Activity 7 – Bird Breeders

Purpose:
How Can Selective Breeding Change a Population?

Procedure:
You will be cooperating with a team of other students trying to selectively breed a bird.

Observe:
The litter of cats shown in the photograph in class shows visible variations in the traits between the kittens. In addition to the two traits listed below, add the observable variations you see in the other traits.

Trait	Variations
Reaction time	Slow, fast
Weight	2.7 to 2.9 lbs, 3.0 to 3.2 lbs, 3.3 to 3.5 lbs
Spottedness	
Color of fur on paws	

Exploration 1:

Question
"How can selective breeding change the traits in a population over many generations?"

Goal
Breed a bird that has a red tail feathers, red wing feathers, purple breast feathers, and blue head feathers in the fewest number of matings possible.

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

Team Leader Player 1	Player 2	Player 3	Player 4

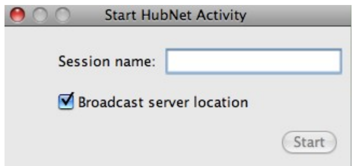
Procedure for Joining Your Team

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.

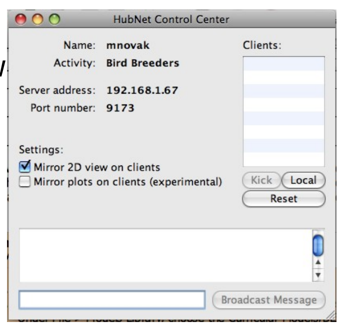
INSTRUCTIONS FOR THE GAME LEADER ONLY

1. *Open the Bird Breeders 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.*

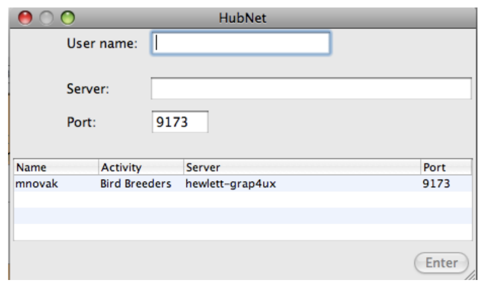
5. *Once you see all the players appear in the CLIENTS section of the HUBNET CONTROL CENTER, you may join the game yourself by pressing the LOCAL button.*

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 1-3 TEAM PLAYERS

- Open HubNet on your computer.

- A connection box will appear like the one below. In this box type your user name (8 characters or less).

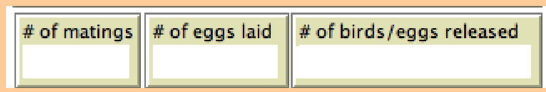


- Click on the Server name in the list below which has the **name of the Group Leader** in it. Then press enter.

- 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

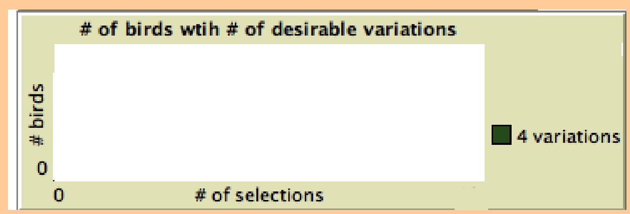
1. *Ask the other players if they want you to read through the directions. If so, look at the window in the top left corner in the model for further instructions.*
2. Press the SETUP, and then GO/PAUSE in *to run the model.*
3. If you want to restart the selective breeding program repeat step 2. Remember there are two separate windows to keep track – one for hosting the game and one for playing the game.



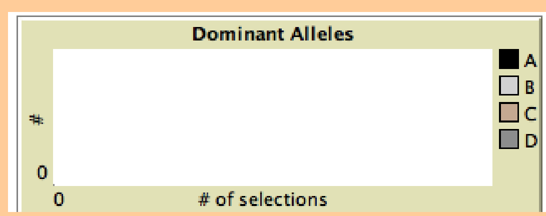
Record Your Observations:

Did you successfully breed 3 birds, each with blue feathers on its head, purple feathers on its breast, red feathers on its wings, and red feathers on its tail? _______________

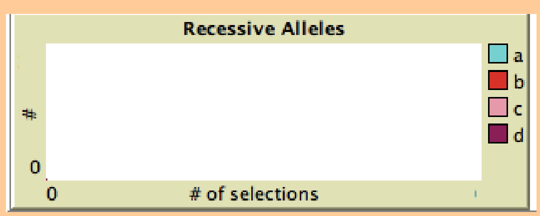
Sketch the shape of the graph for the # of birds with 4 desirable variations as the # of selections increased. This is only one of the four lines that appear on the graph in the NetLogo model. Try to include fluctuations and general trends in the shape of the graph.



Sketch the shape of the graph for one of the # of dominant alleles in the gene pool of the population as the # of selections increased. Try to include fluctuations and general trends in the shape of the graph. In the key for the graph, circle which dominant allele this is a graph of.



Sketch the shape of the graph for one of the # of recessive alleles in the gene pool of the population as the # of selections increased. Try to include fluctuations and general trends in the shape of the graph. In the key for the graph, circle which recessive allele this is a graph of.



Follow-up:

The population of birds your group ended with did not look the same as the population of birds you started with. Describe how the variations in the traits changed over many generations.

The gene pool for your population of birds that your group ended with did not have the same frequency of alleles as gene pool of the population of birds you started with. Describe how the frequency of alleles in the population changed over many generations.

How did selecting which birds to breed together influence the gene pool of the population?

How did selecting which birds or eggs to release influence the gene pool of the population?

How did mating contribute to fluctuations in the gene pool the population?

Discoveries and Insights:

What discoveries did you make regarding the question of this lesson -
"How Can Selective Breeding Change a Population?"

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How does understanding the mechanisms at work in selective breeding help you answer the driving question for the unit - "How do Population Changes?"

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Homework 7 - Selective Breeding

For thousands of years, some people have been carefully controlling the breeding of different types of animals in an effort to reliably produce a specific combination of traits in the offspring for their livestock or their pets. This intentional selection of which individuals to breed for more desirable offspring is called **selective breeding**. It is called selective breeding because humans (not the animals), carefully select which individuals they will allow to mate and have offspring.

In class today you selectively bred birds in a computer model. As you chose which birds to breed and which offspring to keep, you were intentionally trying to develop an offspring with a particular set of variations for four different traits (wing color, tail color, head feather color, and chest feather color).

Question 1: In addition to feather colors, what are some other traits that you think people might want to selectively breed for in birds?

Trait	Possible Variations
Chest feather color	Gray, red

Selective breeding has been done with dog populations for thousands of years. By selectively breeding a population of dogs, a person can make intentional choices about what traits and variations they are trying to get to appear in the offspring. For example if a person always breed tall legged dogs with short tailed dogs they have a better chance of getting a pup that is both long legged AND short tailed. Likewise, a person can always breed the dogs they own with a dog that has shiny coat of fur. Each new litter of dogs from these parents has a better chance of some of the pups having genetic information for producing the substance that gives dogs a shiny coat of fur, than if both parents did not have shiny coats of fur.

