Name: Key - JR p25 Date:

Unit 4: Why do scientists claim our ancestors were fish?
Unit 4B: Population Evolution

Performance Task 1: What happens when genetics converges with evolutionary theory?
Activity A: Complete the following Questions/Notes while watching "The Making of the Fittest: Natural Selection in Humans" video clip. (http://www.hhmi.org/biointeractive/making-fittest-natural-selection-humans (stop at 9:30 for now)

1. What disease do both siblings have? Sickle cell anemia
2. What cellular change causes the wide variety of symptoms suffered by those with sickle cell anemia?
   RBC → crescent shape, don't carry O_2 properly to body cells
3. Is sickle cell a rare disease? NO
   What is the frequency of the disease among African Americans? 1/500
   Why is the high frequency of disease particularly perplexing? Because we would expect harmful traits to disappear from gene pool
4. What was Dr. Allison's driving question?
   Could the common ABO blood types say anything about the evolutionary history of East African tribal people?
5. What was Dr. Allison's initial observation regarding the frequency of sickle cell disease (which is a genetic disease) with regard to geography?
   High freq. in coast / Lake Victoria
   Low freq. in high country of Nairobi ← breeding ground of malaria parasite
6. What fact did Dr. Allison know about these geographic areas with regard to the infectious disease, Malaria? high frequency = high incidence of malaria (warm, moist regions - breeding ground for mosquitos
7. What problem did Dr. Allison want to address; in other words, what was his hypothesis?
   Look at the children and find out whether they are protected against malaria. If so - predict we'd have high frequencies of sickle cells only in areas w/ high incidence of malaria.
8. What two conditions did Dr. Allison test?
   1. Malaria parasite load 2. Sickle cell (blood)
   What did his findings suggest?
   maps - high incidence of malaria / high incidence of sickle cell
9. What two sets of data supported Dr. Allison's hypothesis?
   Many blood samples + the two maps
10. What are all possible genotypes for the sickle cell trait? What phenotype is the dominant phenotype?
    homozygous (normal) dominant
    heterozygous - carrier
    homozygous recessive - sickle cell

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Textbook Pages 482-486

Activity B: How is evolution defined in genetic terms? What are the sources of genetic variation?

Background

Darwin developed his theory of evolution by natural selection without understanding the mechanisms by which inherited traits pass from generation to generation. Even though Mendel's studies on pea plant inheritance were published during Darwin's lifetime, no one made the connection between both lines of study. In addition, while Darwin based his theory on heritable variation, he had no idea where that variation originated. Once researchers discovered that heritable traits are controlled by genes carried on chromosomes, and that changes in genes and chromosomes generate variation, evolutionary theory could be studied and defined in genetic terms.

Recall from our meiosis and genetics unit:

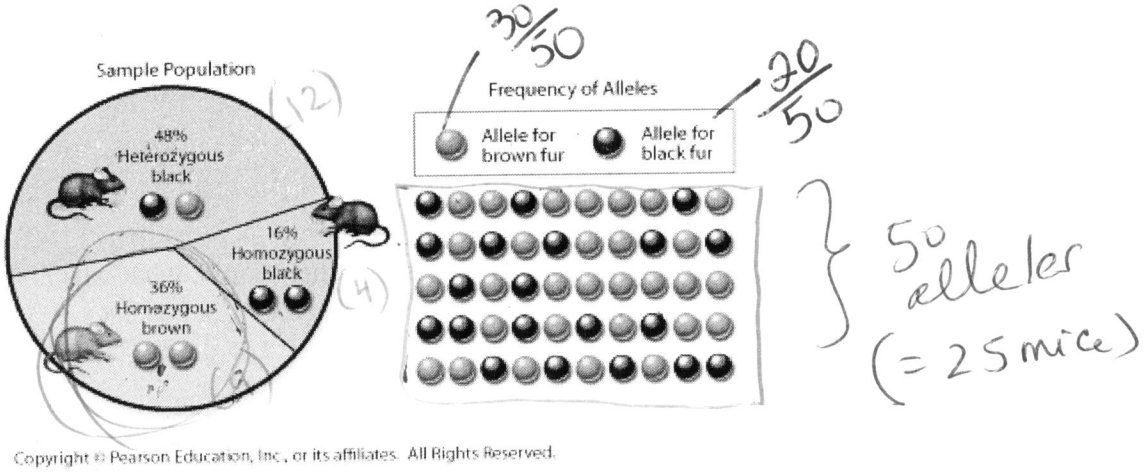
There are three ways sexual reproduction contributes to genetic variation:

- Crossing over - Pro. I in meiosis
- Indep Asst - Meta I of meiosis
- Random fert.

Genetic variation and evolution are both studied in populations. What is a **population**?

A group of individuals of the same species that live in the same area (can interbreed to produce fertile offspring)

Alleles in a population:



When scientists try to determine whether a population is evolving, they study its **allele frequencies**. The diagram above shows allele frequencies for fur color in a mouse population. Here, in a total of 50 alleles, 20 are B (black) and 30 are b (brown).

How many of **each allele** would be present in a **total of 100 alleles**? (double) 40 black, 60 brown

So, what is the **frequency** of each allele? 40% 60%

How would you define **allele frequency** in your own words?

The # of times an allele occurs in a gene pool, compared to the total # of alleles for that gene in that gene pool p.483

Remember, there are **50 alleles represented** in this gene pool. **How many total individuals** are there in this population?

