Biology 11
J. Harwood
Howe Sound Secondary School

Name:

Microevolution – Beyond Darwin's Theory of Natural Selection

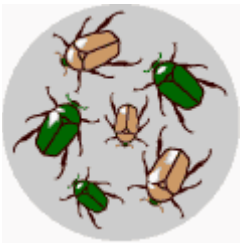
Instructions: While reading the following pages, fill in the blanks, and answer the questions where required.

Background:
Evolution is the process by which modern organisms have descended from ancient ancestors. Evolution is responsible for both the remarkable similarities we see across all life and the amazing diversity of that life—but exactly how does it work?

Review:
What is microevolution?

Why does is happen?

What is the primary process for 'how' it happens?



1. Natural Selection: A Summary of Modern Darwinism

I. Variation in _____ (visible traits) – differences caused by _____ and _____.

II. Selective pressures must be present – individuals are removed from the population. Common examples include:

_____

_____

_____

_____

III. Survival of the Fittest – those individuals with the most favorable traits tend to _____.

IV. Differential reproduction – the fittest individuals tend to _____ more often, passing on their _____ to the next generation. The population will tend to have more individuals with the _____ trait.

Changes in Phenotype and Genotype Frequency Due to Natural Selection

The diagram below shows an imaginary species of beetles with 3 phenotypes determined by the amount of pigment deposited in the cuticle (exoskeleton). The gene controlling this trait is represented by 2 alleles (2 forms of the gene) identified as **A** and **a**.

Phenotype	Genotype (alleles present)
Black	AA = homozygous dominant
Dark	Aa = heterozygous
Pale	aa = homozygous recessive

Notice the dark coloured beetles 'carry' the recessive 'a' gene.

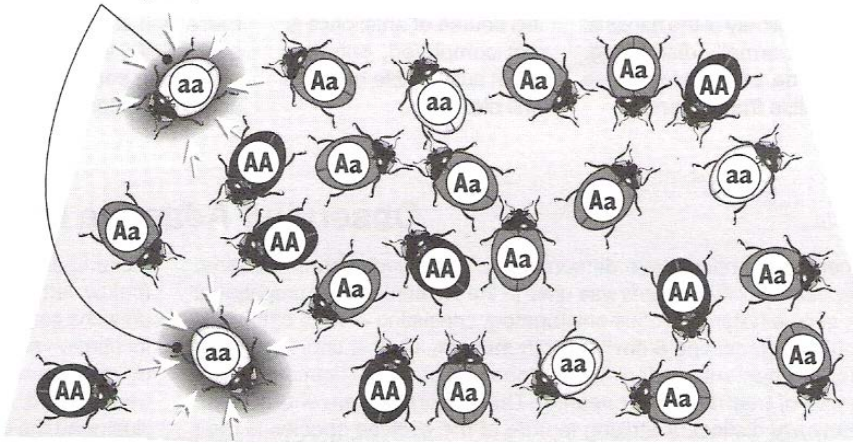
Initial gene pool - Calculate the frequencies

Phenotype Frequencies				Allele Frequencies		
Black	Dark	Pale		Allele	Actual numbers	Allele Frequency %
				Allele A		
				Allele a		
				Total		

Selective pressure applied causing Natural Selection – Calculate the frequencies

Phenotype Frequencies				Allele Frequencies		
Black	Dark	Pale		Allele	Actual numbers	Allele Frequency %
				Allele A		
				Allele a		
				Total		

Two pale individuals died and therefore their alleles are removed from the gene pool.



