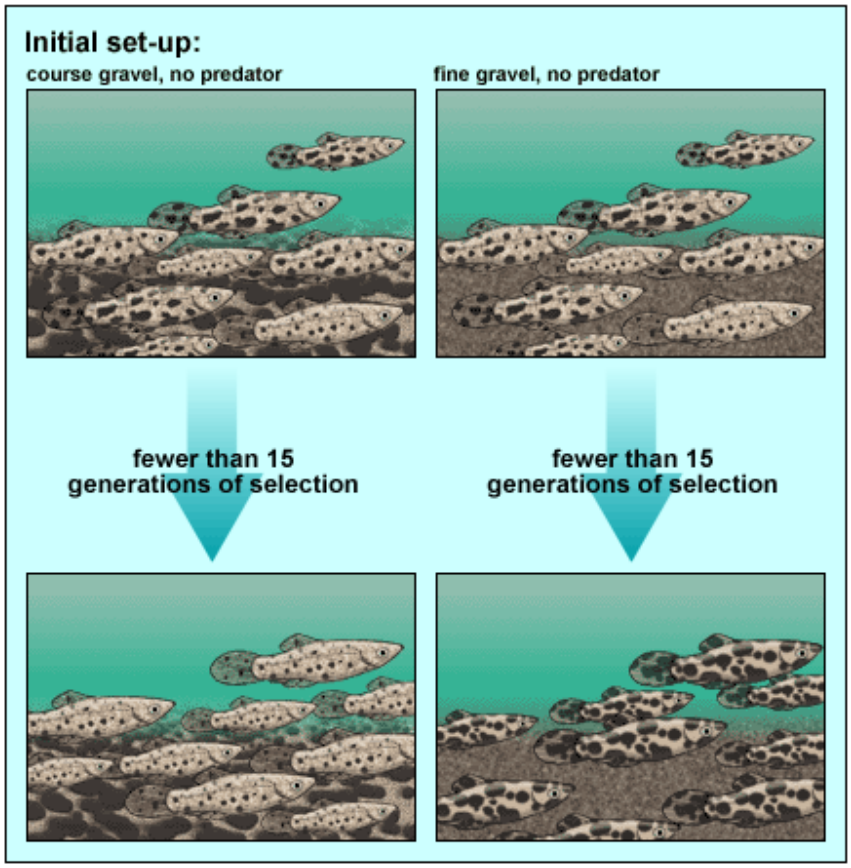
Question 7: In this first experiment, with predators in both tanks, why does each population evolve to have different spotting characteristics in the individuals?

_____

_____

_____

Endler then performed a 2nd experiment, with the same pond set-ups but without predators. The picture below summarizes his results from this 2nd experiment.



In the experiments you did in class with the NetLogo computer model your group probably generated similar outcomes. In tanks with no predators and only mates, fish tend to look more garish and stand out more. In tanks with predators, fish tend to blend into the surrounding more.

Question 6: In your own words, why, with no predators in either tank, did each population evolve to have different spotting characteristics in the individuals?

Lesson 16: Bug Hunt Coevolution

Purpose:

Do Adaptations in One Population Influence Adaptations in Other Populations?

Procedure:

Exploration 1:

Question

"Will the same adaptations appear in both a predator and a prey population"

Model Rules

What traits can be inherited by the bugs?

_____

What traits can be inherited by the birds?

_____

Predict

If predators can have offspring with speeds that can be slightly different than their parents, how do you predict the speed of the predators would evolve?

_____

_____

If prey can have offspring with speeds that can be slightly different than their parents, how do you predict the speed of the prey would evolve?

_____

_____

Test Your Predictions

1. Open the "Bug Hunt Coevolution" model.

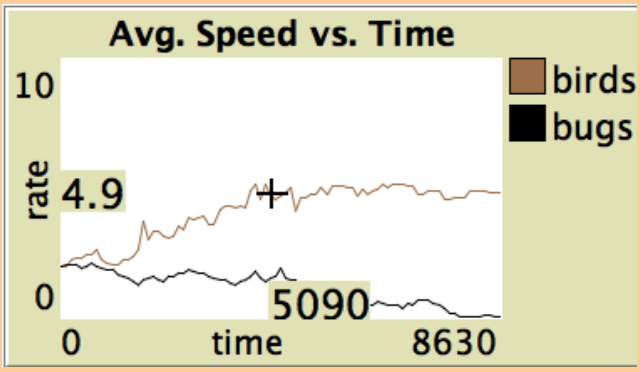
2. Set the initial values to:

Setting	Value
INITIAL-BUG-SPEED	2
INITIAL-BIRD-SPEED	2
INITIAL-BUG-VISION	0
INITIAL-BIRD-VISION	0
BUG-SPEED-MUTATION	1
BIRD-SPEED-MUTATION	1
BUG-VISION-MUTATION	0
BIRD-VISION-MUTATION	0
NUMBER-BUGS	60
NUMBER-BIRDS	10

3. Press SETUP, and then GO/PAUSE to run the model.

4. Stop the model once both populations have evolved to achieve new stable values for their avg. speeds OR once the BUGS BORN monitor shows a value of more than 5000. *To speed the model up, turn the VIEW UPDATES checkbox off.*

5. Use the Avg. Speed vs. Time graph and your cursor to record the times at which the populations reached new stable values for the average values for speeds in the Observation section below. *In the example below you can see that the cursor shows that the bird population reached an average speed of about 4.9 at around a time of 5090.*



Record Your Observations:

Value	Did this reach a new stable value (yes or no)?	If yes, what was the new stable value?	If yes, at what time did the population first achieve this new stable value?
Average speed of bugs			
Average speed of birds			

Making Sense of Your Data:

Did the evidence from the model, support your predictions about the evolution of the bugs?

_____

_____

Did the evidence from the model, support your predictions about the evolution of the birds?

_____

_____

Exploration 2:

Question

"Will the same adaptations as before appear again in a population, even when the population it is interacting can't evolve? "

Predict

If only predators can evolve to have different speeds, but prey can't, will predators evolve in the same manner that they did in the previous exploration?

_____

_____

If only prey can evolve to have different speeds, but predators can't, will prey evolve in the same manner that they did in the previous exploration?

_____

_____

Design Your Experiment

Choose a question to investigate and circle the question you chose below:

- What when predators can evolve different speeds but prey can't?
- What happens when predators can evolve different speeds but prey can't?

Test Your Predictions

1. To investigate the first question, "What when predators can evolve different speeds but prey can't?", change the following initial values :

Setting	Value
BUG-SPEED-MUTATION	1
BIRD-SPEED-MUTATION	0

2. To investigate the first question, "What when prey can evolve different speeds but predators can't?", change the following initial values :

Setting	Value
BUG-SPEED-MUTATION	0
BIRD-SPEED-MUTATION	1

3. Press SETUP, and then GO/PAUSE to run the model. *If you want to watch the model run in the WORLD & VIEW, remember to turn the VIEW UPDATES checkbox back on.*

4. Stop the model once both populations have evolved to achieve new stable values for their avg. speeds OR once the BUGS BORN monitor shows a value of more than 5000. *To speed the model up, turn the VIEW UPDATES checkbox off.*

5. Use the Avg. Speed vs. Time graph and your cursor to record the times at which the populations reached new stable values for the average values for speeds in the Observation section below.

Record Your Observations:

Value	Did this reach a new stable value (yes or no)?	If yes, what was the new stable value?	If yes, at what time did the population first achieve this new stable value?
Average speed of the population you allowed to evolve			

Making Sense of Your Data:

For the questions below, compare the evolutionary outcomes for the population that evolved in this experiment to the outcomes for that same population in the experiment from the first exploration. Look back at the data and observations from that first experiment.

Did the population reach a new stable value in both experiments? _____

Was the new stable value similar in both experiments? _____

Was the time at which the population first achieve this new stable value similar? _____

Feel free to repeat either of the experiments from the 1st or 2nd exploration to verify your results.

Making Sense of Your Data:

Make a claim to answer this question:
Can evolutionary outcomes for a population be influenced by how other populations are evolving?

_____

_____

_____

What evidence from the first two investigations support your claim?

_____

_____

_____

Exploration 3:

Question

"Are evolutionary outcomes for a population influenced by how other populations are evolving?"