25 → because each person contributes 2 alleles to the gene pool

Calculate the number of individuals in this population with each of the three genotypes:

Phenotype	Genotype	% of the population (out of 25 people)	# individuals
Black	BB	16% of 25 = .16 × 25 →	4
Black	Bb	.48 × 25 →	12
brown	bb	.36 × 25 →	9

How would you define **genotype frequency** in your own words?

How common each genotype is in that population. (% of population that is homo dom / hetero / homo rec.)

More vocabulary- **Think about it**: Perhaps the most common definition of the noun *pool* is a large man-made body of water in which you can swim. However, a *pool* can also refer to the available supply of some resource. How would you define **gene pool** in your own words?

All the genes (including all the different alleles for each gene) present in a population.

Explain how natural selection acts on phenotypes:

It's an entire organism (w/ its particular phenotypes) that is selected as more / less "fit"

How does this impact genotype frequency?

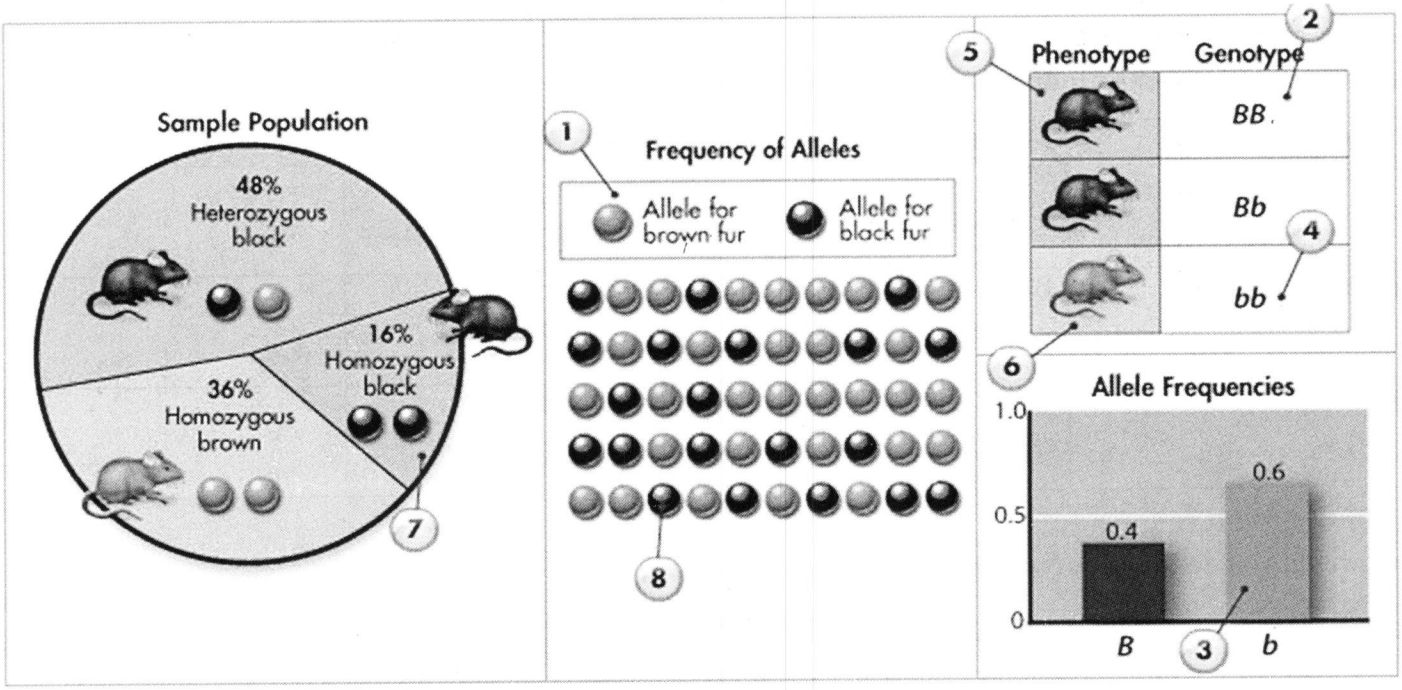
The better-suited individuals (selected for) produce more offspring ∴ more copies of their genes are passed on to the next generation so those will make certain genotypes more or less common in the population.