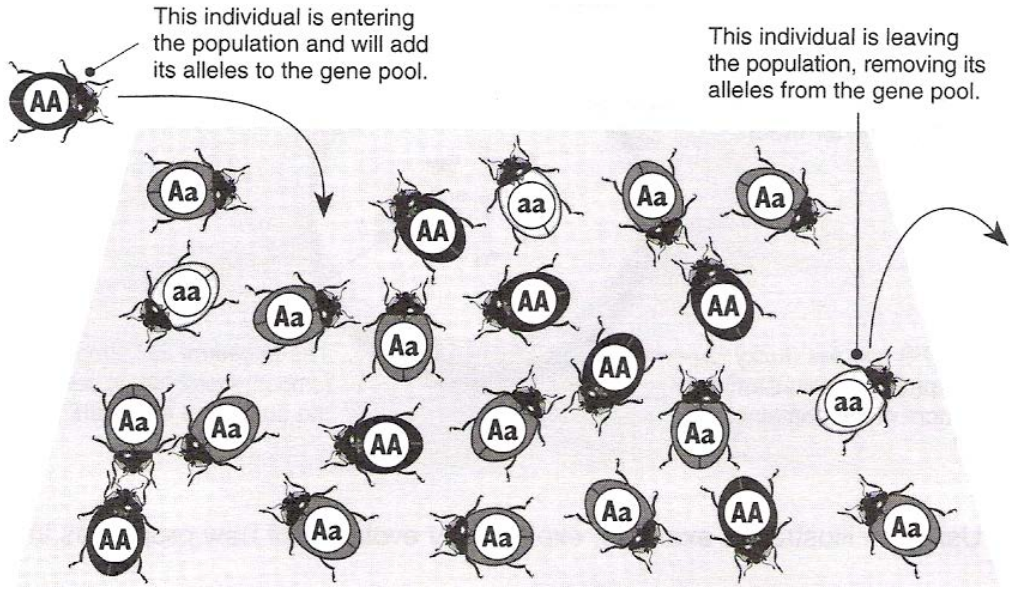
Are there other mechanisms that can create changes (cause microevolution) in a population?

Natural Selection is not the only way a population might change. In the following pages you will examine other ways a population might change through gene flow, genetic drift, the founder effect and genetic bottlenecks.

2. Gene Flow:

Changes in Phenotype and Genotype Frequency Due to Gene flow (immigration and emigration) - Calculate the gene frequencies

Phenotype Frequencies				Allele Frequencies		
Black	Dark	Pale		Allele	Actual numbers	Allele Frequency %
				Allele A		
				Allele a		
				Total		



* Notice the changes in phenotype and genotype frequencies due to gene flow through immigration and emigration. This migration of individuals adds new alleles (forms of a gene) to a population. These changes in the population were not due to natural selection.

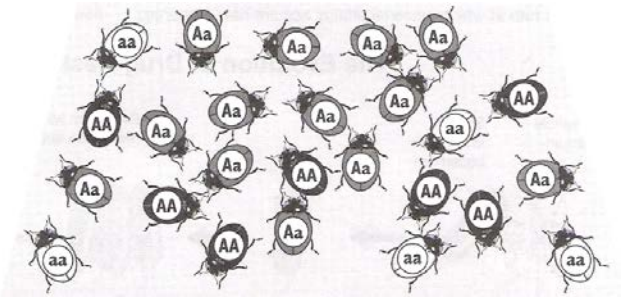
3. Genetic Drift:

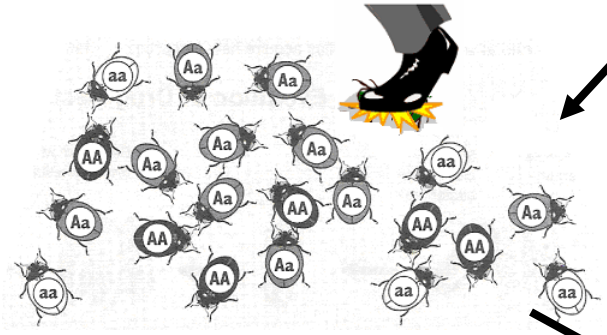
By chance, some alleles (forms of a gene) do not get passed on to the next generation. The population tends to show a particular trait but this is not due to natural selection.

Not all individuals, for various reasons, will be able to contribute their genes to the next generation. **Genetic drift** refers to the random changes in allele frequencies that occur in all populations, but are much more pronounced in small populations.