One goal of some breeders is to develop or maintain a stock of **purebred** animal. A purebred animal is an individual animal that reliably passes only one variation in genetic information for a trait in its sex cells. Two purebred dogs with the same trait variation, when mated, will produce offspring that only show that trait variation. No other variations will appear in their offspring.

For example, when one purebred dog of a specific breed such as a poodle is mated with another purebred dog of the same breed (another poodle), the offspring will have all of the same traits as its parents that would qualify it as a poodle.

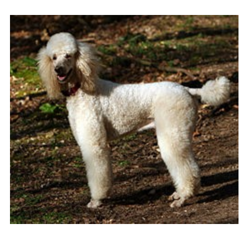
image from http://en.wikipedia.org/wiki/Poodle

People have been experimenting with developing new breeds of dogs for thousands of years. Many new breeds of dogs have been developed in that time. For example, breeds of dog such as the poodle were developed in the past 1000 years, while the Chinook breed was developed about 100 years ago (in 1917 in America).

image from http://en.wikipedia.org/wiki/Chinook_%28dog%29

Question 2: What are some of the expected variations that you would expect to see in the fur, ear shape, and body size in a litter of pups that might be produced as offspring form the mating of the poodle with Chinook shown on the previous page?

People have selectively bred other species of animals besides dog and birds. By selectively breeding cattle, birds, and fish, new breeds of these animals have been created by people over time that have new sets of desirable characteristics. The characteristics that people have bred animals include traits such as running speed, color, size, fur, quality of meat, quality of milk, growth rate, strength, hunting instincts, and sociability.

Question 3: List some of the types of animals, that you think people might have selectively bred in the past to develop new colors of skin, fur, or scales?

Question 4: List some of the types of animals, that you think people have selectively bred in the past to be more sociable with humans?

People have changed the characteristics of many kinds of animals and plants over time by selecting which ones will reproduce together. Some plants that people have selectively bred for thousands of years include rye, peas, wheat, olives, grapes, rice, and corn.

To see the effect of selective breeding on plants over thousands of years, compare modern day corn to its ancient ancestor (Teosinte). A picture of both of these plants is shown to the right. Notice how dramatically different the end result of selective breeding is. Modern corn has many times more kernels of corn per ear, it has larger ears and larger kernels, it has a different kernel color, and it is less bushy plant than its ancestor.

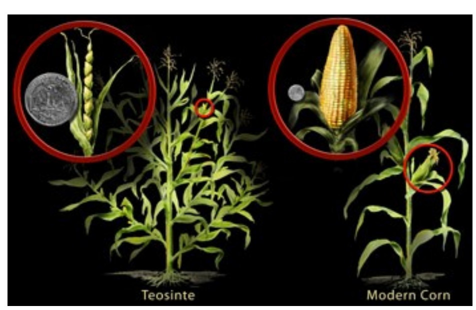

image from
http://www.nsf.gov/news/mmg/mmg_disp.cfm?med_id=55528&from=mn

The dramatic difference between the characteristics of modern sweet corn, poodles, and birds compared to the characteristics of these organisms ancestors are the result of three interacting principles:

- Sexual reproduction, creates new combinations of characteristics in each offspring, through random recombination of half the genetic information from each parent.
- In a single generation of offspring, new variations will probably be apparent due to random selection of which chromosome is passed on to the sex cells for each individual offspring. Some variations are closer to the desired characteristics, some are not much different than the parents, and some have less of the desired characteristics that the breeder wants.
- By selecting individuals to keep based on these characteristics, the breeder is choosing which genetic information is more likely to be increased in frequency in the population over time.

Question 5: What do you think are some other types of plants that people have selectively bred throughout history?

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Question 6: In general, why is selective breeding a process that requires many generations of offspring to get a desired outcome:

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To someone who hasn't been involved in a selective breeding program, it can seem astonishing to see how much people have been able to change the characteristics of animals and plants over time by selecting which ones will reproduce together.

Dogs have been made tame through a process of selection to become accustomed to human provision and control. This taming process is called **domestication**. in some parts of the world dogs have been domesticated for at least 12,000 years. Before being domesticated, dog ancestors were wild and did have traits that allowed them to interact peacefully and submissively to people. Scientists have long wondered about how dogs were first domesticated. It is well understood that dogs were bred from wild wolves, but the question remains how did this occur? Was it done intentionally at first? Was it a selective breeding process? What part of the world was it done in? How many generations did it take to domesticate the first wolves to become more dog-like? Was there some advantage for humans in having domesticated "wolves" as part of their early camps and settlements?

Question 7: List some traits people might have selected wolves for, when they were first being domesticated. Why would people have selected for these traits?

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Some scientists have attempted to domesticate the fox in order to better understand how selective breeding might have led to a domesticated dog. The surprising results of this experiment showed how quickly such selective breeding can lead to a "tame fox". The details of this experiment can be read further in at the following url: http://animals.howstuffworks.com/pets/dog2.htm

In summary the results from this experimented demonstrated that wild foxes can be quickly domesticated within nine generations to have traits that allow them to be handled as tame "pets" of humans. This rapid change in behavioral traits in the foxes, occurred through selective breeding for tamer behaviors in each new generation of offspring. It led has some led scientists to propose a hypothesis about the origin of dogs. Surprisingly, the selective breeding also up generating other unexpected characteristics, such as floppy ears, curly tails, foxes that barked more, and had offspring more often and at a younger age than their ancestors just a few generations before. These are the same characteristics that we see in dogs, but never in wolves.

Question 8: Wild cats of various species live in many parts of the world. These cats are larger than house cats, more ferocious, and have behavioral traits that make them flee any perceived threat (including when they are startled or see an animal larger than it like a human). It is believed house cats were domesticated in one part of the world (the Middle East) as people began to settle in town and cities and started storing large amounts of harvested grains in the town. Storing grains led the arrival of pests and more bothersome animals that eat grains such as mice and rats. **Propose your own hypothesis about why house cats might have been first domesticated from wild cats. Include examples of possible variations in traits people might have found more advantageous in one cat over another.**

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Activity 8 – Bug Hunt Speeds

Purpose:
How Does Nature Select For Some Trait Variations Over Others?

Procedure:
You will be using a computer model today to control the movement of a bird and some of its interactions with a population of bugs.

Brainstorm some ways that birds in the wild might select (intentionally or unintentionally) which bugs to eat?

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Exploration 1:

Question

Use the model to explore, "How will hunting change the speed a population?"

Model Rules

When you start the model, how many variations in speed should there be in the bug population?

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Make A Prediction

If you were try to "eat" the bugs as fast as possible, what, if anything, do you predict will happen to the average (and distribution 1st question) speed of the bug population after you have caught many bugs?