Vocabulary Practice

Online textbook Activity 17.1 Art in Review

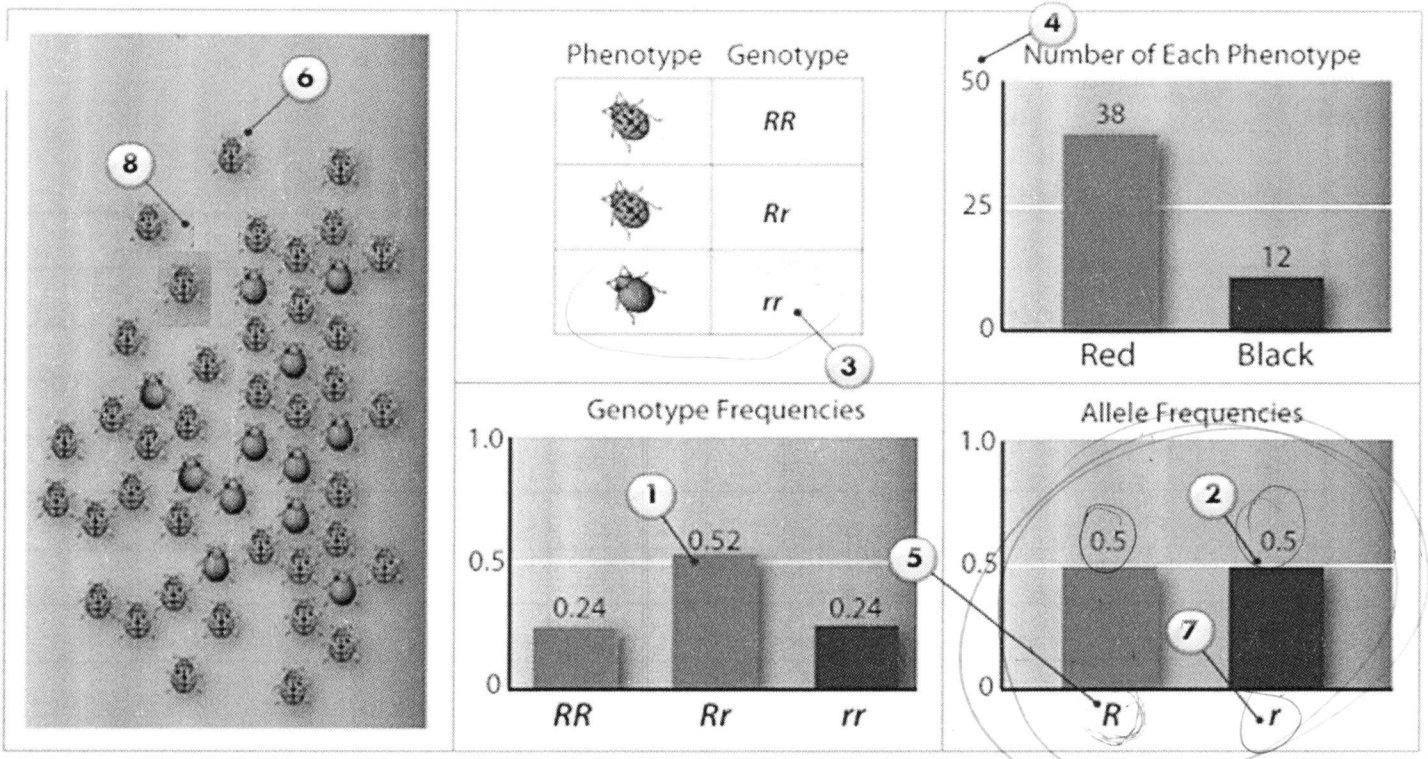
Log on to the textbook website (do not open the textbook). Go to "EXPLORE". Choose "~~Chapter 5~~ Unit Evolution" and Lesson 17.1 "Genes and Variation". Go the "ACTIVITIES" Art Review- Frequency and Dominance. Complete each activity, submit your answers and record the correct answers below.

Population #1



1. recessive allele	2. homo. dom.	3. recessive frequency	4. recessive genotype
5. dom phenotype	6. rec. phenotype	7. rarest genotype	8. rarest allele

Population #2



1. hetero freq.	2. rec. freq.	3. rec. genotype	4. pop size
5. dom allele	6. dom phero	7. rec allele	8. rec phero

Examine the data shown in Populations 1 and 2. Does **allele frequency** correlate with whether that allele is dominant or recessive? Explain.

NO. Frequency means how common it is — which depends on natural selection. (Not all dom. genes are best!)

(In pop# 1 the rec. allele was more frequent than the dominant. In pop #2 they're equally common)

Performance Task 2: What conditions are required to maintain genetic equilibrium?
Activity: Hardy Weinberg Equilibrium: Read pages 491-492 in the textbook (you will not need to know the mathematical equation, but we will model the relationships below). List and write a brief summary describing each of the conditions that can disturb genetic equilibrium.

There are 5 conditions that can disturb genetic equilibrium:

- nonrandom mating (sexual selection occurs)
- small pop size (tendency for genetic drift)
- immigration/emigration - (addition/removal of alleles w/ gene pool)
- mutations - (new alleles in gene pool)
- nat selection - (some phenotypes have higher fitness which will change the allele frequencies)

How can we model what is happening in a gene pool over a long period of time?

Recall the Punnett Square we used to predict the offspring of a **single cross,** when the alleles contributed by a set of parents are known. The Punnett square shown below is a model that represents the cross between two parents that are heterozygous for a particular trait that follows simple dominance pattern of inheritance.

Complete the Punnett Square.

Circle the alleles contributed by the parents.

Put an "✕" over each box of the homozygous dominant offspring.

Put a "★" over each box of the heterozygous dominant offspring.

Put a "✓" over each box of the homozygous recessive offspring.

What percentage (frequency) of the offspring does each individual box represent? 25

One generation.

♀ \ ♂	**R**	**r**
R	✕ RR	Rr ★
r	Rr ★	rr ✓

What are the predicted genotypic ratios of the offspring?
25% RR, 50% Rr, 25% rr

What are the predicted phenotypic ratios of the offspring? (phenotypes: just say 'dominant' vs. 'recessive')
75% dom, 25% rec

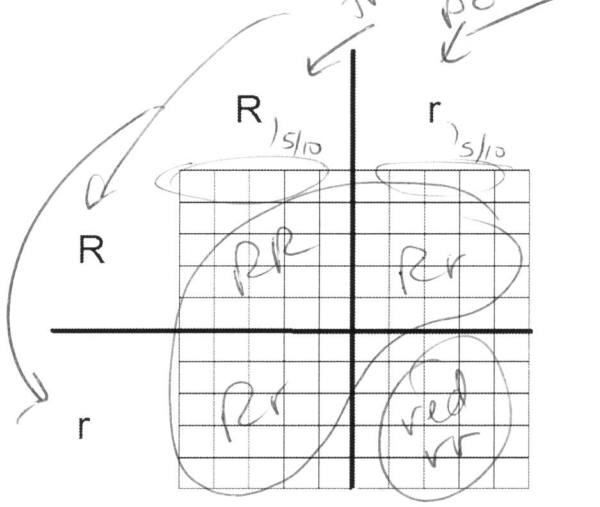
How can we revise the Punnett Square model to predict the offspring of a **population**?
We have to consider the frequency of each allele in the population (in the gene pool). It's not all 50/50!