Starting Population

Phenotype Frequencies		
Black	Dark	Pale
		
Allele Frequencies		
Allele	Actual numbers	Allele Frequency %
Allele A		
Allele a		
Total		

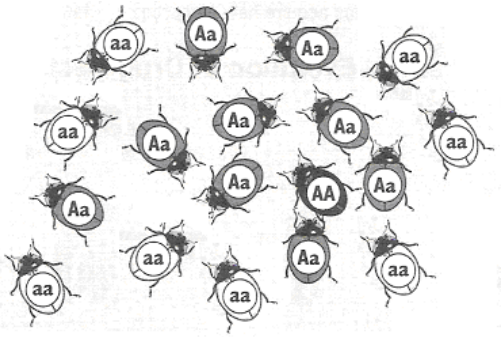




Some individuals are 'killed' by chance

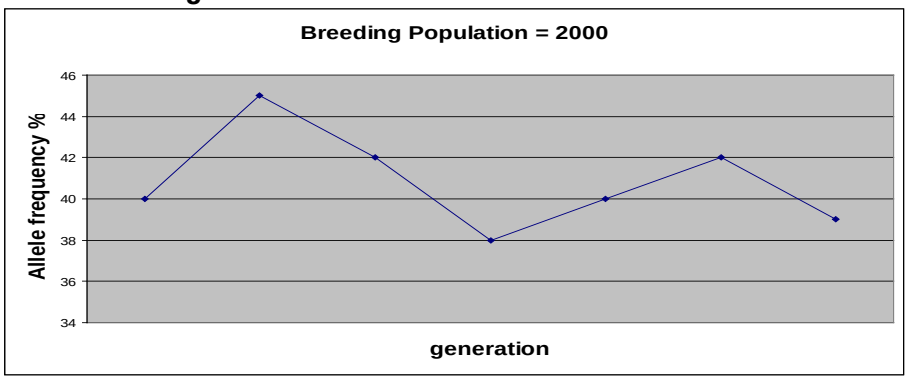
Population after Genetic drift

Phenotype Frequencies		
Black	Dark	Pale
		
Allele Frequencies		
Allele	Actual numbers	Allele Frequency %
Allele A		
Allele a		
Total		

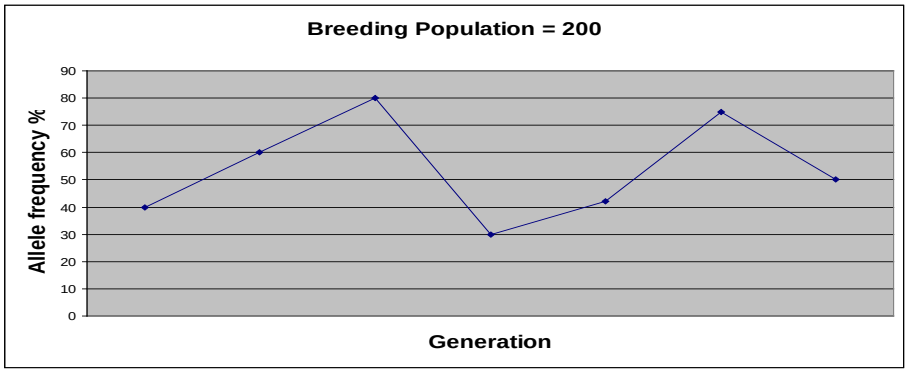


* Notice the changes in phenotype and genotype frequencies due to random genetic drift. These changes in the population were not due to natural selection.

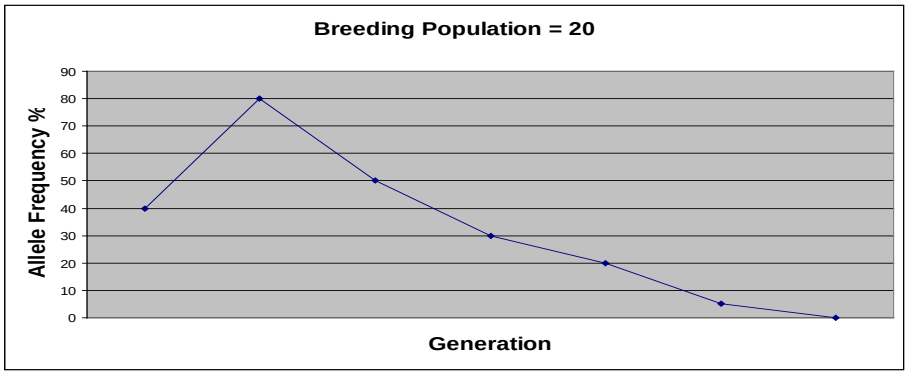
Simulation of genetic drift:



Large breeding population: Fluctuations are minimal in large breeding populations because the large numbers protect the population against random loss of alleles. On average, losses for each allele type will be similar in frequency and little change occurs.