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Test Your Predictions

1. *Open the "Bug Hunt Speeds" model.*
2. Set the initial values to:

Setting	Value
INITIAL-BUGS-EACH-SPEED	6
SHOW-COLORS?	Off

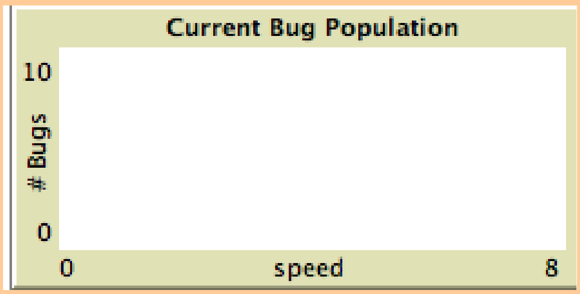
3. Press SETUP, and then GO/PAUSE *to run the model.*
4. C*hase the bugs around the screen, clicking on them as fast as you can.*
5. After you have eaten at least 100 bugs and the model is still running, change this value to:

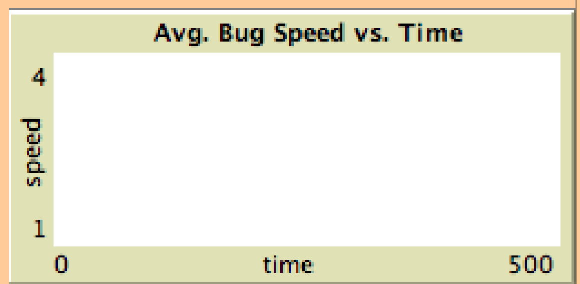
Setting	Value
SHOW-COLORS?	On

6. *Stop the model now.*

Record Your Observations:

Sketch the results from the model run below (change scale 1-6).





Making Sense of Your Data:
Did the model provide evidence to support your prediction ? _________

What evidence did it provide?

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Exploration 2:

Question
Use the model to explore, "How will changing your hunting strategy change the speed of the bug population?"

Model Rules
You will be using the same model in exploration 1.

Predict
- When you setup the model again, at first, some bugs will be moving slowly and other bugs will be moving faster. If you were to close your eyes and "eat" only the bugs that happened to run into you, what if anything do you predict will happen to the population of bugs over time?

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Procedure to Test Your Prediction

1. Make sure these sliders and switches have these values:
   - INITIAL-BUGS-EACH-SPEED slider to "10"
   - *SHOW-COLORS switch to "on"*
   - Press the SETUP button again.

You should see 60 bugs appear on the screen, each 10 of each different color.

1. Press GO/STOP to watch the bugs move about the screen.

5. *Place your mouse in the WORLD & VIEW, and hold the button down on the mouse. Don't move the mouse around. You will see that bugs that run into your mouse cursor get automatically eaten.*

6. Now close you eyes, keeping the mouse button pressed down so that you continue eating the bugs as they run into you. Do this for about 1-2 minutes.

7. Open you eyes and check to see that you have eaten about 200 bugs, stop hunting the bugs if you have. *If you need to eat more bugs, repeat the previous two steps.*

8. Study the population of bugs on the screen and the graphs in the model and you can see that the proportion of different variations of bug speeds has changed over time.

9. *Record evidence from the model to help you determine whether your prediction was correct in the DATA AND OBSERVATIONS* section.

Data and Observations:

Follow-up:

In this last exploration, why did slower bugs have a competitive **advantage** for survival when you waited for all the bugs to run into you to catch some?

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In the very first exploration, why did slower bugs have a competitive **disadvantage** for survival?

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Did you intentionally or unintentionally select which bugs to remove in both explorations? (In other words, were you making a purposeful effort to remove only the slow bugs in the first exploration and making an effort to remove only the fast bugs in the second exploration?). ____________________

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Which of the following mechanisms in the model are contributing to changes in the bug population (you may choose more than one)?

_____ There is variation in a trait and this variation is inherited

_____ Any bug is able to reproduce a new offspring

_____ Individual bugs learn to avoid the predator (you)

_____ The predator (you) is removing some variations more often than others

_____ The same variation of bug is always chosen to be the one that reproduces.

_____ The predator (you) has to intentionally decide which variation(s) of bugs will survive

_____ The same bug speed gives the same competitive advantage for every bug in every situation.

Overall, which of these statements best describes how the computer model works?

a) The computer model is preprogrammed to show the details of the model run as it was showing a movie, where the details of the story are predetermined.

b) The computer model generates similar, but not exactly identical outcomes due to clever programming, regardless of how you interact with it.

c) The computer model generates an outcome that results from simple rules for bug behavior and your interactions with those bugs.

Discoveries and Insights:

You discovered that the type of selection you did as a predator (natural selection) could help explain "How Does Nature Select For Some Trait Variations Over Others?"

What are some of the **conditions** that need to exist in order for natural selection to occur?

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What are some of the **outcomes** when natural selection to occurs related to the driving question for the unit - "How do Population Change?"

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Homework 8 – Natural Selection

Natural selection is a mechanism that leads to individuals with trait variations that give them a competitive advantage becoming progressively more common in the population with each new generation.

This mechanism emerges when there are two conditions: 1) the individuals in a population have variation in in an inherited trait 2) interactions in the environment give individuals with some variations a competitive advantage for survival or reproduction over other individuals.

In the previous model you saw how interactions with a simulated predator led to different types of selective pressures. In one case, when the predator was chasing the bugs, this led to selective pressure which resulted in a population of bugs that became faster over time. In the other case, when the predator waited for the bugs to come to it, this led to selective pressure which resulted in a population of bugs that became slower over time.

Question #1: Besides predators, there are other living organisms in an ecosystem that interact with a population that can cause natural selection to occur. Brainstorm a list of some of the other organisms in an ecosystem that might contribute to natural selection through their interactions with a bug population:

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Question #2: Besides predators, there are other non-living (**abiotic**) objects and events in an ecosystem that that might lead to natural selection through their interactions with the population. Brainstorm a list some of non-living objects or events in an ecosystem that might contribute to natural selection:

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Migrating Deer Scenario: *Imagine a population of deer lives in the valleys between mountain ranges. The deer have had no natural predators in these ecosystems for many years.*

One group of deer wanders into a new ecosystem they haven't been in before. It is a hard to reach valley between two mountain ranges. The deer find plenty of food to eat in this valley to sustain a large carrying capacity for deer. Shortly after arriving in the valley, a population of wolves also wanders into the same ecosystem. The wolves are predators for other animals, including deer.

Question #3: After wolves enter the ecosystem, what do you expect would happen to the proportion of fast deer in this population in each future generation?

a) Nothing would happen. The proportions of fast deer in the population would never change in each new generation because trait variation related to speed gives no competitive disadvantage or advantage in this ecosystem.
b) There would be some slight fluctuation in the proportion of fast deer in the population. The proportions of fast deer in the population would vary up and down in each future generation, but it would remain close to a stable value because the wolves can not change the trait variations in the deer population.
c) The proportion of fast deer in the population would decrease in future generations because the selective pressure from wolves would be to kill off the easier to catch deer. The faster deer are easier to catch so they would be removed from the deer population more frequently than the slower deer.
d) The proportion of fast deer in the population would increase in future generations because the selective pressure from wolves would be to kill off the easier to catch deer. The easier to catch deer are the slow ones. Dead slow deer can't have babies, but alive fast dear can.
e) Its hard to predict, since there are many opposing selective pressures. One pressure is that using up food too quickly by running too fast might cause the fast deers to starve more quickly. Another pressure is from running to fast and increases the chances of breaking a leg and getting caught by a wolf. Another pressure is from running too slow and being caught by a wolf.