Design Your Experiment

You will be able to change how many mutations each population can incur for either of two traits: speed or vision distance. This means that you can set it up so either population can evolve one of the traits, both of these traits, or none of these traits. And the value for each amount of mutations for that can be incurred for each trait can be set from "0" (no mutations) to 1 (fast mutations).

In order to investigate this question you must have:

- at least one of the mutation values set to something other than "0" in both conditions.
- at least one of the mutation values set to "0" in only one (not both) of the conditions.

Experimental Condition 1	
Setting	**My chosen value**
INITIAL-BUG-VISION	
INITIAL-BIRD-VISION	
BUG-SPEED-MUTATION	
BIRD-SPEED-MUTATION	
BUG-VISION-MUTATION	
BIRD-VISION-MUTATION	

Experimental Condition 2	
Setting	**My chosen value**
INITIAL-BUG-VISION	
INITIAL-BIRD-VISION	
BUG-SPEED-MUTATION	
BIRD-SPEED-MUTATION	
BUG-VISION-MUTATION	
BIRD-VISION-MUTATION	

Predict

For each mutation setting that you plan to keep at something other than zero in both conditions, make a prediction whether the evolutionary outcome will be the same.

Setting	Is this value going to be something other than "0" in both conditions?	If yes, do you predict the same evolutionary outcomes in both conditions for this mutating trait?
BUG-SPEED-MUTATION		
BIRD-SPEED-MUTATION		
BUG-VISION-MUTATION		
BIRD-VISION-MUTATION		

Test Your Predictions

1. Apply your condition #1 settings to the model.
2. Press SETUP, and then GO/PAUSE to run the model. *If you want to watch the model run in the WORLD & VIEW, remember to turn the VIEW UPDATES checkbox back on.*
3. Stop the model once both populations have evolved to achieve new stable values for their avg. speeds OR once the BUGS BORN monitor shows a value of more than 5000. *To speed the model up, turn the VIEW UPDATES checkbox off.*
4. Use the Avg. Speed vs. Time graph and your cursor to record the times at which the populations reached new stable values for the speeds and vision for both the bugs and the birds. Record your results.
5. Repeat these instructions for the settings you chose for condition #2.

Record Your Observations

Trait	Final stable value for condition #1	When was this stable value first reached?	Final stable value for condition #2	When was this stable value first reached?
BUG-SPEED				
BIRD-SPEED				
BUG-VISION				
BIRD-VISION				

Making Sense of Your Data:

Were the evolutionary outcome the same for each condition, in terms of how fast the population reached final stable values for the average trait values? _____

Were the evolutionary outcome the same for each condition, in terms of what the final stable values were for the average trait values? _____

Follow-up:

Make a claim regarding this statement. Does the evolution of the predator population influence the evolution of the prey population AND does the evolution of the prey population influence the evolution of the predator populations?

_____

_____

What evidence supports your claim?

How does understanding these mechanisms or outcomes help you answer the driving question for the unit?

Homework 16 – Coevolution

Jumpstart: In the coevolution model you explored in class, you discovered that the evolution of one population can put selective pressure on the evolution of another population. As predators evolve, this puts new selective pressures on the prey, which then evolve, which in turn, puts new selective pressures on the predators. **Coevolution** is a word that summarizes this effect. It means to "evolve together". In this reading you will learn more about everyday examples of coevolution.

In some cases, when interacting species evolve together, their evolution in population tends to reinforce and strengthen the effects of evolution on both populations. One example of this would be when faster moving predators unintentionally create additional selective pressure for faster moving prey, which in turn select for even faster moving predators, which in turn select for even faster moving prey, etc….

Even populations that interact indirectly (such as grass and birds in the first ecosystem model) can cause exert coevolutionary pressures on each other, since they both interact with other populations in the ecosystem and with the abiotic environment. This cycle of interactions can continue for any population of organisms in an ecosystem.

Now consider a real world ecosystem where bugs eat grass and birds eat bugs.

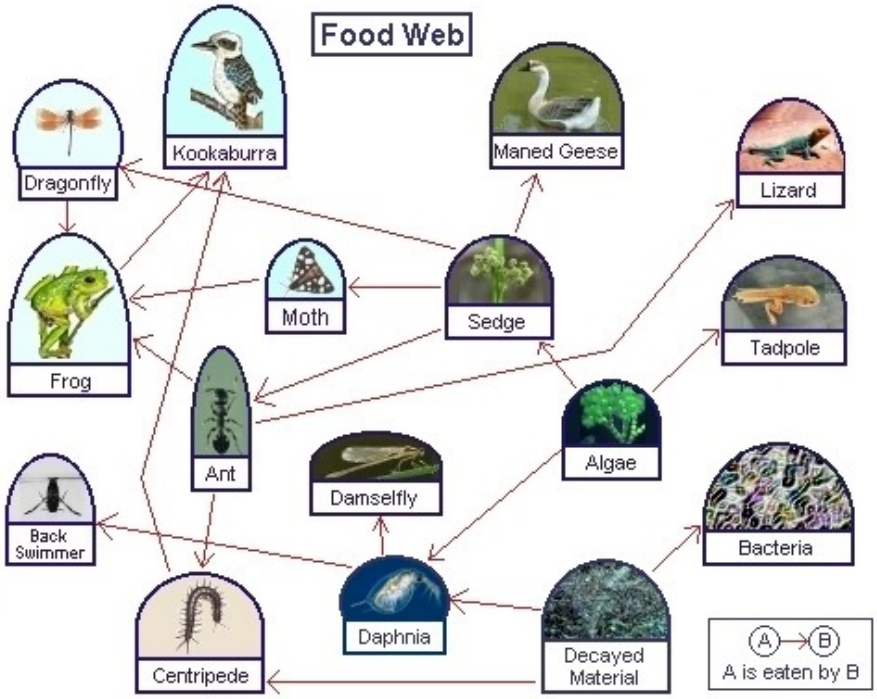
Question #1 Why might grass evolution and bug evolution affect each other?

Question #2 Why might bug evolution and bird evolution affect each other?

Question #3 Why might grass evolution and bird evolution indirectly affect each other?

In a real world ecosystem there are often more than just 3 different populations of organisms. Food

webs, which show the number and type of interactions for food represent some of the ways that populations might interact. Study the diagram below of an ecosystem food web:



http://www.arcytech.org/java/population/images/food_web.jpg

Question 4: Why might the evolution of the frog population in this ecosystem affect the ant population?

Question 5: How might the evolution of the bacteria in this ecosystem indirectly affect the evolution of the Dragonfly population?

Question 6: The diagram above only shows the ways in which organisms interact for food. But since they share the same environment, they also interact for other resources necessary for survival. How would changes to the soil, sunlight, water, and geology indirectly affect the evolution of the birds?

Question #7 Even though the environment changes over time, why would it be incorrect to say that the non-living environment "evolves" in the same way that we say living organisms evolve?

Sometimes different species coevolve together in a such a way that the interactions between the populations mutually benefit each other. When each species derives a benefit from the interaction, such an interaction is referred to a **mutualism**.

In order to reproduce, many plants depend on insects or other creatures for pollination. Likewise, the plants or insects that pollinate the plants often derive a benefit from being a pollinator. This relationship is an example of mutualism.

Question 8: Is the coevolution of the bugs and birds you saw in the NetLogo model you expolored in class an example of mutualism? _____

Why or why not?_____

_____

_____

Before 65 millions years ago, there is no record of any fossils of flowering plants. It is believed that the evolution of pollination and flowering plants are tied together, starting during that time period Here is a proposed model for how such coevolution might have developed over the past 65 million years.

Text and images from http://biology.clc.uc.edu/Courses/Bio303/coevolution.htm
Permission needed. Text paraphrased and copied in sections:

Ancient plants pollinated using the wind. The ovule (the female structure of the plant) secreted sap to catch pollens of grain floating in the wind. This is similar to how modern pine trees and other gymnosperms reproduced.

Insects that crawled on the sap of these plants found the sap and pollen to a be useful source of food. This began a form of natural selection, which selected for individuals who had inherited traits that led them more readily to the sap and pollen producing plants. In time, some species of insects adapted to seek out the plants that had this food source. In doing so, they ended up carrying pollen from plant to plant. This form of pollination would have been much more efficient for the plant than the wind (for some species).

