New Jersey Center for Teaching and Learning

Progressive Science Initiative

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AP BIOLOGY

Big Idea 1
Part A

August 2012

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Big Idea 1:

The process of evolution drives the diversity and unity of life.

Big Idea 1

The following is the AP's explanation of the first Big Idea:

"Evolution is a change in the genetic makeup of a population over time, with natural selection its major driving mechanism. Darwin’s theory, which is supported by evidence from many scientific disciplines, states that inheritable variations occur in individuals in a population. Due to competition for limited resources, individuals with more favorable variations or phenotypes are more likely to survive and produce more offspring, thus passing traits to future generations...

Big Idea 1

In addition to the process of natural selection, naturally occurring catastrophic and human induced events as well as random environmental changes can result in alteration in the gene pools of populations. Small populations are especially sensitive to these forces. A diverse gene pool is vital for the survival of species because environmental conditions change. Mutations in DNA and recombinations during meiosis are sources of variation. Human-directed processes also result in new genes and combinations of alleles that confer new phenotypes. Mathematical approaches are used to calculate changes in allele frequency, providing evidence for the occurrence of evolution in a population."

Big Idea 1: Part A

Click on the topic to go to that section

- Darwin Helped Define Biological Evolution
- Darwin's Evidence
- Natural Selection
- Mutations & Hardy-Weinberg
- Evidence for Evolution

Darwin Helped Define Biological Evolution

Return to Table of Contents

Evolution Defined

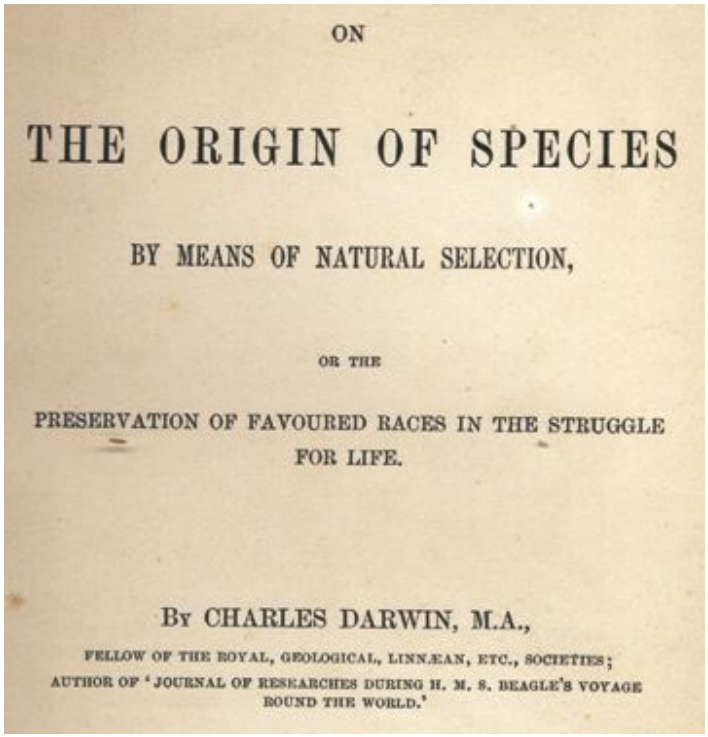
ev·o·lu·tion

Biology- **a. Change in the genetic composition of a population during successive generations, as a result of natural selection acting on the genetic variation among individuals, and resulting in the development of new species.**

Evolution Defined

"Change in the genetic composition of a population during successive generations, as a result of natural selection acting on the genetic variation among individuals, and resulting in the development of new species."