You've seen how natural selection could influence one trait in a population of prey – namely their speed of movement. Consider how natural selection might influence other traits:

Question #4: If smaller animals are harder to find, how might natural selection also influence the size of prey over time?

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Question #5: How might natural selection influence the color of fur in a population of prey that lives in a snow covered ecosystem that has many predators in it?:

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Insecticides are chemical substances that are used to reduce the population of insects. Many types of insecticides used around the home are bug sprays and solids that kill bugs that are exposed to them. Insecticides are also used by farmers to keep harmful bugs from destroying crops.

A population of insects have variation in their inherited traits. On the outside one can observe that insects in the population are larger, or slower, or have different coloration than others. Insects also have variation in their internal structures and substances they produce. Some insects may produce substances that allow them to digest food more slowly, that enable them to reproduce more quickly, or that give them greater resistance to effects of poisonous substances.

Ground application to mustard
[Picture by C. Welty]

http://www.entm.purdue.edu/entomology/Vegisite/insect_ID_pics/IPM%20Techniques/ground_application.jpg

Insecticide resistance scenario: *In the early 1900's people started to notice that bug populations were now more **resistant** to some pesticides that used to work relatively well. As new insecticides were invented, again cases of resistance were reported in the bug populations they were used on just a few years later.*

Question #6: In the past, these same pesticides used to be far more effective on populations of bugs. They used to kill off most of the bugs in the population when they first were used. Use the mechanism of natural selection to explain why current populations of bugs are now more resistant to the pesticides that had been used on the population in them in the past.

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Herbicides resistance scenario: *Herbicides are chemicals that kills off certain types of plants. Imagine a new type of herbicide is invented this year. It starts being sold in stores under the brand name "DandelionBeGone". Homeowners who use the herbicide the first year might find it works very well, killing off approximately 98% of the dandelions in a lawn with one spraying, without killing the grass.*

Question #7: If homeowners continued to use the same herbicide for many years in a row, the mechanisms at work from natural selection might lead to a disappointing outcome. Homeowners might find it doesn't work so well in future years on the lawn that it used to, even if the company doesn't change the ingredients in the "DandelionBeGone" herbicide they sell. Why?

Activity 9 – Fish Tank Genetic Drift – part 1

Purpose:
How Do Random Selection Events Change Gene Pools?

Procedure:
You will be using a computer model today to experiment with a fish population in a fish tank. You will also be observing changes that occur in the gene pool of that population as new fish are born and old fish die off.

Exploration 1:

Question

Use the model to explore, "How is the frequency an allele in a population related to the frequency of a trait variation?"

Model Rules

What other trait variations appear can appear in the fish besides those listed below:

Trait	Observable variations
Sex	Pink (female) or blue (male) body
Body spots	Black spots, no black spots
Dorsal fin color	Green, not green (blue/gray)
Tail fin shape	
Tail color	

When fish have the following two alleles for their genotype what will their phenotype be?
Fill in each missing piece of information by studying the model rules summarized in the model interface.

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There are four possible allele combinations for dorsal fin color.
- Out of these four, how many will yield a green dorsal tail phenotype? ________
- Out of these four, how many will yield a non-green dorsal tail phenotype? ________

Make A Prediction

In a population of 16 fish, 50% of the alleles are "g" and the other 50% of the alleles were "G". The 32 alleles are randomly distributed, two to every fish.

- What number of fish do you predict would have a green dorsal fin? ____________
- What number of fish do you predict would not have a green dorsal fin? ____________

Test Your Predictions

7. *Open the "Fish Tank Genetic Drift" model.*
8. Set the initial values to:

Setting	Value
INITIAL-#-FEMALES	16
INITIAL-#-MALES	0
INITIAL-ALLELES-BIG-G	50%

9. Press SETUP.
10. Study the population of fish on the screen and the graphs in the model. Record the results from this setup of the model.
11. Repeat the past two steps and record the results again.
12. Adjust these values to:

Setting	Value
SEE-BODY-CELLS?	"On"

13. Press GO/STOP to run the model. Allow the fish to move apart so that you can see their genotype. In the fish show here, for example, you can see that it has a genotype of "gG".

14. Press GO/STOP to pause the model and record the genotypes of the fish.

Record Your Observations:

Data and Observations:

	Trial 1	Trial 2
# of fish with a green dorsal fin		
# of fish without a green dorsal fin		

	Results from Trial 2							
	Fish 1	Fish 2	Fish 3	Fish 4	Fish 5	Fish 6	Fish 7	Fish 8
Genotype								

Making Sense of Your Data:

Did the evidence from the model support your prediction ? ________

Were half of the alleles “g” and half of the alleles “G”? ___________

Each time you press SETUP you get a different random distribution of the alleles based on the slider values for each allele. Why is it possible when 50% of the alleles for dorsal fin color in the population are “g” and 50% of them are “G”, that all of the fish may appear (phenotype) with a green dorsal fin?

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Why is it possible (but unlikely) that one of the times you press SETUP that half the fish will have GG and half the fish will have gg genotypes.

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Exploration 2:

Question

Use the model to explore, "How do frequencies of alleles change in population?"

Model Rules

- In addition to the rules from the model you used in exploration 1, fish in this exploration will now also be able to have offspring through sexual reproduction.
- When the number of fish in the tank is below the carrying capacity of the tank, every old fish that dies in the population will be replaced by a new fish that is the offspring from a randomly selected male and female pair of fish parents.

Predict

The population of fish will initially contain 8 of each of these type of alleles:
(G and g), (B and b), (F and f), (T and t)

How do you predict the frequency of the alleles in the population will compare after 10 deaths and births?

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Procedure to Test Your Prediction

1. Set the initial values to:

Setting	Value
TANK-CARRYING-CAPACITY	8
INITIAL-#-FEMALES	4
INITIAL-#-MALES	4
INITIAL-ALLELES-BIG-B	50%
INITIAL-ALLELES-BIG-G	50%
INITIAL-ALLELES-BIG-F	50%
INITIAL-ALLELES-BIG-T	50%
AUTO-REPOPULATE?	"On"
SEE-BODY-CELLS?	"Off"
SEE-SEX-CELLS?	"On"

2. Press SETUP and GO/STOP.

3. Either use the mouse cursor to hover over a fish to remove and press the mouse button down to select that fish or press the RANDOMLY REMOVE A FISH button.

Notice that a new fish was born when you removed an old one. When a new fish is to be born, a heart will first appear on the female fish, then genetic information (represented as alleles in a sex cell) will appear. The sex cell from the male (a blue triangle) will travel to the female sex cell (a pink triangle). When those two sex cells join, all the alleles merge and the heart turns into a fully formed fish.