_ population punnet square!

Compare the Punnett square below to the one on the previous page. Notice the additional boxes in this Punnett square.

What does each small box represent in terms of percentage or frequency? 1% of org. w/ that genotype from gene pool

When using the Punnett square to the right as a model for predicting offspring in a population, the alleles represented on the top and side represent the **allele frequencies** available for reproduction in that population.



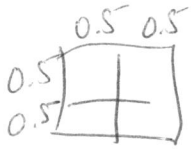
Example 1: In this population, the allele for red hair (r) is recessive to brown hair (R). The frequency of each allele (dominant or recessive) is 50% or 0.5. Complete the Punnett square.

What are the predicted genotypic ratios of this population?

25% RR 50% Rr 25% rr

What are the predicted phenotypic ratios of this population?

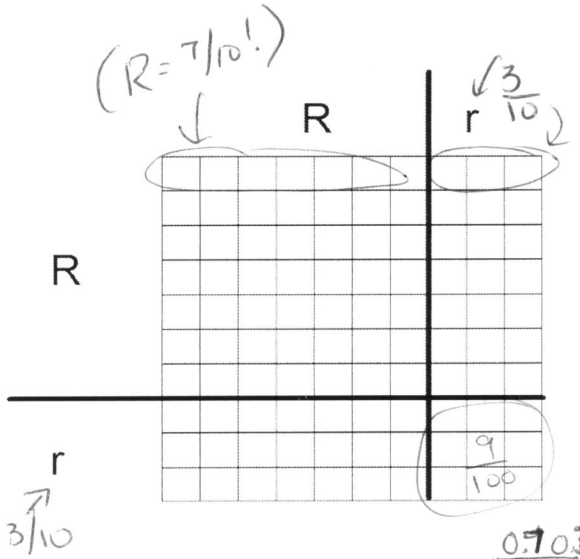
75% brown (dom) 25% red (rec)



Example 2: The allele frequency of the recessive red allele in the population of Scotland is 30% or 0.3. How does this change the model compared to Example 1?

It makes the "rr" sections smaller, and "RR" sections bigger

Complete the Punnett square.

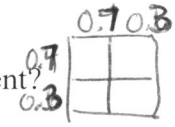


What are the predicted genotypic ratios of this population?

49% RR, 42% Rr (=21+21), 9% rr

What are the predicted phenotypic ratios of this population?

91% Brown (49+42), 9% red (9/100)



Compare the genotypic ratios and phenotypic ratios for these two examples. Are they the same or different?

different.

NOW Top + Sides = freq. of the dom + rec allele in the gene pool itself for population

Example 3:

A population of mice have two phenotypes for fur color- black and brown. The black allele (B) is dominant over the brown allele (b). After counting the fur types in the population, it is determined that 36% show the phenotype for brown fur.

What is the **frequency** of the brown allele? 0.6

What is the **frequency** of the Black allele? 0.4

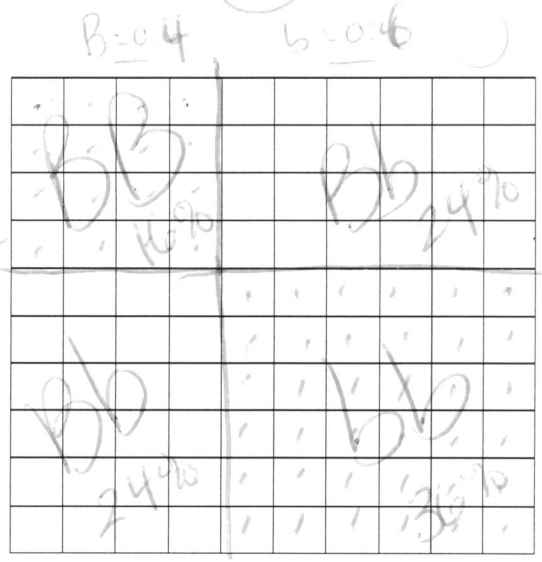
Record this information on the Punnett square at the right and complete the Punnett square.

What are the predicted genotypic ratios of this population?

16% BB, 48% Bb, 36% bb

What are the predicted phenotypic ratios of this population?

64% black (16+48), 36% brown



Start here → (6x6=36)

Example 4:

After many generations, the population of mice in Example 3 is surveyed, and it is determined that 16% show the phenotype for brown fur.

What is the **frequency** of the brown allele? 0.4

What is the **frequency** of the Black allele? 0.6

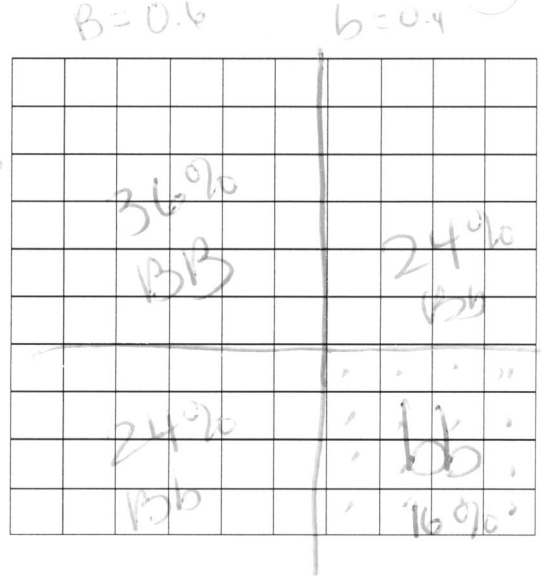
Record this information on the Punnett square at the right and complete the Punnett square.