The person most responsible for this current definition of biological evolution is **Charles Darwin** and his theories presented in his book "**The Origin of Species**"



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

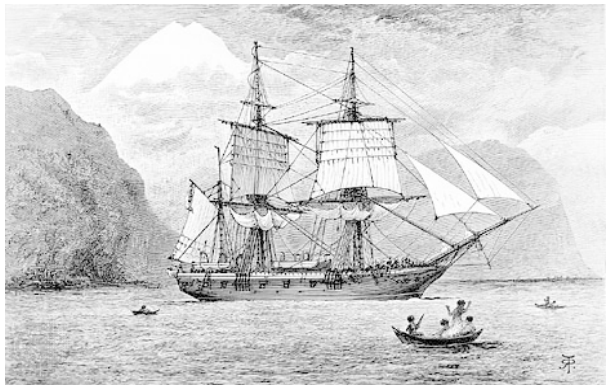
By CHARLES DARWIN, M.A.,

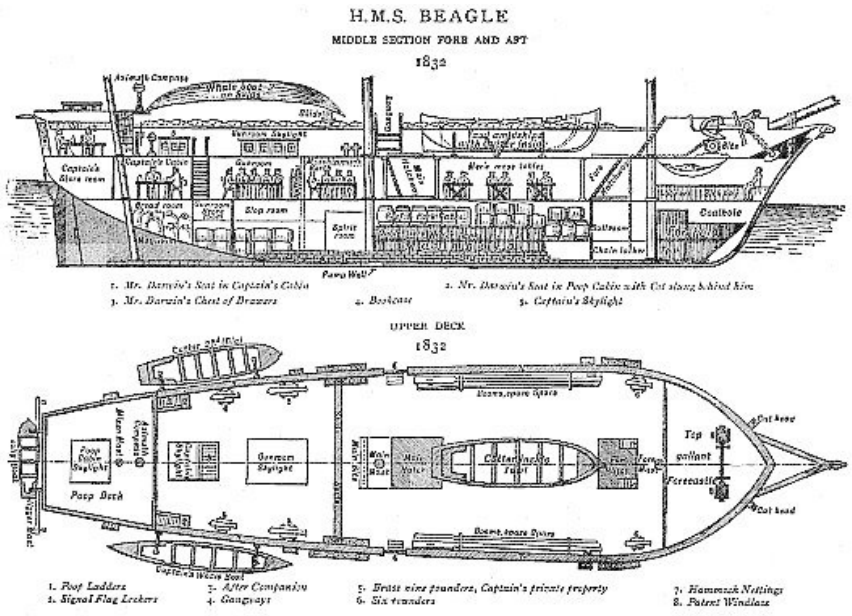
FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