4. Now press the RANDOMLY REMOVE A FISH button 9 more times.

5. Study the graphs of the alleles. Record evidence from these graphs to help you determine whether your prediction was correct in the DATA AND OBSERVATIONS section.

Data and Observations:

Which alleles changed in frequency ? ____

How did reproduction cause this?

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Exploration 3:

Question

Use the model to explore, "How do frequencies of alleles change in population?"

Model Rules

- In addition to the rules from the model you used in exploration 1, fish in this exploration will now also be able to have offspring through sexual reproduction.
- When the number of fish in the tank is below the carrying capacity of the tank, every old fish that dies in the population will be replaced by a new fish that is the offspring from a randomly selected male and female pair of fish parents.

Predict

How do you predict the frequency of the alleles in the population will compare after 100 deaths and births?

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Procedure to Test Your Prediction

1. Set the initial values to:

Setting	Value
TANK-CARRYING-CAPACITY	8
INITIAL-#-FEMALES	4
INITIAL-#-MALES	4
INITIAL-ALLELES-BIG-B	50%
INITIAL-ALLELES-BIG-G	50%
INITIAL-ALLELES-BIG-F	50%
INITIAL-ALLELES-BIG-T	50%
AUTO-REPOPULATE?	"On"
AUTO-REMOVE?	"On"
SEE-BODY-CELLS?	"Off"
SEE-SEX-CELLS?	"Off"

2. Press SETUP and GO/STOP.

3. Run the model until the #-of-fish-that-died monitor reports 100 or until the fish stop

reproducing (this may happen if they are all male or all female).

4. Study the graphs of the alleles. Record evidence from these graphs to help you determine whether your prediction was correct in the DATA AND OBSERVATIONS section.

Data and Observations:

Which alleles disappeared from the population completely ? ________________________

Does your population still contain males and females ? ____________

Follow-up:

If you reran the model in the last exploration for thousands of more deaths and rebirths, why is it likely that eventually all but one allele will be left for each of these traits: body spots, dorsal fin color, tail shape, and tail color?

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If you reran the model and started with only 2 females and 2 males, and selected 100 times to randomly kill off a fish and try to create a new offspring why would this increase the likelihood of soon ending up with a population of only females or only males?

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Discoveries and Insights:

What discoveries did you make regarding the question of this lesson -
"How Do Random Selection Events Change Gene Pools?"

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How does understanding the answer to the previous question help you further answer the new driving question for the unit - "How does the Distribution of Traits in a Population Change?"

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Homework 9 – Genetic Drift

You also discussed some of the random selection mechanisms involved in reproduction. This resulted in fluctuations in allele frequencies in a gene pool over time.

Question 1: What is one random selection mechanism involved in reproduction?

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From your class results you also determined that the proportions of alleles in the gene pool will fluctuate over time from random events related to meiosis, reproduction, and death. This fluctuation is called **genetic drift**. It refers to the drifting up and down of allele frequencies over time.

If a proportion of alleles drifts down until it reaches a value of zero, it has then been completely eliminated from the gene pool of that population. Once this happens, no additional copies of that allele exist in the population to make copies of (through meiosis) or to put into sex cells or to pass on to offspring.

This means that over time genetic drift reduces the diversity of alleles and therefore reduces the diversity of trait variations in a population.

Scenario 1: *Picture a very large heard of animals (all the same species) that travels in herds in the real-world. The herd has individuals with many different phenotypes. There are at least five different traits for shapes of horns in this herd.*

Question 2: Be creative and draw five different horn shapes, that you imagine in this herd of animals. Draw a picture of them here:

A	B	C	D	E

One day a huge snow storm causes the animals to become separated into three separate herds. One travels to the east, one herd travels to the west, and one herd travels to the north. Each herd keeps traveling until it enters a new ecosystem. Due to continued changes in the climate, rivers form (from the melting snow) that keep the herd of animals permanently separated from each other. These herds live separate from each other for 1000 years. Now individuals can only interbreed within the new smaller herd they are in.

Question 3: If genetic drift occurs in each of these herds, why might the horns of all the individuals in one herd look identical after a thousands years?

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Question 4: If genetic drift occurs in each of these herds after a thousand years., why might the horns of the individuals in one herd look different than the horns of individuals in another herd?

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Scenario 2: Again picture a very large herd of animals (all the same species) that travels in herds in the real-world. The herd has individuals with many different phenotypes. There are at least five different traits for shapes of horns in the herd (which you showed in question 1). There are also five different traits for different shapes of tails.

Question 5: Make up the five different shapes of tails you imagine in this herd of animals. Draw a picture of them here:

1	2	3	4	5

Question 6: In your herd there would be 25 different possible combinations of both horn shape and tail shape. Look back at your pictures you drew in question 3 and question 6. Of the 25 possible combinations, show a picture of what an individual animal looks like if it has these combinations:

C and 2	D and 4	F and 1	A and 2	C and 4

Scenario 3: One day a huge snow storm causes the animals to become separated into three separate herds. One travels to the east, one herd travels to the west, and one herd travels to the north. Each herd keeps traveling until it enters a new ecosystem. Due to continued changes in the climate, new paths for rivers form (from the melting snow) that keep the herd of animals permanently separated from each other. These herds live separate from each other for 1000 years. Now individuals can only interbreed within the new smaller heard they are isolated in.

Question 7: If genetic drift occurs in each of these herds after a 1000 years., why might the horns AND tails of individuals in one herd look different than the horns AND tails of individuals in another herd?

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Question 8: How might the horns AND tails of individuals in one herd look different than the horns AND tails of individuals in another herd after those 1000 years? Refer to question 7 in your answer.

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Question 10: If genetic drift occurs for not just two traits (tail shape and horn shape), but hundreds of other traits, including things like bone size, eye size, fur color, diet, speed, number of offspring in each litter, amount of fat on body, grazing instincts, flight from predator distance, etc...), how would you expect two populations of animals to look and act if they were isolated from one another for millions of years:

a) They two populations would look and act exactly the same.
b) The populations would act and look a little bit differently.
c) The populations would look and act very differently.

Activity 10 – Fish Tank Genetic Drift – part 2

Purpose:
How is population size and barriers related to the outcomes of genetic drift?

Procedure:
You will be using a computer model today to continue your experiments with fish. You will test different factors that contribute to genetic drift.

Exploration 1:

Question
Use the model to explore, "Are the outcomes of genetic drift predictable?"

Model Rules
In a population of 16 fish, 50% of each of the alleles for each trait variation will be assigned the value recessive value (small letter) and the other 50% of the alleles will assigned the dominant value (large letter).

% of this Allele initially	% of this Allele initially
B = 50%	b = 50%
G = 50%	g = 50%
F= 70%	f = 30%
T = 90%	t = 10%

Make A Prediction
With each new births occur and old fish die, the effects of genetic drift may cause the frequency of an allele to fluctuate. Circle which allele in the table above you expect you to first disappear from the gene pool of the population completely.

Will your predicted outcome occur every time you run the model? ____________________

What is the reason for your prediction?