Small breeding population: Fluctuations are more severe in smaller breeding populations because random changes in a few alleles cause greater percentage changes in allele frequencies.



Very small breeding population: Fluctuations in very small breeding populations are so extreme that the allele frequency can become fixed (frequency = 100%) or lost from the gene pool altogether (frequency of 0%).

Genetic drift summary:

I. Define the term genetic drift.

II. Describe what happened to the allele frequency when several green beetles were killed by accident?

III. Explain how genetic drift affects the genetic variation within very small populations.

IV. Why do you think scientists are worried about habitat destruction?

V. Research: Find out and give a description of a small breeding population in Canada in which genetic drift could be occurring.

4. The Founder Effect – Another example of genetic drift

Occasionally, a small number of individuals from a large population may migrate away, or become isolated from, their original population. *If this colonizing or 'founder' population is made up of only a few individuals, it will probably have a non-representative sample of alleles from the parent population's gene pool. As a consequence of this founder effect, the colonizing population may evolve differently from that of the parent population, particularly since the environmental conditions for the isolated population may be different*. In some cases, it may be possible for a certain allele to be missing altogether from the individuals in the isolated population. Future generations of this population will not have this allele.

Some individuals from the mainland population are carried at random to the offshore island by natural forces such as strong winds.

This population may not have the same allele frequencies as the mainland population.

Mainland Population **Colonizing Island Population**

	Allele frequencies				Allele frequencies	
	Actual numbers	Allele frequency %			Actual numbers	Allele frequency %
Allele A				**Allele A**		
Allele a				**Allele a**		
Total				**Total**		

Phenotype Frequencies				Phenotype Frequencies		
Black	**Dark**	**Pale**		**Black**	**Dark**	**Pale**
						

I. Describe how the allele frequencies of the 2 populations are different.

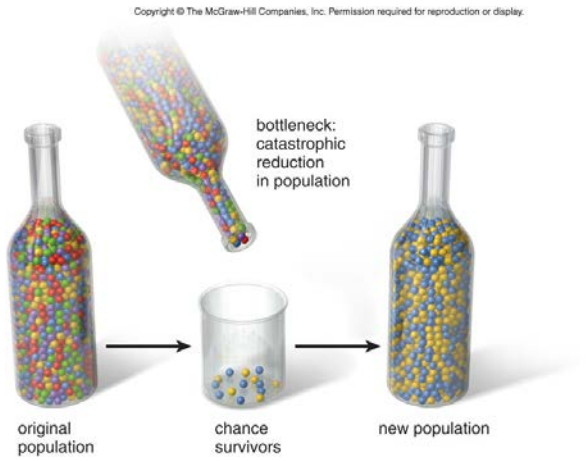
II. Describe why scientists might be worried about a species' biodiversity when the founder effect occurs (frequency of alleles in the population).

III. Research: Find and describe an example of the 'founder effect' in a human population.

5. The Bottleneck Effect – Another example of genetic drift

A similar situation, called a *population bottleneck, occurs when a population is reduced to low numbers because of predation, disease, or periods of climate change*.

For example, the world population of cheetahs currently stands at fewer than 20 000. Recent genetic analysis has found that the entire population exhibits very little genetic diversity. It appears that cheetahs may have narrowly escaped extinction at the end of the last ice age, about 10 - 20 000 years ago. If all modern cheetahs arose from a very limited genetic stock (small gene pool), this would explain their present lack of genetic diversity. The lack of genetic variation has resulted in a number of problems that threaten cheetah survival, including sperm abnormalities, decreased offspring produced, high cub mortality, and sensitivity to disease.



Research: Use the following web site. http://www.abc.net.au/science/articles/1999/08/02/40791.htm

I. Describe the population bottleneck that has put cheetahs at risk of extinction.

II. Find out how salmon from salmon farms in BC may be endangering wild salmon populations.

6. Sexual Selection... still to come