What are the predicted genotypic ratios of this population?

36% BB, 48% Bb, 16% bb

What are the predicted phenotypic ratios of this population?

84% black, 16% brown



Evolution, in genetic terms, involves a change in the freq. of alleles in a pop. over time

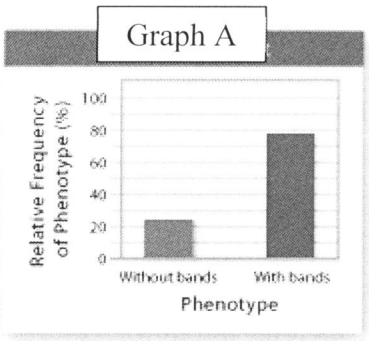
Has evolution occurred in the populations of mice of Examples 3 and 4? yes!

<u>Performance Task 3:</u> How does natural selection affect single gene and polygenic traits?

Activity A: What determines the number of phenotypes for a given trait?

Whether it's single or multiple gene trait (polygenic)

In our studies of Mendelian patterns of inheritance, we saw that the presence or absence of a trait can be controlled by one gene. This is called a ***single-gene trait***. Note the type of graph used to record the frequencies of each of two traits controlled by a single gene.

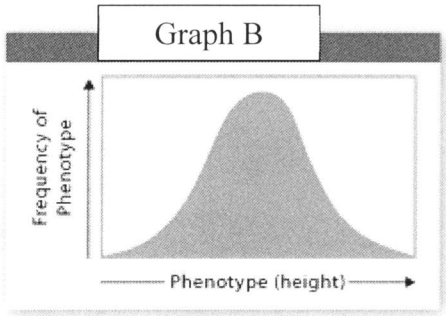


Many traits are controlled by two or more genes and are called ***polygenic traits.*** A well-known example is the height of individuals.

remember- prev. unit 3 pract 3

The bell-curve shape of this graph indicates that there is a range of heights of individuals in the population, few individuals are very short or very tall- most are in the middle of the range.

polygenic : wide range of phenotypes



STOP and THINK:

A black guinea pig and a white guinea pig mate and have offspring. All the F1 offspring are black. The F2 generation shows some black and some white individuals. Is the trait of coat color probably a single gene trait or a polygenic trait?

Single gene

Which Graph above does this scenario match? A

The genetics of eye color are complex, and there are many variations of eye color among humans. While we may just say that a person has brown eyes, you might notice that there are many shades of brown, all a result of a complex pattern of inheritance. Is the trait of eye color probably a single gene trait or a polygenic trait?

polygenic

Which Graph above does this scenario match? B

Activity B: Natural Selection on a Single Gene Traits- Effect of Color Mutations on Lizard Survival

Natural selection on a single-gene trait can lead to changes in the allele frequencies and, thus, to evolution.

Recall from Unit 4A:

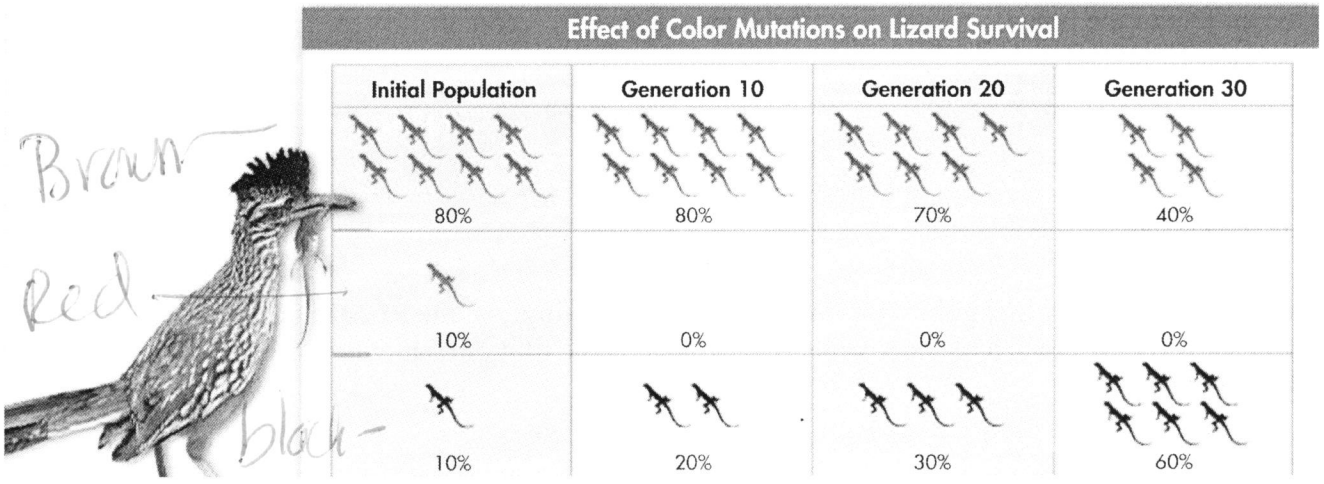
Evolutionary **fitness** means an organism can survive & reproduce in its environment

Evolutionary **adaptation** means a char. that increases an organism's fitness (survive → reproduce) in an environment

Consider the following scenario:

A lizard population experiences mutations in the gene that determines body color. The normal color of the lizards is brown. Random mutations in that gene for body color produce two new phenotypes: red and black, as shown in the data table below. Red colored lizards are more visible to predators. Black colored lizards absorb more sunlight and move faster than red and brown lizards on cold days. High body temperature allows lizards to move faster to feed and avoid predators.