____

____

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Test Your Predictions

15. Open the "Fish Tank Genetic Drift" model.

16. Set the initial values to:

Setting	Value
CARRYING-CAPACITY	16
INITIAL-ALLELES-BIG-B	50%
INITIAL-FEMALES	50%
INITIAL-ALLELES-BIG-G	50%
INITIAL-ALLELES-BIG-F	70%
INITIAL-ALLELES-BIG-T	90%
AUTO-REMOVE?	"On"
AUTO-REPLACE?	"Off"

17. Press SETUP and GO/STOP.

18. Observe the graphs for # alleles until one of them shows that an allele has disappeared completely from the population. Press GO/STOP to pause the model and record this result.

19. Repeat the experiment seven more times and record your results

Record Your Observations:

Data and Observations:

	Trial							
	1	2	3	4	5	6	7	8
Which allele disappeared from the gene pool first?								

Making Sense of Your Data:

Did the evidence from the model support your prediction ? ________

Why or why not?

____

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____

Exploration 2:

Question

Use the model to explore, "How does population size affect the loss of diversity?"

Predict

What do you predict the relationship is between the size of a population and how fast it looses alleles due to genetic drift?

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Procedure to Test Your Prediction

1. Design your experiment, by selecting some different population sizes to test, in addition to the size you have been testing. Add those to this design plan table:

Setting	**Values to test** (assign any even value from: 2 to 50)			
	1st	**2nd**	**3rd**	**4th**
MAX-CARRYING-CAPACITY	8			

2. Set the first MAX-CARRYING-CAPACITY to the 1st value you chose to test.

3. Set the rest of these values to these settings:

Setting	Value
INTIAL-FEMALES	50%
INITIAL-ALLELES-BIG-B	50%
INITIAL-ALLELES-BIG-G	50%
INITIAL-ALLELES-BIG-F	50%
INITIAL-ALLELES-BIG-T	50%
AUTO-REMOVE?	"On"
AUTO-REPLACE?	"Off"

4. Press SETUP and GO/STOP.

5. Observe the graphs for # alleles until one of each of these alleles: (B or b) and (G or g) and (F or f) and (T or t) has disappeared completely from the population. Press GO/STOP to pause the model and record how long this took to occur.

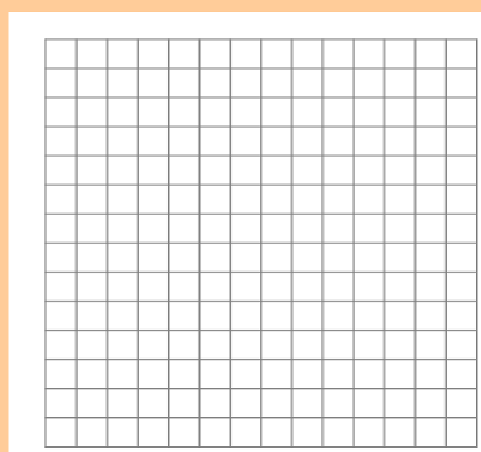
6. Repeat steps 1-5, for each MAX-CARRYING-CAPACITY value you wanted to test.

Data and Observations:

Setting	Results for the values you tested			
	1st	2nd	3rd	4th
MAX-CARRYING-CAPACITY	8			
Time it took to lose an allele from the gene pool				

Making Sense of Your Data:

Graph MAX-CARRYING-CAPACITY vs. the time it took to lose an allele for each of the four values you tested



What was the general relationship between population size (MAX-CARRYING-CAPACITY) and the time it took to lose an allele from the gene pool?

a) as population size increased the time it took to lose an allele from the gene pool increased.
b) as population size increased the time it took to lose an allele from the gene pool decreased.
a) as population size increased the time it took to did not change.

Exploration 3:

Question

Use the model to explore, "How do barriers and isolation affect the outcomes of genetic drift?"

Predict

How will adding barriers to split the tank that will split it into isolated sections of fish affect the outcomes of genetic drift?

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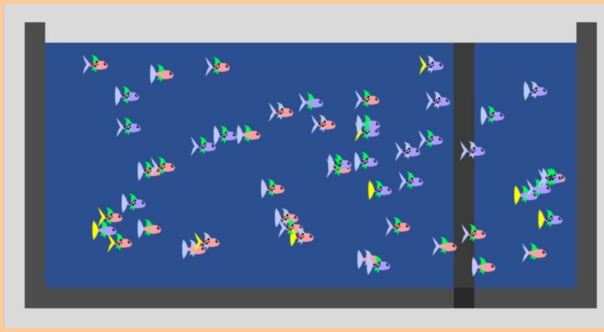
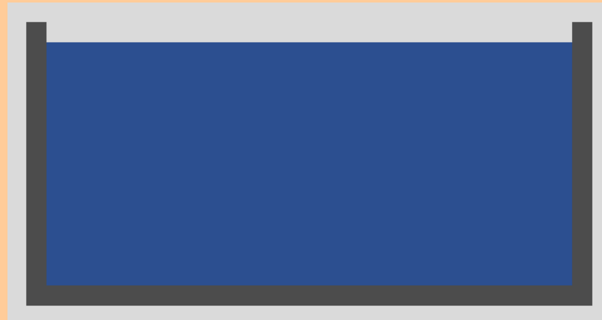
Will each isolated section of fish lose the same alleles from genetic drift as the other isolated section(s) of fish? ___________

Design Your Experiment

Below is an example of a tank with one vertical barrier added. The fish that are on the right side of the barrier can not interbreed with the fish on the left side of the barrier.	How many vertical barriers do you plan to add to the tank in your experiment? _______ Where do you plan to place those barriers? Add lines to the tank below to show where you plan to add those barriers to the fish tank in your experiment.





Procedure to Test Your Prediction

1. Set the rest of these values to these settings:

Setting	Value
MAX-CARRYING-CAPACITY	40
INTIAL-FEMALES	50%
INITIAL-ALLELES-BIG-B	50%
INITIAL-ALLELES-BIG-G	50%
INITIAL-ALLELES-BIG-F	50%
INITIAL-ALLELES-BIG-T	50%
AUTO-REPLACE?	“Off”

2. Press SETUP and GO/STOP.

3. Add dividers to all the locations you planned in your experimental design. You can press the mouse button to add dividers to any location in the tank. Move the mouse cursor to the bottom of the tank. When the cursor is over the bottom floor of the tank and it appears like the picture of the right you can click the mouse button to add a divider.

4. Now let the model run until 500 fish have died. To speed the model up you can turn VIEW UPDATES off by removing the check mark from the box next to it:

5. Turn the VIEW UPDATES back on when the #-FISH-THAT-HAVE-DIED monitor reports at least 500 fish have died. Record your results below.

Data and Observations:

Which (if any) populations of fish now appear different than the populations of fish in other sections of the tank?

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Making Sense of Your Data:

Were the outcomes of genetic drift identical in each section of the tank? ____________

If you reran the experiment with a new population and used the same dividers, would the outcomes of genetic drift be identical in each section of the tank? __________

One student notices that after running the model for a long period of time, the fish on one side of the tank have spots and green tails and the fish on the other side of the tank do not have either. How could genetic drift explain this outcome?