With this evolution of the insects, natural selection would have started selecting for plants that attracted insects, as they would have a reproductive advantage over other individuals.

Next to occur would have been the evolution of nectaries, nectar secreting structures, to lure the pollinators.

Development of white or brightly-colored, conspicuous flowers to draw attention to the nectar and/or other food sources would also have occurred.

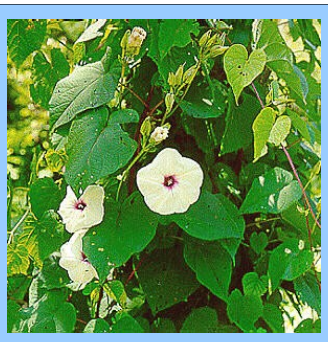
y the beginning of the Cenozoic Era (65 mya), the first bees, wasps, butterflies, and moths had evolved. The significance in this is that these are insects for which flowers are often the only source of nutrition for the adults.

From this point on, certain plant and insect species have had a profound influence on one another's evolution. A flower that attracted specific pollinators on a regular basis had an advantage (less wasted pollen) over flowers that attracted "promiscuous" pollinators. It is also an advantage for the pollinator to have its own "private" food source because there is less competition. The varied shapes, colors, and odors of flowers allowed sensory recognition by pollinators and excluded unwanted, indiscriminate pollinators.

Today, over 65% of Angiosperms are insect-pollinated and 20% of insects, at least at some stage, depend on flowers for their food.

Bees don't see red, but do see in yellow, blue, and ultra-violet. Many bee pollinated flowers are mostly yellow or blue with ultra-violet nectar guides (landing patterns) to guide the bee. They usually have a delicate, sweet sent, and a small, narrow floral tube to fit the tongue-length of that species of bee. The flowers are sturdy and irregularly-shaped with a specific landing platform adapted for a specific insect. For example, snapdragon flowers will only open for a bee of the right weight.

Moths are nocturnal, have a good sense of smell, and are hover-feeders. These flowers are white or pale colors so they are visible at night, and may only be open at night. Typically, these flowers have a strong, sweet scent (again, maybe only at night) and deep tubes to match the length of the appropriate moth's tongue. The petals are flat or bent back (recurved) so the moth can get in.



Coevolution is often seen in a number of species of flowering plants that coevolved with specific pollinators (insects, bats, etc). The pollinator gets a reward such as nectar for pollinating the plant. Moth-pollinated plants often have spurs or tubes the exact length of a certain moth's "tongue." For example, Charles Darwin predicted the existence of a moth in Madagascar based on the size and shape of a flower he saw there. The moth was actually discovered about 40 years later.

Question 9: What are some other examples of mutualism and coevolution that may have occurred?

_____

_____

_____

_____

_____

_____

Lesson 17: Extinction

Purpose:

Why Do Some Species Go Extinct?

Procedure:

You and a partner will be assigned two factors that can contribute to the extinction of a species from your **Conclusion & Big Ideas** Section. For each factor compare which species would be at the highest risk of extinction, species A or B (listed on the Transparency your teacher displays in class). After discussing this with your partner, come to agreement and circle either A or B in pencil and provide a reason why.

What is your First Factor	**Which species would be at the highest risk of extinction in the near future?**	
_____	A. _____	B. _____
Why?:		

What is your Second Factor	**Which species would be at the highest risk of extinction in the near future?**	
_____	A. _____	B. _____
Why?:		

Discoveries and Insights:

Factor	Which species would be at the highest risk of extinction in the near future?	
1. Population size	A. A few individuals	B. Many individuals
Why?:		
2. Distribution	A. In many different ecosystems	B. In one ecosystem
Why?:		
3. Trait variation	A. Lots of variation between individuals	B. Individuals are nearly identical
Why?:		
4. Gene Pool	A. Only one allele for most genes	B. Many alleles for most genes
Why?:		
5. Changes in the environment	A. are gradual and small	B. are sudden and dramatic
Why?:		
6. Rate of reproduction	A. very slow (many years)	B. very fast (within minutes)
Why?:		
7. food web	A. will interact with the same species it has interacted with for a long time in the past	B. new species are introduced to the food web that it has never interacted with before
Why?:		

How does understanding these mechanisms or outcomes help you answer the driving question for the unit?

Homework 17 – Extinction

lots of text from http://en.wikipedia.org/wiki/Extinction

Jumpstart: Do you think any species gone extinct while you have been alive? How about over the past 100 years? Extinctions can be caused by many factors. You identified some of these factors in class. In this reading you will learn more about examples of species that have gone extinct and evidence that helps scientists identify possible causes were for those extinctions.

You might be surprised to learn that over 97% of species that ever lived are now extinct! Some of these species went extinct long ago. Others have gone extinct more recently.

Between the year 1500 and the year 2009, 875 extinctions have been documented. But scientists suspect that many more extinctions have occurred than have been recorded or observed.

One of the earliest documented species to go extinct was the Dodo bird, a native species that used to live on the island of Mauritius in the Indian Ocean.

It became extinct in the 1600s after humans settled the island it lived on, destroyed the forests where the birds made their homes, and invasive species that ate the Dodo bird's eggs.

http://en.wikipedia.org/wiki/Dodo

Not all species go extinct because of human actions or invasive species. In class you studied other factors that might cause a species to go extinct. Some were complex, others were simple.

A simple explanation for all extinctions is that a species is unable to survive or reproduce in its environment. If it is also unable to move to a new environment where it can do this, it dies out and becomes extinct. A more complex explanation would take into account what environmental factors affected the survival of these species and how fast the extinction occurred.

Some extinctions seem unpredictable and to come on suddenly, such as when an otherwise healthy species is wiped out completely (like when pollution destroys an entire ecosystem). Other extinctions seem to be predictable and to come on more slowly, such as when a species gradually loses more and more population each season as it competes with individuals form other species for the same resources necessary for survival.

In general, extinctions become more frequent when changes in the environment occur more suddenly. This is because even though mutation can generate new genetic information, it often takes many generations to accumulate enough constructive mutations to result in adaptations that would allow the offspring to survive the very different environment. When the environmental change is large, the slow rate of evolution can't keep pace with the rate of environmental change.

Many environmental groups and some governments are concerned with the current rate of extinction of species on Earth. They suspect that these extinctions are indirectly being caused by human activity. Some human suspected causes include over-harvesting, pollution, habitat destruction,

introduction of invasive species, over-hunting, and climate change.

Some of these groups are trying to combat further extinctions through a variety of conservation programs. Some programs are aimed at conserving the natural ecosystems of endangered species to prevent further changes to the ecosystem by humans.

Question 1: In your opinion which of the causes listed in the paragraph above would be most likely to lead to extinction of native species in your area?_____

Question 2 Why?

_____

_____

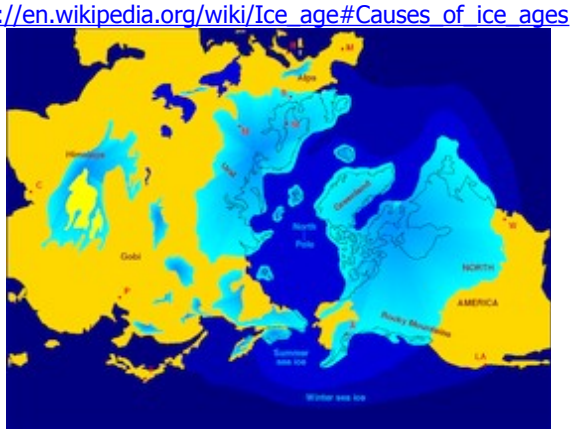
_____

Recent human history isn't the only time rapid environmental change that has occurred, and humans are not the only cause of environmental change.

The last ice age occurred 26,000 to 13,300 years ago. During this period, many parts of the northern hemisphere were covered in ice year-round, and global temperatures were lower on average.

At the end of this ice age, global temperatures increased and the vast ice sheets melted quickly.

image from
http://en.wikipedia.org/wiki/Ice_age#Causes_of_ice_ages



Many creatures that were alive during the ice age became extinct at its end (or shortly after). Some of these creatures included the Sabertooth cat and Woolly mammoth.