Charles Darwin

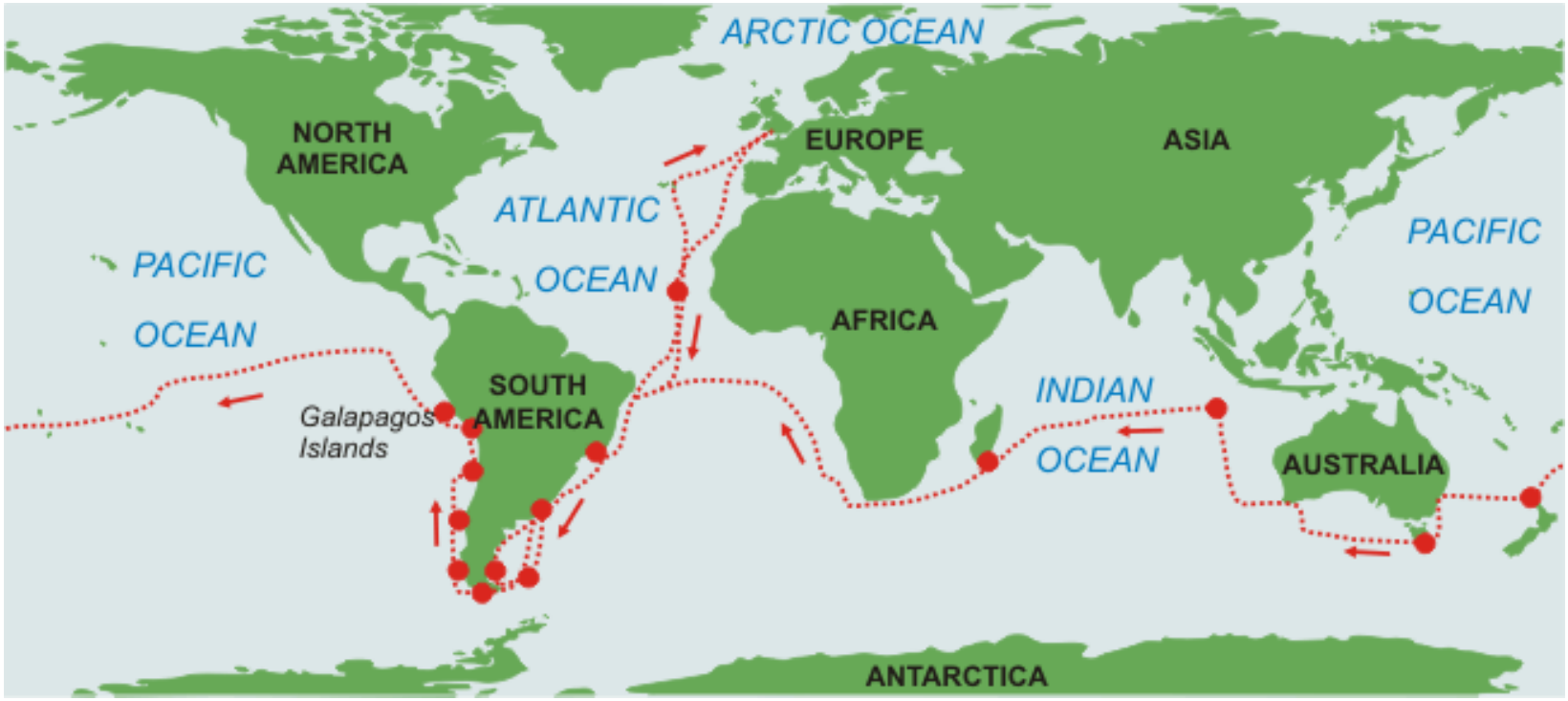
Upon graduation from Cambridge University, Charles Darwin took a position as a naturalist on a ship called the H.M.S. Beagle. The main purpose of the Beagle was to map out the coastline of South America.

Darwin was on board the Beagle from 1831 to 1836.





Journey of the H.M.S. Beagle 1831-1836



The Galapagos Islands

In the 4th year of the voyage, the H.M.S Beagle reached the Galapagos Islands off the coast of Equador.

Darwin found many plant and animal species that were very similar to the species on the mainland of South America.

He compared the island and mainland species and found that the island varieties had different adaptations from the same mainland species.

Darwin in South America

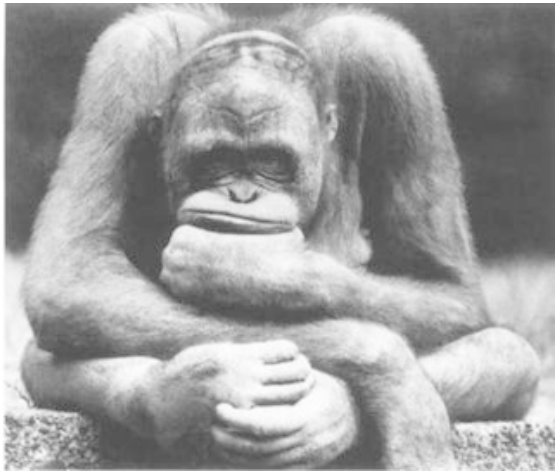
As the ship's crew surveyed the coast of South America, including the Galapagos Islands, Darwin spent most of his time inland collecting thousands of living plants and animals as well as old bones.

During his 5 year voyage Darwin made many observations that led to his published theories.

Darwin's Observations

As we go over the 5 major observations that Darwin made in South America, write down some of your own theories.
The question we need to answer:

Why do living things do what Darwin observed?