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Discoveries and Insights:

What discoveries did you make regarding the question of this lesson -
"How do population sizes and barriers affect genetic drift?"

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How does understanding the answer to the previous question help you further answer the driving question for the unit?

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Homework 10– Population Bottle Necks & Founder Effects

A **population bottleneck** (or genetic bottleneck) are when the size of a population becomes very small. This can happen when a significant percentage of a population or species is killed or otherwise prevented from reproducing. On a real bottle, the thin part of the bottle is called the neck. It is where the width of the bottle is the narrowest. For this smaller populations the effects of genetic drift can appear more quickly than on larger populations.

Questions 1 What are some events in the real world that might cause a significant percentage of a population or species to be killed or otherwise prevented from reproducing?

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Thus populations that experienced a bottleneck at some point in the past typically end up having less genetic diversity in their gene pool than populations that never reached such small sizes. And they therefore have less variation in the traits of the individuals in the population.

Reduced genetic variation often also means that the population may not be able to adapt to to new selection pressures (such as climate change or a shift in available resources, because the genetic variation that natural selection would have acted on may already have been eliminated from the gene pool). Therefore, changing selective pressures are likely to cause smaller populations or populations with less diversity it their gene pool to go locally extinct, instead of undergoing the effects of natural selection.

In the article below you will read about one species that encountered a population bottleneck about 10,000 years ago, and how that has affected the gene pool of the population as well mating behaviors of individuals now many years after the population bottleneck.

http://evolution.berkeley.edu/evolibrary/news/070701_cheetah
Cheating cheetahs prosper
July 2007

Philandering males, sneaking around behind their partners' backs or openly canoodling, are a stock character on Animal Planet. Male lions, male chimps, and male elephant seals (along with many others) play the Casanovas, pairing up with multiple females. But now researchers have revealed that cheetahs buck this sexual stereotype. According to the May 2007 study, female cheetahs seem to be at least as promiscuous as their male counterparts. Females frequently mate with several different males while they are fertile and are then likely to bear a single litter of cubs fathered by multiple males — making many of the cubs within a single litter only half-siblings. This discovery has important implications for the conservation of these endangered animals. Though it conflicts with the idea that cheaters never prosper, evolutionary theory suggests that, in this case, cheating may be exactly what the doctor ordered.

How did biologist Dada Gottelli and her colleagues at the Zoological Society of London figure out that female cheetahs were fooling around with so many different suitors? Cheetahs seem to be modest about mating. Biologists have rarely caught cheetahs "in the act," but they *have* been able to pick up what cheetahs leave behind in their daily routine: poop. Feces contain traces of DNA. And cheetahs, like us, get half of their DNA from their mother and half from their father. So Gottelli's team collected feces from mothers, their cubs, and potential fathers and then extracted and analyzed the DNA to perform paternity tests on the cubs

Conservation biologists are interested in cheetah cheating because it impacts the cheetah population's level of genetic variation. Loosely, genetic variation is a measure of the genetic differences within a population. A population in which every individual has the same gene version (i.e., allele) at a particular location in the genome has less genetic variation for that gene than a population in which many individuals carry different gene versions at that location.

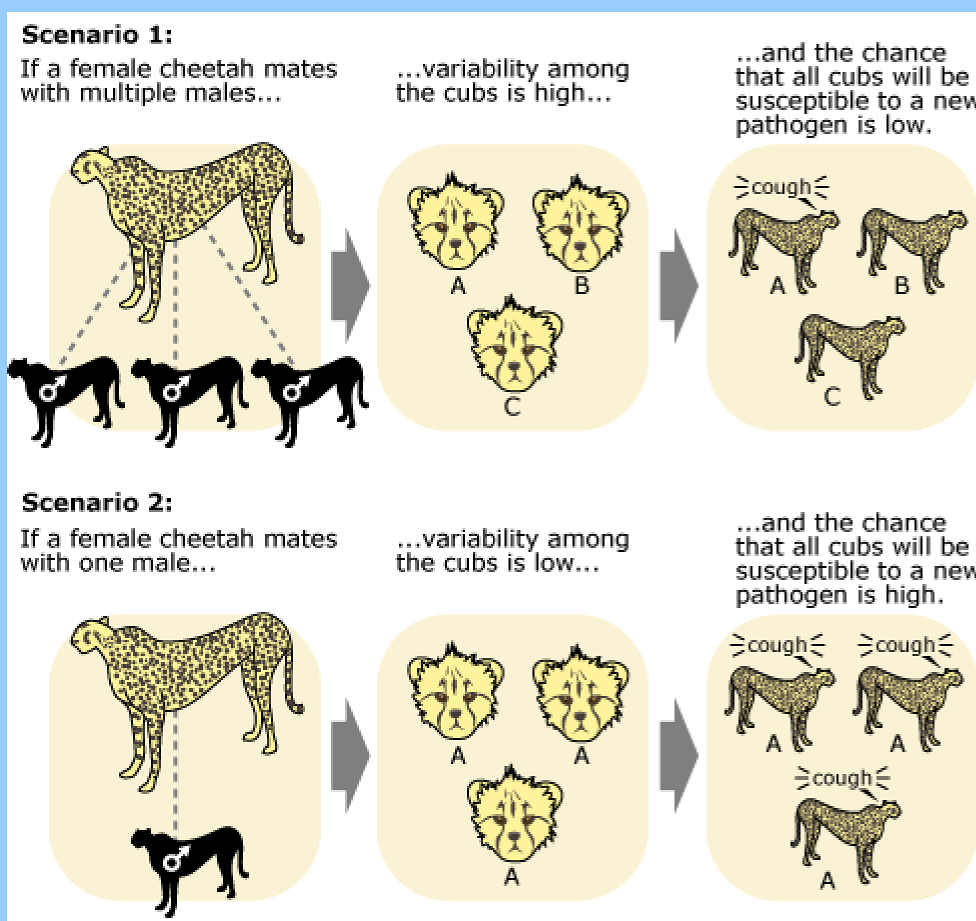
Genetic variation is a key ingredient of evolution. Natural selection acts on the genetic variation present in a population to remove those variants that fail to produce offspring in a particular situation and spread those variants that are particularly good at producing offspring. A population with no genetic variation (in which every individual is genetically identical) cannot evolve in response to environmental or situational changes. If, for example, a genetically uniform population were exposed to a new pathogen and did not carry the gene versions necessary to fend off the disease, the population could face complete extinction. On the other hand, a population with high levels of genetic variation is much more likely to include at least a few individuals carrying the gene versions that provide protection from the pathogen — and, hence, to evolve in response to the new situation instead of going extinct. A population with low genetic variation is something of a sitting duck — vulnerable to all sorts of environmental changes that a more variable population could persist through.

And unfortunately, those are exactly the circumstances faced by cheetahs today. As a species, cheetahs have famously low levels of genetic variation. This can probably be attributed to a population bottleneck they experienced around 10,000 years ago, barely avoiding extinction at the end of the last ice age. However, the situation has worsened in modern times. Habitat encroachment and poaching have further reduce cheetah numbers, consequently snuffing out *even more* genetic variation and leaving cheetahs *even more* vulnerable to extinction.