Two different types of saber-toothed cats lived in the midwestern U.S. at the end of the last Ice Age. One type was the familiar sabertooth, represented by the genus *Smilodon*. These cats had the enlarged canines usually associated with the name sabertooth. Their canines were up to 18 centimeters (7 inches) long. A mounted skeleton of *Smilodon fatalis* is shown in the photograph to the right.

http://www.museum.state.il.us/exhibits/larson/smilodon.html

Preserved frozen remains of woolly mammoths, with much soft tissue remaining, have been found in the northern parts of Siberia. This is a rare occurrence, essentially requiring the animal to have been buried rapidly in liquid or semi-solids such as silt, mud and icy water which then froze. This may have occurred in a number of ways. Mammoths may have been trapped in bogs or quicksands, and they either died of starvation or exposure, or drowning if they sank under the surface. A stuffed and preserved set of these frozen remains can be seen in a St. Petersburg, Russia museum (shown in the photograph to the right).	 http://en.wikipedia.org/wiki/Woolly_mammoth

*S*ome scientists have proposed that extinction of these species was primarily due to human activity. Other scientists suggest that their extinction was primarily due to large rapid changes in the environment due to the melting of the glaciers at the end of the last ice age.

Question 3 How might advances in human hunting technologies and techniques during this time have led to the extinction of these species?

Question 4 How might the climate changes that occurred at end of the ice age have led to the extinction of these species?

Question 5 What other factors might have contributed to the extinction of these species?

Scientists determined when these species went extinct by studying the fossil record. In general, rocks and fossils that are buried deeper in a sedimentary layer are older than rocks and fossils closer to the surface. By studying the location of sedimentary rocks and the composition of those rocks, scientists can determine roughly when the individual died.

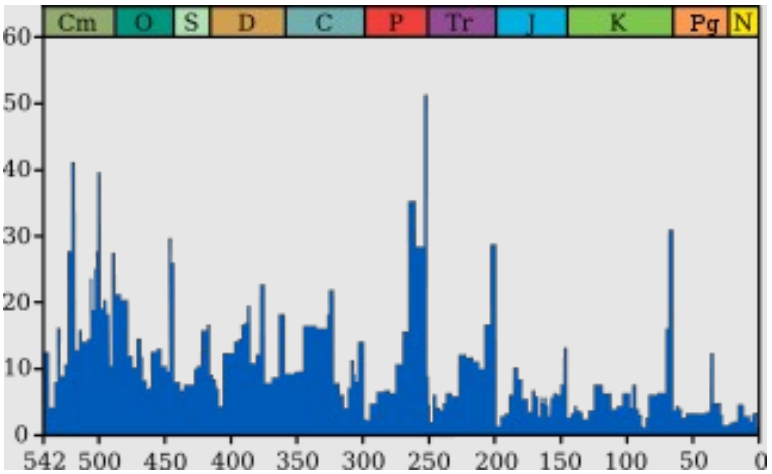
By studying the fossil record, scientists have determined that there have been some very major extinction events in Earth's past. They have noted that there are sometimes layers of sedimentary rock that show a sharp decrease in the number of species that left fossils in a relatively short period of time. Scientists refer to such an event as a **mass extinction event**.

On the right is a graph of Marine extinction intensity through time over the past 540 million years. The blue graph shows the apparent percentage (not the absolute number) of marine animals becoming extinct during any given time interval. It does not represent all marine species.

Notice the largest spike in this graph occurred a little over 250 million years ago. The next big spike to occur appears just over 200 million years ago, and the most recent spike occurred about 65.5 million years.

http://en.wikipedia.org/wiki/Extinction_event#Extinction_events

Percentage of marine species that went extinct vs, how many millions of years ago



We are going to investigate the two most recent spikes. These are the two most recent mass extinction events in the fossil record. They each have been given names. The most recent one, called the Cretaceous-Tertiary mass extinction event, is also referred to as C-T (or K-T). Another major extinction even before C-T is the Triassic-Jurassic mass extinction even,(also referred to as T-J.

Question 6 Label these spikes on the graph:

a) the C-T mass extinction event which occurred approximately 65.5 million years ago.
b) the T-J mass extinction event, which occured approximately 200 million years ago.

Non-avian Dinosaurs (those that are not birds) are found only in rocks that are older than the C-T and older than the T-J event boundaries. This indicates that non-avian dinosaurs became extinct immediately before or during the C-T mass extinction event. In addition to the extinction of dinosaurs, mosaurs, plesiosaures, pterasuars, many species of plants and invertebrates also became extinct at this event (or shortly before it).

*S*ome scientists have proposed that the C-T extinctions were caused by some catastrophic

environmental change. Possible causes of a major change in the past that have been proposed include either a massive asteroid impact or increased volcanic activity.

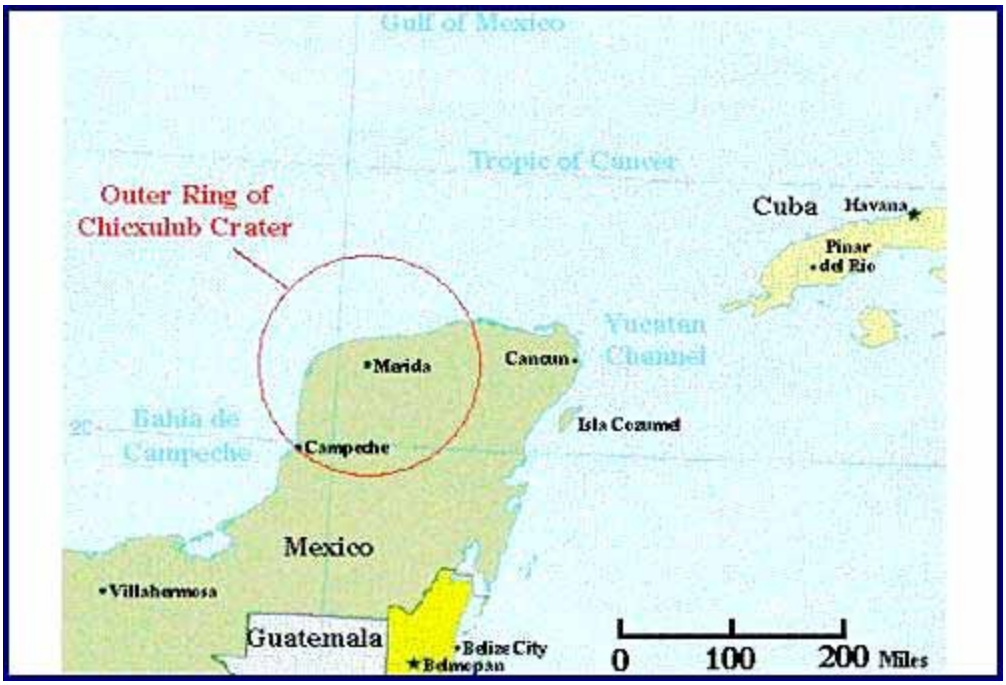
Both of these events would have had major effects on all ecosystems on Earth, affecting the amount of dust in the atmosphere, the amount of sunlight reaching the ground, and the average air temperature. Both would have affected most types of plant growth.

Other researchers don't believe that the species that went extinct did so suddenly. They believe the C-T boundary marks the end of a slower environmental change, such as gradual change in sea levels or a gradual shift in climate.

When this massive asteroid impact hypothesis was first proposed, it was not widely accepted. This was largely due to the fact that no visible impact crater could be found on the surface of the Earth to coincide with this event. Even with weathering and the gradual filling in of sedimentary materials, it seemed as if there should have been some trace of a crater left by such an impact.

Scientists have recently discovered a very large impact crater, buried beneath the soil of Mexico and the Gulf of Mexico using satellites that employ radar to penetrate the ground and show the structure of the rock beneath the surface, s. It appears to have been made by a 10-20 km wide asteroid. As the map shows below, the size of the crater is massive. Its ring is surrounded by a series of caves, and changes in the composition of the rock.

http://www.space.com/php/multimedia/imagedisplay/img_display.php?pic=h_chicxulub_map_02a.jpg



The evidence related to this crater helps support the claim of a massive asteroid impact being at least partially responsible for the environmental change that led to the extinction of the dinosaurs.