Using the information provided in the data table below complete the bar graph with colored pencils.



100												
90												
80												
70												
60												
50												
40												
30												
20												
10												
%	Initial population			Generation 10			Generation 20			Generation 30		

Summarize the series of events that occurred in order to produce the population shown in Generation 30.

Red color mutation (variation) arose but quickly died off b/c predators could easily find them. Black color thrived - so they survived + reproduced most successfully

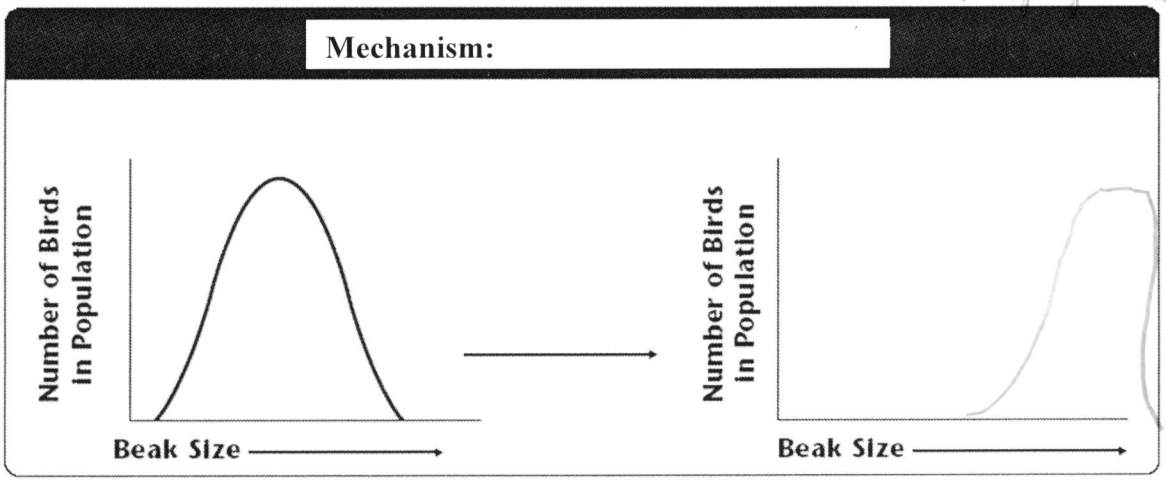
<u>Activity C:</u> Natural Selection on Polygenic Traits

Log on to the textbook website (do **not** '*open*' the textbook). Go to "EXPLORE". Choose "Chapter 5 Evolution" and Lesson 17.2 "Evolution as Genetic Change in Populations". Go the "ACTIVITIES" Art in Motion- Natural Selection. Complete each activity: **describe the scenario**; using lines, **diagram** the observations on the graphs provided; and **identify** the mechanism illustrated.

Scenario 1:

Finch population - only large seeds avail after drought. Selecting for "larger beak size" after several generations, avg. beak size ↑ (large beak size more common in population)

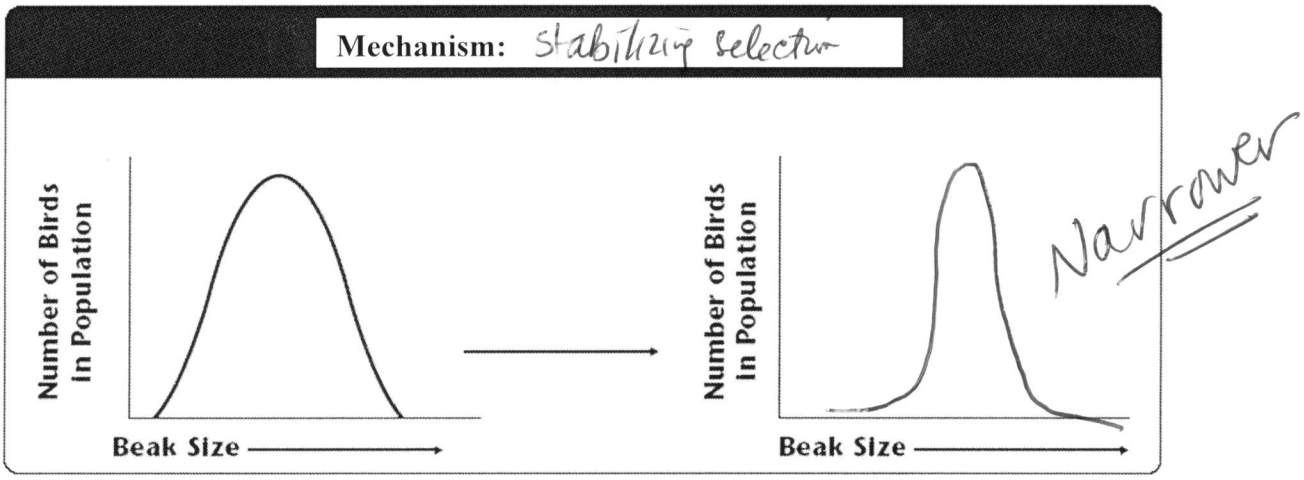
Mechanism:



shift in size b/c environmental pressure of ↑ seed size favors large beak

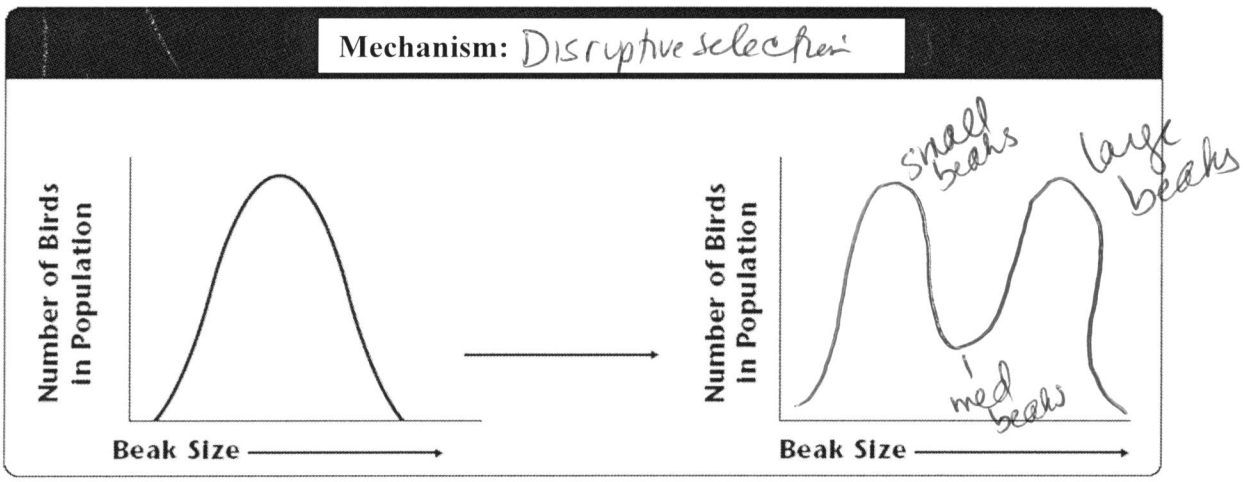
Scenario 2:

Seeds surviving which are most easily eaten by birds w/ med-size beaks. Eventually the med size beak birds become most common



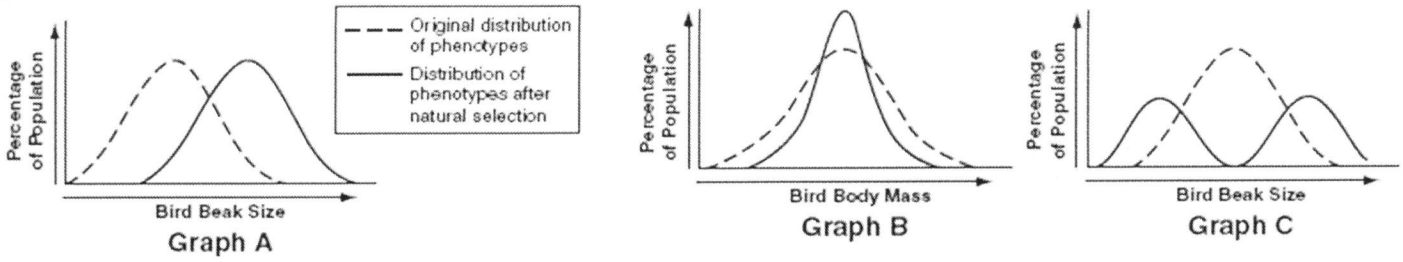
Scenario 3:

Weather favors very large and very small seeds. So birds w/ beaks at either extreme are selected for. But the medium-sized beaks aren't well adapted to either, so they're selected against.



Follow up: Natural Selection on Polygenic Traits

Use the diagram below to answer the following questions.



1. Match each Graph above with the mechanism of Natural Selection working on that population:

Graph (letter)	Mechanism
C	Disruptive
A	Directional
B	Stabilizing

2. Which of the three graphs shown above might show a population of birds with members that specialize in different types of food? Explain.

C

3. What factors or conditions might have led to the change shown in Graph A?

drought, availability of food, competition, etc

4. Complete the table below.

A. Stabilizing selection B. Directional selection C. Disruptive selection

Mechanism	Scenario
C	If there are two types of seeds to eat for a population of birds, either of two different beak shapes (sharp or blunt) might be selected for, but a beak that's the average of the two shapes might not be particularly good at eating either seed, so it would be selected against.
A	A plant that is too short may not be able to compete with other plants for sunlight. However, extremely tall plants may be more susceptible to wind damage. Combined, these two selection pressures select to maintain plants of medium height. The number of plants of medium height will increase while the numbers of short and tall plants will decrease.
B	In a population of plants, flowers with the brightest color might be selected for because they attract the most pollinators.

<u>Performance Task 4</u>: What is genetic drift?

Natural selection is not the only source of evolutionary change. In small populations, an allele can become more or less common by random chance.