Nevertheless, conservation biologists may have reason to hope that this genetic variation will not drain away as quickly as was thought — now that researchers from the Zoological Society of London have laid bare female cheetahs' cheating hearts. The scientists have found that not only do female cheetahs bear single litters with multiple fathers, but those fathers are rarely near neighbors. Females seem to mate with individuals from far-flung regions, meaning that the cubs' fathers are only distantly related to one another. Furthermore, female cheetahs don't even return to the same males year after year: consecutive litters from the same mother all had different sets of fathers. In short, female cheetahs' mating habits wind up getting genetic information from lots of different fathers into the next generation — and that helps preserve genetic variation!

In fact, the impact of multiple matings on genetic variation may help explain how the trait evolved in cheetahs in the first place. Biologists hypothesize that in an unpredictable environment, like the Serengeti, having variable offspring would have been advantageous to a female cheetah. Even if several of her cubs were killed by a new disease, succumbed to a novel environmental stress, or just didn't have what it took to make a living in the Serengeti, a female with a variable litter could still hope that one of her cubs would have "the right stuff" to survive (shown in Scenario 1 below). Biologists refer to this as "bet-hedging" — not putting all your eggs (or in this case, cubs) in one basket. On the other hand, a female with a more genetically uniform litter might not have any of her cubs survive their dicey environment (Scenario 2 below).

In this case the female who mated multiple times and had variable offspring would pass her genes on to the next generation, while the female who mated singly and had a more uniform litter would not. Over time, if this imbalance persisted, natural selection would favor females with genetically variable litters — and hence, females who engaged in multiple matings. So perhaps, what we humans perceive as promiscuity is actually an adaptation that allows female cheetahs to increase the odds of having at least one cub survive to pass on her genes.



While it's certainly possible that the multiple mating strategy spread because of its impact on the genetic diversity within litters, biologists have also come up with two main alternative hypotheses to explain why multiple mating is common in cheetahs:

Perhaps, multiple mating is really a strategy to avoid expending extra energy fending off would-be suitors. In other words, maybe females mate multiple times not because it ensures genetic variation in offspring, but because it's so much easier than fighting off males right and left.

Or perhaps, multiple mating evolved as a way to deter infanticide. In some big cats (and in many other species), males try to kill cubs that are not their own — a phenomenon known as infanticide. However, if a mother mates with many different males, it is more difficult for a male to tell whether or not a cub is his own — and the male would likely be deterred from killing the cub. This third hypothesis suggests that multiple mating was favored by natural selection because it discouraged infanticide against a female's cubs, not because it increased the litter's genetic variation. This third hypothesis fits with the observation that wild cheetah males seem to rarely (if ever) commit infanticide, though it is common in lions and other big cats.

Figuring out which of these three hypotheses (if any) is the right one will require further research. But regardless of what we learn about the evolutionary origins of multiple mating in female cheetahs, its evolutionary consequences today are clear. The fact that female cheetahs bear young with many different fathers helps preserve what little genetic variation the species has left — and could even buy us some time in our efforts conserve these endangered animals

Question 2: Why would interbreeding with more mates be likely to increase the amount of genetic variation in that parent's offspring?

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Endangered species are those whose population size is becoming so low, that scientists worry both about the immediate loss of the species, as well as the inability of the species to survive even if its numbers get very low, but does not immediately go extinct.

These are three species that are on the endangered species list: The California Condor, the Sea Otter, and the Loggerhead Sea Turtle.

Question 3: Even if a small number of individuals survive from each of these species for now, why might genetic drift in combination with the population bottleneck effect, hurt the long term chances of survival for all of these species?

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Another type of event that also reduces population size and leads to an increased rate of genetic drift is called **the founder effect**. The founder effect occurs when a new isolated colony individuals is started (or founded) by a few members of the original population. This small "founding" population size means that the colony is likely to have a smaller gene pool and less variation then the original population they migrated away from.

Such reduced genetic variation is apparent in colonists who have remained reproductively isolated from individuals outside their population for many generations. Many example of such reduced genetic variation and some of the genetic diseases that can result from the founder effect can be found in isolated populations of people. In the article below you will read about how the founder effect has influenced the traits of a population of Amish people whose ancestors settled in Pennsylvania in the 1700s.

Genetic Drift and the Founder Effect: text & image http://www.pbs.org/wgbh/evolution/library/06/3/l_063_03.html

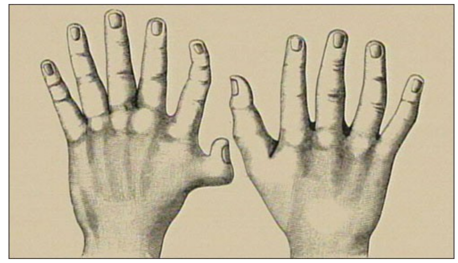
Eastern Pennsylvania is home to beautiful farmlands and countryside, but it's also a gold mine of information for geneticists, who have studied the region's Amish culture for decades. Because of their closed population stemming from a small number of German immigrants -- about 200 individuals -- the Amish carry unusual concentrations of gene mutations that cause a number of otherwise rare inherited disorders, including forms of dwarfism.

One form of dwarfism, Ellis-van Creveld syndrome, involves not only short stature but polydactyly (extra fingers or toes), abnormalities of the nails and teeth, and, in about half of individuals, a hole between the two upper chambers of the heart. The syndrome is common in the Amish because of the "founder effect."

When a small part of a population moves to a new locale, or when the population is reduced to a small size because of some environmental change, the genes of the "founders" of the new society are disproportionately frequent in the resulting population.

If individuals in the group tend to marry within it, there's a greater likelihood that the recessive genes of the founders will come together in the cells that produce offspring. Thus diseases of recessive genes, which require two copies of the gene to cause the disease, will show up more frequently than they would if the population married outside the group.

In the Amish, in fact, Ellis-van Creveld syndrome has been traced back to one couple, Samuel King and his wife, who came to the area in 1744. The mutated gene that causes the syndrome was passed along from the Kings and their offspring, and today it is many times more common in the Amish population than in the American population at large.



Polydactyly -- extra fingers or sometimes toes -- is one symptom of Ellis-van Creveld syndrome.

The founder effect is an extreme example of "genetic drift." Genes occurring at a certain frequency in the larger population will occur at a different frequency -- more or less often -- in a smaller subset of that population. As in the example of human diseases, genetically determined traits that would ordinarily be uncommon in the overall gene pool might crop up with distressing frequency in a small subset of that pool.

Question 4: How are both the founder effect and population bottle neck similar with regard to the sizes of populations they effect?

a) They both are related to small populations
b) They are both related to large populations
c) Neither are related to population size

Question 5: How are both the founder effect and population bottle neck similar with regard to their affect on the diversity of the gene pool of the population?

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Question 6: Why might islands be good ecosystems to explore to better understand the outcomes of the founder effect?

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