In addition, rock formations around the world, similar to the one shown on the right, provide additional evidence for the massive meteor impact affecting ecosystems all around the Earth.

The photograph shows a badlands rock formation near Drumheller, Alberta Canada where erosion has exposed the C-T boundary. The rock that marks the layer between the boundaries contains 1000 more times iridium than the upper and lower layers. Iridium is rare on earth, but is a common element found in some meteors. This iridium layer at the C-T boundary has been found in rocks on every continent around the world.

http://en.wikipedia.org/wiki/K-T_extinction

During or shortly before the T-J mass extinction event, 20 percent of all marine families, many large amphibians were wiped out and half of species known to have been living on Earth went extinct at that time. This event also changed environmental conditions so much, that dinosaurs then evolved to assume the dominant role in most ecosystems (until the C-T mass extinction event).

Several explanations for this earlier T-J mass extinction event have been suggested, but all have unanswered challenges.

Proposed explanation	Current weaknesses with this explanation
Gradual climate change or sea-level fluctuations occurred.	This does not explain the suddenness of the extinctions in the marine realm.
Another asteroid impact.	No impact crater has been found to coincide with the T-J boundary
Massive volcanic eruptions.	Evidence of the corresponding release of huge amounts of carbon dioxide or sulfur dioxide which would cause either intense global warming (from the former) or cooling (from the latter) is still being sought.

Currently, scientists continue to search for geological evidence to help narrow down these possibilities and determine the most likely cause of the T-J mass extinction.

Question 8 Which explanation do you think was the mostly likely cause of the T-J mass extinction event?

_____

_____

_____

Question 9 Why do some species survive and others go extinct during a mass extinction event? Use the mechanisms of evolution in your explanation:

Lesson 18: Plant Speciation

Purpose:

Where Do New Species Come From?

Brainstorm:

You know that many species that were alive in the past have gone extinct. Many of the species that are alive today did not exist at one point in the past. Those facts raise an important question, "where did the species that are alive today come from"?

Identify one or more mechanism of evolution that you think might help explain where new species come from?

_____

_____

_____

In your own words explain how these mechanisms might cause a new species to form:

_____

_____

_____

Procedure:

Exploration 1:

Question

"What parts of the environment favor some trait variations over others?"

Model Rules

Why do some parts of the environment have a greener background and other parts of the environment have a bluer background?

_____

_____

Where do plants initially start growing when you first press SETUP?

_____

Predict

If you started out the initial population so that it was all metal tolerant, and it could have no mutations in the offspring, predict where you will find the plants thriving after many years?

a) I will find more of the offspring growing in the normal soil (left side of the ecosystem), and less growing in the metal contaminated soil (right side of the ecosystem).

b) I will find less of the offspring growing in the normal soil (left side of the ecosystem), and more growing in the metal contaminated soil (right side of the ecosystem).

c) I will find the offspring growing equally well in both the normal soil and the contaminated soil.

d) I will find no offspring anywhere in the ecosystem.

If you started out the initial population so that it was not at all metal tolerant, and it could have no mutations in the offspring, predict where you will find the plants thriving after many years?

e) I will find more of the offspring growing in the normal soil (left side of the ecosystem), and less growing in the metal contaminated soil (right side of the ecosystem).

f) I will find less of the offspring growing in the normal soil (left side of the ecosystem), and more growing in the metal contaminated soil (right side of the ecosystem).

g) I will find the offspring growing equally well in both the normal soil and the contaminated soil.

h) I will find no offspring anywhere in the ecosystem.

Test Your Predictions

1. Open the "Plant Speciation" model.

2. Set the initial values to:

Setting	Value
CHANCE-FLOWER-TIME-MUTATION	0%
CHANCE-TOLERANCE-MUTATION	0%
INITIAL-TOLERANCES	"all full tolerance"
VISUALIZE-TIME-STEPS	"days"

3. Press SETUP, and then GO/STOP to run the model. *Notice that the day monitor is steadily increasing and when it reaches 365, it will set back to 0 and the year will go up by one.*

4. To speed the model up so that you can see what has happened after many years, switch the VISUALIZE-TIME-STEPS to "years". Run the model for at least a hundred years.

5. After a hundred years, pause the model and notice where there are more plants. Record this in your Observation section.

6. Repeat the experiment from the beginning, but change this one initial value before pressing SETUP:

Setting	Value
INITIAL-TOLERANCES	"all no tolerance"

7. Again, after running the model for a hundred years, pause the model and notice where there are more plants. Record this in your Observation section.

Record Your Observations:

Making Sense of Your Data:

Did the evidence from the model, support your first prediction?

_____

Did the evidence from the model, support your second prediction?

_____

In this model run, all of the plants from both model runs are flowering at the same time of year. Since they can only reproduce when they are flowering, are all the plants still part of the same species? _____

Exploration 2:

Question

"When is it advantageous to be able to interbreed with the same population?"

Predict

If you allow flower time mutations to occur in the offspring, do you predict future generations of plants will all flower at the same time of year? _____

Test Your Predictions

1. Set the initial values to:

Setting	Value
CHANCE-FLOWER-TIME-MUTATION	10%
CHANCE-TOLERANCE-MUTATION	0%
INITIAL-TOLERANCES	You may choose any available option
VISUALIZE-TIME-STEPS	"days" or "years" (you may switch back and forth as the model is running)

2. Press SETUP. and Press GO/STOP to run the model.
3. You can switch the VISUALIZE-TIME-STEPS to "years" or "days". Years runs faster, but days lets you see the actual difference (if any) in flowering times between plants.
4. Run, the model for at least a hundred years.
5. Analyze the FLOWER-TIMES graph. Record your data in your Observation section.

Record Your Observations:

What is the range of flower times ? _____

Around what time of year do most of the flowering times occur? _____

Making Sense of Your Data:

Were your predictions correct? _____

All of the plants are flowering in a very narrow range of flowering times. They are opening during nearly similar time of year. Since they can only reproduce when they are flowering, do you think all the plants still part of the same species? _____

How does the shape of the FLOWER-TIME graph from this model run support this claim: "Any individual that flowers earlier than the average flower time or later than the average flower time, will have a lower chance of having offspring?

Which type of individual would have the best chances of being pollinated by other flowers?

a) A plant with a flowering time much earlier than most of the population
b) A plant with a flowering time much later than most of the population
c) A plant with a flowering time similar to most of the population.

Exploration 3:

Question

"Where Do New Species Come From?"

Predict

In the next model run you will allow flower time mutations and metal tolerance mutations to occur in the offspring.

What do you predict the outcome will be for the metal tolerance of the plants?

What do you predict the outcome will be for the flower time of the plants?

Test Your Predictions

1. Set the initial values to:

Setting	Value
CHANCE-FLOWER-TIME-MUTATION	10%
CHANCE-TOLERANCE-MUTATION	10%
INITIAL-TOLERANCES	You may choose any available option
VISUALIZE-TIME-STEPS	"days" or "years" (you may switch back and forth as the model is running)

2. Press SETUP. and Press GO/STOP to run the model.

3. Keep the model running until the SIMULTANEOUS FLOWERING graph shows that the number of simultaneously flowering plants in the contaminated soil and in the regular soil, is very close to zero.

4. Now make sure you have switched back VISUALIZE-TIME-STEPS to "days" mode and keep the model running.

5. Record what you notice about when the flowers on the left side of the ecosystem are blooming versus the flowers on the right side of the ecosystem.

6. *Sketch the shape of the two TOLERANCES graphs in Data and Observations section below. Use a unique pattern or different colored pencil to label and show which line in the graph represents the plants in the contaminated soil and which represents the plants in the regular soil.*

7. *Sketch the shape of the two FLOWER-TIME graphs. Use a pattern or different colored pencil to label and show which line in the graph represents the plants in the contaminated soil and which represents the plants in the regular soil.*

Record what you notice about when the flowers on the left side of the ecosystem are blooming versus the flowers on the right side of the ecosystem.

Making Sense of Your Data:

In the next set of questions you will try to explain why the flowers on the right have a different flower time than those on the left. To do this you may want to rerun this previous exploration in "days" mode, change labels, and study the model graphs. Feel free to conduct new experiments in this exploration to help you understand and explain why the initial plant population has "speciated".