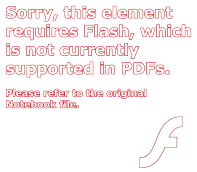


Darwin's Observations

1st Observation

In the majority of species observed by humans, more offspring are born than can survive to become adults. Female fish can hatch thousands of offspring, but usually only one or two survive to become adults. The same is true for the bugs, turtles, birds and plant species Darwin observed.

WHY? Producing offspring uses a lot of energy. Why would individuals make so many if only a few can survive?



Think about it for a minute

Darwin's Observations

2nd Observation

There are a limited amount of resources (food, water, shelter) available to any given species. These resources limit the amount of offspring that can survive, yet species would quickly exceed that limit if all of their offspring survived.

WHY? Species would go extinct if their numbers outgrew the available resources. Why do individuals have the ability to produce enough offspring to easily deplete resources?

Think about it for a minute

Darwin's Observations

3rd Observation

The number of individuals in a group of the same species remains relatively constant over the long term.

WHY? Given the 1st and 2nd observation, why do we not see an increase in the overall number of individuals? Why does the overall number of individuals not decrease due to the limitations of resources?

Think about it for a minute

Darwin's Observations

4th Observation

Individuals of a species vary in almost all of their characteristics. He observed beak sizes in birds, shells of tortoises, spotting patterns of beetles, color of flowers and many more variations of common features.

WHY? It must be important to have these variations, but why?

Think about it for a minute

Darwin's Observations

5th Observation

Each mating season parents produce more offspring. The variations that are present in the successful parents are passed to their offspring. This process of **heredity** is repeated generation after generation.

WHY? It must be important to the species to have the specific variations of the successful parents, but why?

Think about it for a minute

Darwin's Observations

Now take 2 minutes and look over your thoughts regarding the previous questions. Can you put your reasons for these observations of life into a few clear statements. Compare your statements with other students' statements.

Think about it

Darwin's Inferences

In the previous activity you were producing **inferences**. These are statements made taking into account past observations. This is how a hypothesis is created.

Darwin did the same. Compare your inferences with Darwin's...

Darwin's Inferences

1st Inference

A **population** is a group of individuals of the same species living in the same geographic area that are capable of interbreeding. The individuals of a population are in constant competition with one another for the limited resources available.

This inference is based on the first three observations. It accounts for why populations remain relatively constant in number of individuals even though there is a high number of offspring in each new generation.

Darwin's Inferences

2nd Inference

The variations in the individuals of a population help the individual to survive or can lead to its death in the competition for survival.

This inference is based on the fourth observation. It explains the purpose of variation. They give an individual more or less chance at survival. Any variation that consistently helped individuals survive would be beneficial to the entire population.

Darwin's Inferences

3rd Inference

Individuals that survive the competition are able to breed and produce offspring. Since these individuals pass their traits on and the losers do not, over many generations the different rates of survival based on variation causes the population to transform. The "good" traits survive, the "bad" traits are weeded out.

This inference is based on the fifth observation. It explains that heredity is the key to an evolving population. This inference has become know as **survival of the fittest**.

Darwin's Inferences

Practice

Explain the following scenario using Darwin's inferences. Work in small groups to produce step by step reasoning that is consistent with Darwin's ideas.

A population of bears living in southern Oregon has individuals with varying thickness in their coats of fur. Over many years the climate of their area becomes 10 degrees hotter.

A scientist has recorded the number of thick furred individuals and thin furred individuals. Over the 10 years there has been a 50% increase in thin furred and 50% decrease in thick furred.

Darwin's Hypothesis

Statement: Evolution of a species and the genesis of new species occur by a process of **natural selection**.

Explanation: Individuals having certain characteristics that enable them to survive better than others contribute more offspring to the next generation than those having other characteristics. Since these characteristics are inherited the composition of the population is changed in the next generation.

Darwin's Evidence

Return to Table of Contents

Darwin's Evidence

In order to support his hypothesis of natural selection, Darwin collected many samples and other pieces of evidence to support his claim.