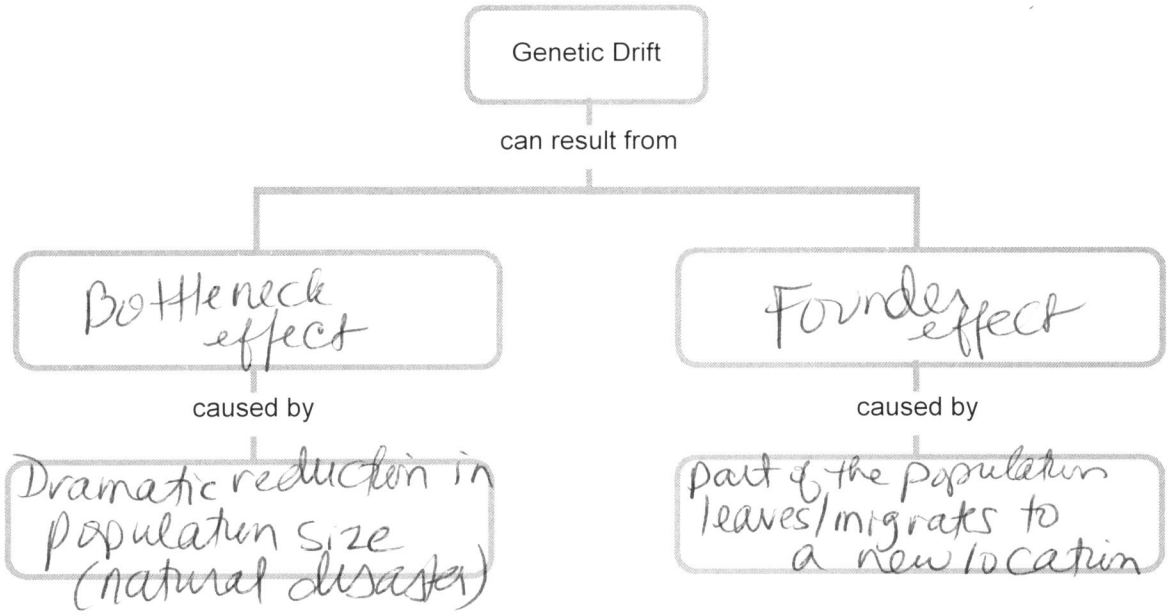
Define the term **random** in your own words:

not following a specific pattern (unpredictable)

"Lego video" **http://tinyurl.com/lnp692p**

Includes numbers **http://tinyurl.com/mjengqn**

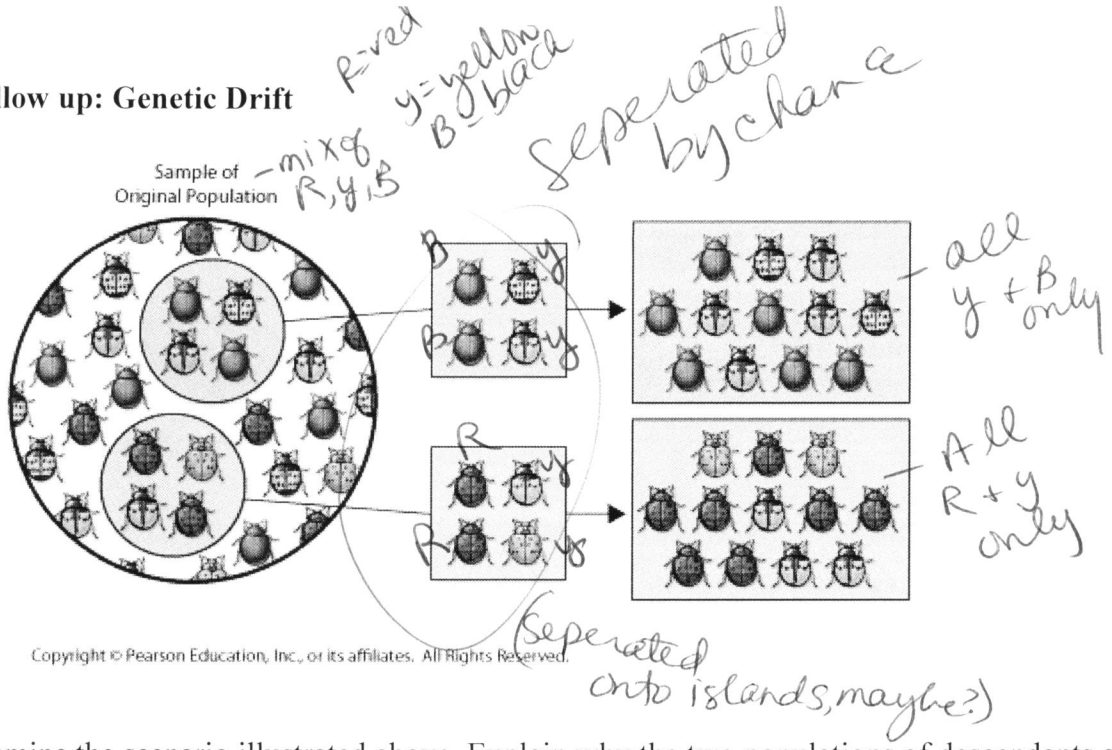
- Founder Effect
- Bottleneck Effect



Define Genetic Drift:

Random change in allele frequency (certain allele become more/less common) in a population

Follow up: Genetic Drift



Examine the scenario illustrated above. Explain why the two populations of descendants are so different from one another and the original population.

Founder effect - only some of the alleles were in each population subgroup so not all the traits from the original population are present in the new groups

<u>Performance Task 5</u>: How can changes in ecosystems contribute to changes in gene frequency over time through natural selection, resulting in adaptation of populations?

<u>The Making of the Fittest- Natural Selection in</u> Humans - Sickle Cell Activity

(Continue Sickle Cell video from 9:31 to end)

[On your own, you may wish to follow up by watching an interesting related video on the evolution of Lactose Intolerance at <u>http://tinyurl.com/ls35upv</u>]

Appendix: Performance Tasks 1-5 Summary Graphic Organizer

After each Performance Task is complete, add a written summary in the graphic organizer describing how the information gathered during the task will help you answer the driving question.

Driving Question:
Why do scientists claim our ancestors were fish?

Performance Task	Summary
1. What happens when genetics converges with evolutionary theory?	
2. What conditions are required to maintain genetic equilibrium?	
3. How does natural selection affect single gene and polygenic traits?	
4. What is genetic drift?	
5. How can changes in ecosystems contribute to changes in gene frequency over time through natural selection, resulting in adaptation of populations?	