Why aren't there many plants in the population with a tolerance in between 10 and 90?

How does natural selection lead to this outcome?

How does the graphs you drew support the claim that "The population of plants on the left side of the ecosystem no longer breed with the population of plants on the right side of the ecosystem"?

If a plant with no metal tolerance, growing on the left side (clean soil) were to reproduce with a plant with metal tolerance growing on the right side (contaminated soil), their offspring would inherit genetic information from both parents. Why would this offspring plant be at a competitive disadvantage for survival compared to other plants growing either in the clean soil or in the contaminated soil?

If a plant has to reproduce with another plant in order to have offspring, why would flowers in metal soil evolve a different average flower time than the flowers in the clean soil?

Discoveries and Insights:

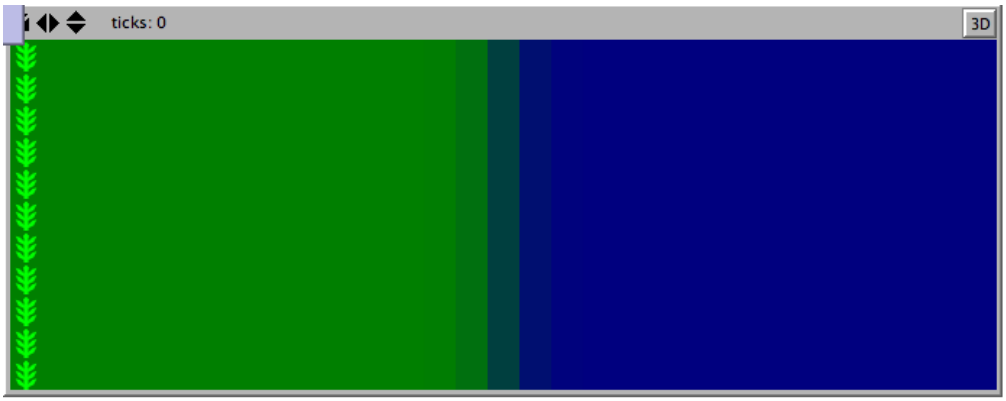
What discoveries did you make regarding the question of this lesson - "Where Do New Species Come From?"

How does understanding these mechanisms or outcomes help you answer the driving question for the unit?

Homework 18 – Speciation

Jumpstart: In the computer model you used in class, you saw how a single population of plants evolved its reproductive behavior so that it became two separate populations that didn't interbreed with each other anymore. Do you think this same sort of evolutionary outcome happens in the everyday world?

As the plants evolved in the model, plants on the left side of the ecosystem adapted to have a low tolerance for metal in the soil, since a low tolerance in the normal soil helps them grow better in that location. Plants on the right side of the ecosystem adapted to have a high tolerance for metal in the soil, since a high tolerance in the contaminated soil helps them grow better in that location.



Question 1: If you were a plant growing in metal contaminated soil, why would having the same flowering time as other plants that grow in this contaminated soil give you a competitive reproductive **advantage**?

flowering time as the plants that grow in the uncontaminated soil give your offspring a **disadvantage** in their survival?

Once both populations evolve behaviors, structures, or substances that prevent them from interbreeding, they are said to be separate **species**. When evolution pushes a population to split into two or more different species, this is called **speciation**.

This scenario, where one plant species evolves into two separate new species, is one that has been extensively studied by scientists. In one example, scientists have determined how speciation occurred for a native grass growing over the past hundred years for at the site of the Trelogan Arsenic Mine in Flintshire, North Wales, UK.

At this mine, a stone wall was erected between the "contaminated soil" from arsenic mine and the uncontaminated soil. This wall was built to help hold back the movement of soil washed away by water, but was not designed to keep plants from reseeding across either side of it.

It is believed that 100 years ago, no plants could would have been found that could grow in the contaminated soil, as that soil was being contaminated with heavy metal tailings being dumped on the ground as the nearby underground mine was being excavated. Over time however, some plants began to evolve the ability to tolerate the contaminated soil. These metal tolerant plants did not grow very well in regular soil. At first both populations would have had nearly identical flowering times, since this was a trait in the parent population that would have been selected for (due to sexual selection). But due to pattern of inheritance in sexual reproduction and mutation, some variation in flowering time developed in all plants. Therefore the average flower-time of the plants with a soil tolerance trait was slightly different than the average flower-time of the plants with no soil tolerance.

Individuals with tolerance to contaminated who had similar flowering times, would have had a better chance of having offspring that had tolerance to contaminated soil. This is because their offspring would be more likely to have been pollinated by two parents from the contaminated soil, and therefore also received the metal tolerance genes from parents with a competitive advantage for this environment.

By evolving reproductive isolation, 2 separate species emerged. Each one was now "specialized" in a survival advantage for a separate environment. In each type of soil environment there is no competitive advantage to being to grow in partially contaminated soil, since there is very little "partially contaminated soil", due to the wall that separates the two areas of the mine.

In any ecosystem there is variation in the physical conditions at different locations. Some spots of the ecosystem may have more water, sunlight, shelter, soil, etc... than others. In a forest, there are very different physical conditions at the bottom of the forest floor than under the tree tops, and there are very different physical conditions at spots where a tree fell down compared to a spot where trees are growing. These "separate areas" within the ecosystem each have their own local environmental conditions that are often different from one another. Such separate areas may lead to speciation, just like the separate areas in the mine.

Describe what physical conditions might be different at each of these locations in the following ecosystems.

Ecosystem: a deep lake
Question 3: How would the physical conditions change the deeper in the lake you go?

Ecosystem: a mountain
Question 4: How would the physical conditions change on the mountain, the higher up you travel the mountain?

Different environmental pressures in different areas within an ecosystem could lead to speciation of a population so that it can take advantage of these different environmental conditions.

Question 5: Which do you predict is more likely to evolve more species of fish: a small shallow lake with little variation in the amount of light or rocks on the bottom of the lake OR a large lake with some deep spots that gives large variation in the amount of light and rocks in the bottom of the lake?

Question 6: In a small forest, there is only one species of frog. In a large forest , there are two species of frogs. What might be different about the variation in the physical conditions in both forests that would lead to different number of species evolving in each?

Evolution can cause populations of the same species to develop into separate species, if enough changes occur in two isolated populations to make interbreeding impossible. Those changes can be in natural breeding patterns, physical structures, or mechanism for gene copying and meiosis.

The exact combination of selective forces that led to the speciation of each species on our planet is hard to determine. We are unable to directly observe events of the past and must do other sorts of comparisons to determine how current and extinct species that live(d) on our planet evolved from their parent population. Comparing the structure of the phenotypes of species is one way to determine how species evolved over time. Another way is to determine how closely related different species are is to compare the genotypes of the species (both alive and extinct).

TWhat is well understood, however it that the longer that separate populations are under the forces of natural selection, sexual selection, mutation, and genetic drift, the more their characteristics will be different from one another over time. And, that these interacting forces can drive the characteristics of a single species to the point that the separate populations become separate species

One instance of creation of new species in the laboratory was performed in the late 1980s. Rice and Salt bred fruit flies (which produce a new generation every 48 hours), *Drosophila melanogaster*, using a maze with three different choices such as light/dark and wet/dry. Each generation was placed into the maze, and the groups of flies which came out of two of the eight exits were set apart to breed with each other in their respective groups. After thirty-five generations, the two groups and their offspring would not breed with each other even when doing so was their only opportunity to reproduce.

Question 8: Describe another experimental setup that you could envision designing, that you believe would lead to the creation of two separate species of bird:

In the natural world, we can observe populations of animals that are very separate species in our own backyard. But we can also find populations of animals some of whom are classified as separate species, some of whom are classified as separate breeds, and some of whom are in between the transition from separate breeds to separate species.

Coyotes and Dogs are separate breeds, but not are not considered separate species. If one kept coyote and dog populations from interbreeding, then over time at some point they might evolve (through genetic drift) so that they would not be able to interbreed any longer. At present, however, they do occasionally interbreed in the wild, even though it is rare. Their offspring are called Coydogs or Dogote

http://www.birdpark.org/birddogs/figures/figure010.JPG.

A Coydog

Lions and tigers are considered separate species since they have never been observed interbreeding in the wild. In fact in the wild, there is only one small region of overlap in their ranges and shared ecosystems, the Gir National Forest in India.

But they are still similar enough in physical structure and gene copying mechanisms in both species to allow them to generate offspring (Ligers). If forced to mate in non natural settings (e.g. zoos) they will develop offspring that can survive and reproduce. Their offspring are called Ligers.

http://news.nationalgeographic.com/news/2005/08/0804_050804_ligers_2.html A liger

Horses and Donkeys are consider separate species. Their gene copying mechanisms are different in some important ways that do not permit them to generate a fertile offspring. So though the gene information that results in the offspring when a horse and donkey interbreed together is still similar to create an offspring that can survive, it is not similar enough for it also to produce its own offspring. Since it can't produce offspring it is considered **sterile**. This animal is known as a mule.

Foxes and dogs are separate species. They can't produce any viable offspring at all. Their genetic information is gives conflicting genetic instructions for creating an offspring.

Question 9: What are two animals that might be the same species, but look and act very differently?

_____ _____

Lesson 19: Adaptive Radiation

Purpose:

Why are there so many different species?

Brainstorm: What are some inherited traits or trait variations of a trait that might give a bird a competitive advantage for collecting seeds compared to others birds?

Think about the different types of birds you have seen throughout your life. Use these experiences and your own creativity to draw 5 different possible variations that you might see in the shape or size of the beak of a bird.

Predict:

Which (if any) of these beaks, would give that bird a competitive advantage in collecting & eating food?

Explain: *For the beak you chose, what types of food would this beak be better at collecting and/or eating?*

Procedure:

1. Your group will be simulating the life of different birds at four of the stations you visit in the lab today. Before you visit these stations you will be assigned a group. You and your group will travel to each station together.

2. Your teacher will assign you each different bird species, by handing each member a cup with a letter on it. Record the group members name for the species they were assigned in the table below.
3. Your teacher will assign you a station color to start at. Write this starting station color in the first shaded row in the table. At each new station you move to, write the next station color in the next shaded row.
4. Notice that you are assigned to use a single beak shape for your bird. You will the same tool of this shape at every station you visit. At four different stations there will be different types of foods you will try to pick up with your beak and put it in your cup.
5. When the teacher signals the start of a competition at your station, each group member should compete to get the most seeds they can out of the container without touching the container or moving it. And players may not touch, block, or interfere with each others tools. All players are competing indirectly with each other for food, not directly with each other. So players should use careful movements to control how they use the tool.
6. At each station you will count the amount of seeds in your cup. If a seed does not end up in the gathering cup it does not count as "gathered".
7. Return the seeds back into the same area of the environment that you gathered them (as best as you can). garbage before going to the next station.
8. All group members should share their results record their results, and follow the directions at the lab for resetting up the station for the next partner.
9. Your teacher will hand out tools now and you will go to your first station with your group. Take your lab sheet, cup, and pencil with you and wait for your teachers signal to start.

Data and Observations

Group Members:					
Bird Species A	Bird Species B	Bird Species C	Bird Species D	Bird Species E	Bird Species F
Beak Shape:					
Chopsticks	Turkey Baster	Large Pliers	Needle Nose Pliers	Tweezers	Clothes Pin
1st Station Color _____		Record # of Seeds Collected Below			
2nd Station Color _____		Record # of Seeds Collected Below			
3rd Station Color _____		Record # of Seeds Collected Below			
4th Station Color _____		Record # of Seeds Collected Below			

Class Results:

Bird Species A	Bird Species B	Bird Species C	Bird Species D	Bird Species E	Bird Species F
Beak Shape:					
Chopsticks	Turkey Baster	Large Pliers	Needle Nose Pliers	Tweezers	Clothes Pin
Station Color _____					
Station Color _____					
Station Color _____					
Station Color _____					

Making Sense of the Data

Station	Which tool gave the greatest competitive advantage at this station?	Which tool gave the least competitive advantage at this station?
Red		
Yellow		
Gray		
Green		

Why didn't one tool give the same tool give the same competitive advantage in different environments?

What is one tool that never had the greatest competitive advantage in any environment?_____

Describe a type of environment (including a food source) that you think this tool would have the greatest competitive advantage in?

What best summarizes the competitive advantage of these tools:

a) *One tool always gives a competitive advantage in **every** environment*
b) *No tool gives a competitive advantage in **any** environment*
c) *In different environments, different tools give different competitive advantages*

What would best summarize which traits give organisms a competitive advantage:

a) *One variation of a trait always gives a competitive advantage in **every** environment that same variation is found in.*
b) *No variation gives a competitive advantage in **any** environment*
c) *In different environments, different traits give different competitive advantages*

In previous activities you discovered that a single species may speciate into many more new species under certain conditions. Describe the type of conditions that tend to lead to speciate:

What mechanisms of evolution contribute to speciation?

Separate species don't interbreed. If separate species developed specialized adaptations for different environments, why would it be advantageous for them to not intermix with each others gene pools when breeding?

Discoveries and Insights:

What discoveries did you make regarding the question of this lesson - "Why are there so many species"

How does understanding these mechanisms or outcomes help you answer the driving question for the unit?

Homework 19 – Adaptive Radiation

Jumpstart: In class today, you performed some experiments related to the topic of adaptive radiation. You discovered that some tools that have a competitive advantage in certain environments don't have the same level of competitive advantage in other environments. Because of this, sometimes new species tend tend to form so that each can accumulate specialized adaptations for specific environmental conditions. In the reading below you will learn about how this idea of adaptive radiation was first developed by Charles Darwin and how it became part of his larger theory of evolution he developed to explain many of the questions you investigated in this unit.

Question 1: Think back to the your experiences with the Bug Hunt Speed model you used in earlier activities. What did you discover best summarizes the relationship between the evolution of bug speed and different predators?

c) Bugs always evolve to get faster for any environment, since faster is always better regardless of what type of predator is in the environment.

d) Bugs evolve to get faster in certain environments and slower in other environments; it depends on what trait gives the bug a competitive advantage for the predators it encounters.

e) Bugs always evolve to get slower for any environment, since slower is always better, regardless of what type of predator is in the environment.

Question 2: Think back to the your experiences with the Fish Spotters model you used in earlier activities. What did you discover best summarizes the relationship between the evolution of adaptations that increase the chances for survival versus those that increase the chances for reproduction?

a) Fish always evolve to become camouflaged for any environment, because camouflaging gives fish a better chance of surviving and a better chance of reproducing with a mate.

b) Fish always evolve to become less camouflaged for any environment, because getting a mate is more important than surviving.

c) Fish evolve to become more camouflaged in some environments, and in other environments, fish evolve to become less camouflaged. It depends on which selective pressure is greater: that from predators or that from mates.

In many of the situations you have studied in this unit you discovered that there are tradeoffs in the competitive advantage for certain variations of a trait. What works well in one environment may not work so well in another. Because of these tradeoffs, the direction of evolution is always dependent on the environmental conditions. In different environments, different traits give different competitive advantages, because different ecosystems exert different selective pressures.

A trait variation that gives a competitive advantage in a jungle ecosystem might give a competitive disadvantage in a desert ecosystem. A trait variation that gives a competitive advantage in one lake, might give a competitive disadvantage in a different lake. Even within a small ecosystem where the environment changes just a little, there can be a tradeoff in competitive advantage depending what part of the ecosystem you are in.

Question 3: Give an example of different locations in these ecosystems that have different environmental conditions that might lead to evolution of different traits. The first ecosystem has been started for you:

A forest with variation in the environmental conditions.
location 1: ___the forest floor where some trees have failed down_____
location 2: ___the forest floor where there are lots of trees overhead_____
location 3: _____

A canyon with variation in the environmental conditions.
location 1: _____
location 2: _____

The side of a mountain with variation in the environmental conditions.
location 1: _____
location 2: _____

A river with variation in the environmental conditions.
location 1: _____
location 2: _____
location 3: _____

The concepts of natural selection and evolution were first developed by Charles Darwin over a hundred years ago. Darwin developed his ideas through careful observation of animals interacting in ecosystems, and by studying the different traits he saw in those populations. For two years, he traveled on the ship the H.M.S BEAGLE while observing, measuring, and recording the living creatures in different ecosystems around the world. He also noted the forms of skeletons of extinct animals he found. He wondered why some species went extinct, where new species came from, and why there were different species in different ecosystems.

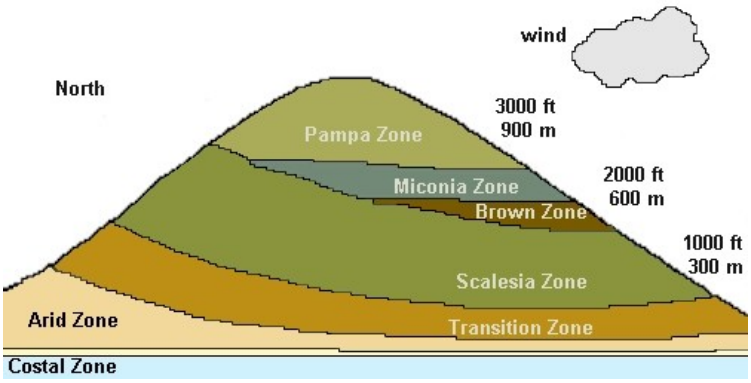
An important development of his understanding was his visit to the Galapagos Islands in the Eastern Pacific Ocean. It was there that he began to see new patterns in the populations of plants and animals on each different island that led him to understand how plants and animals evolve through natural selection.

Darwin found that the Galapagos Islands had species unique to them, found in no other part of the world. He also found that the species on the island had strong similarities to ones that existed on the nearby coast of South America (600 miles to the east).

Darwin identified 14 species of finches in the Galapagos Islands. He wondered why there were 14 species on these islands, when there was only one species of finch on the mainland of South America. He determined that the finches on the islands descended from finches that travelled to the islands at some point in the past. But even if this was the case, why were there now such striking differences in the descendants? Why were there so many species that came from that one ancestor species?

Question 4: Some ocean islands are geographically isolated from nearby continents by vast stretches of water. Because of this isolation, they often contain species unique to that isolated ecosystem, not found anywhere else in the world. What are some islands around the world that you know of that you now suspect might contain unique species?

While every island in the Galapagos Islands is a unique ecosystem, the number of different ecosystems on each island also varies. Darwin noticed that different species of plants and different species of animals lived in different ecosystems on the island. Here is a diagram of the different ecosystem zones he observed on one island:



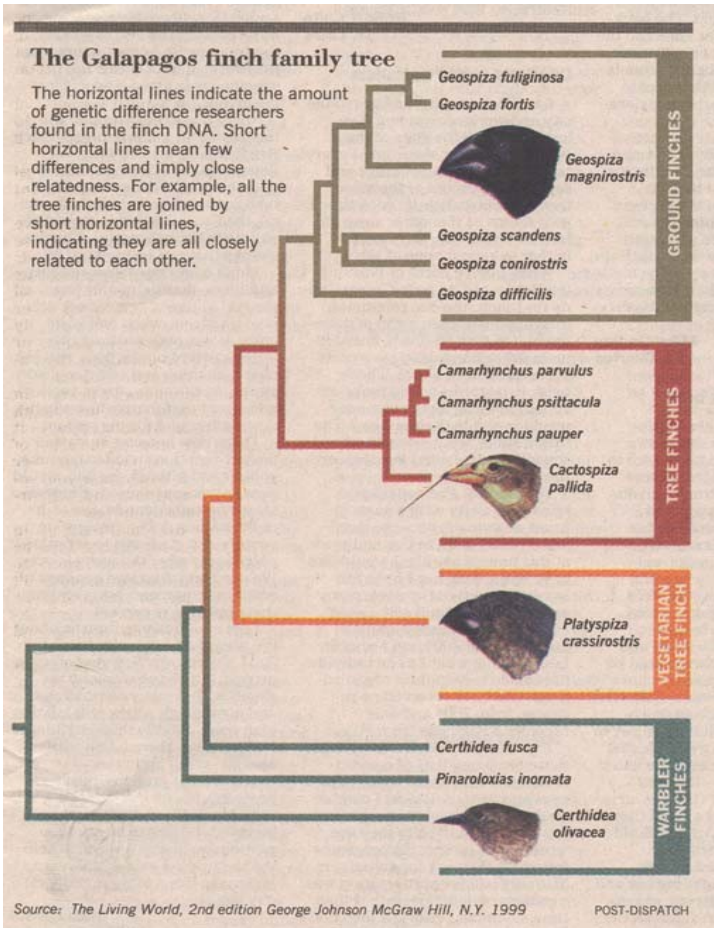
Question 5 Why might plants with different sized seeds grow better in different types of ecosystems or in different zones within the same ecosystem?

Question 6: In an earlier exploration with the Plant Speciation Model, you investigated how speciation occurred in an ecosystem with two distinct regions of normal and contaminated soil. In this diagram, you can see that are many more than two distinct zones where the environment is different. Why might evolution of a single species of bugs on this island lead to large number of new species of bugs?

Question 7 Compare the typical shape and beak of a ground finch to a tree finch in the diagram below. Which type of food might a ground finch be able to catch and break open more easily with this type of beak: a large tree nut with a very hard to crack shell or a very small seed with a thin easy to break shell?

Darwin carefully measured the beak size and shape of birds in each species. He noticed that the beak differences were associated with differences in diet and the different sources of food they ate.

He concluded that the descendants of the finches that reached the islands in the past adapted to different ecosystems on these islands, as each population on each island encountered different selective pressures from the different food sources (seeds, insects, flowers, the blood of seabirds, and leaves). Over many generations, beaks changed in structure and function in ways that gave that population a competitive advantages for getting certain foods more easily so that they could survive and reproduce. This idea is called **adaptive radiation**. It refers to this type of branching evolution where different groups of individuals become isolated from each other.



In their relative isolation (each island was separated from one another by miles of sea), natural selection exerted a different set of pressure on each population. They were forced to adapt to take advantage of different food sources in different ecosystems, as well as in different environmental conditions in different areas of the same ecosystem. This leads to formation of many different species across many different ecosystems.

Darwin realized that **every** population has individuals that have traits that are slightly different from one another (**variation**). This variation gives some individuals a **competitive advantage for survival** in a certain environment. Those that have the competitive advantage stay alive longer and **reproduce more often** than other individuals, and they are the ones that **pass on their traits to the next generation more often** than other individuals. Over time, their traits become more common in the population. This process **repeats each generation** and from this repeating cycle of **natural selection** the population **evolves over time**.

Because there are different ecosystems for populations to evolve in, a population that enters one ecosystem will evolve differently than a population that does not enter that ecosystem. As populations migrate, expand, or become isolated from each other, evolution causes those populations to change. They become better fit to survive and reproduce in their new ecosystem (or new zone within an ecosystem).

Specialized traits in different populations form in ecosystems (such as specialized bird beaks for specific food sources found on different islands). Over time, these differences in variations between populations become more and more pronounced through mutation, genetic drift, and natural selection. And as each population continues to acquire more and more specialized traits for survival in that ecosystem, they also become more specialized at reproducing with other members of their population (since it would be a competitive disadvantage to mistakenly try to reproduce with members from other populations). Eventually, this specialization in mating leads to reproductive isolation of the population and a new species is formed.

The Galapagos finches provide an excellent example of this process. Among the birds that ended up in arid environments, the ones with beaks better suited for eating cactus got more food. As a result, they were in better condition to mate. Similarly, those with beak shapes that were better suited to getting nectar from flowers or eating hard seeds in other environments were at an advantage there. Darwin did not believe that the environment was producing the variation within the finch populations. He claimed that variation already existed in the population and that nature just selected for the most suitable beak shape and against less useful ones. Darwin described this process as the "survival of the fittest." Darwin was unaware of the mechanisms of inheritance, DNA, and protein synthesis, many of which would not be discovered until after his death.

Question 8 Critique Darwin's phrase "survival of the fittest". You have learned from earlier activities that the very fittest don't always outcompete all of their competitors all the time. Suggest a more accurate phrase to use that would capture the main idea about who tends to survive due to evolution.