This evidence along with supporting input and evidence from many other scientists and institutions is why we now call Darwin's hypothesis...

The Theory of Evolution by Natural Selection.

Species of the Galapagos

The Galapagos Islands provided Darwin his important observations and the specimens of species he collected from them served as his primary evidence.

The Islands are close enough together to have similar climates but far enough apart to isolate the species that live on one island from the other islands.

Species of the Galapagos

Also their proximity to South America allowed Darwin to compare species from the main land to species in the islands.

Marine and Terrestrial Iguanas

Terrestrial iguana
Mainland S.America

- round tail
- eat mostly cactus fruit on land
- fear of man
- smaller skin flaps on back
- short, rounded claws
- small, flat teeth

Marine iguana
Galapogos

- flat tail
- dove to the bottom of the ocean to eat algae on the rocks
- no fear of man
- large skin flaps on back
- longer and sharper claws
- longer and sharper teeth

Physical Adaptations of the Marine Iguana

Darwin suggested that the terrestrial iguanas were ancestors of the marine iguanas who adapted to the conditions on the islands.

The main source of food for terrestrial iguanas was fruit from a cactus that is not available on the islands. This means the marine iguanas need to find another food source.

Physical Adaptations of the Marine Iguana

Suggest reasons for each of the trait adaptations below and compare to Darwin's reasoning.

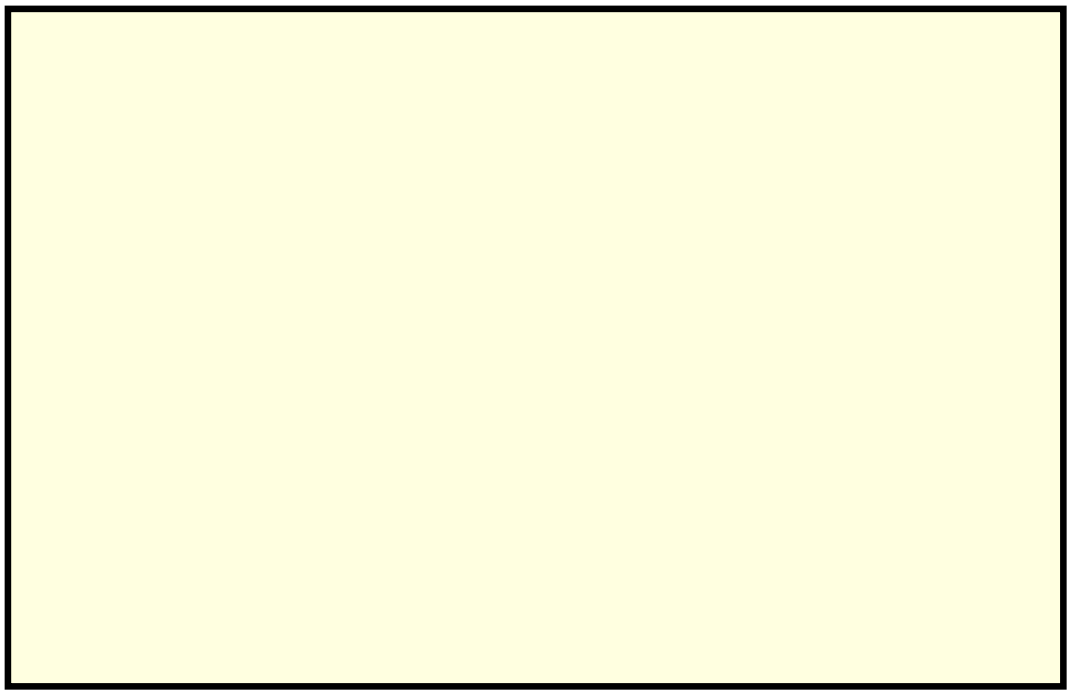
Flat tail:

Eat algae:

Large skin tags:

Sharp claws:

Sharp teeth:



Click square to see Darwin's reasoning

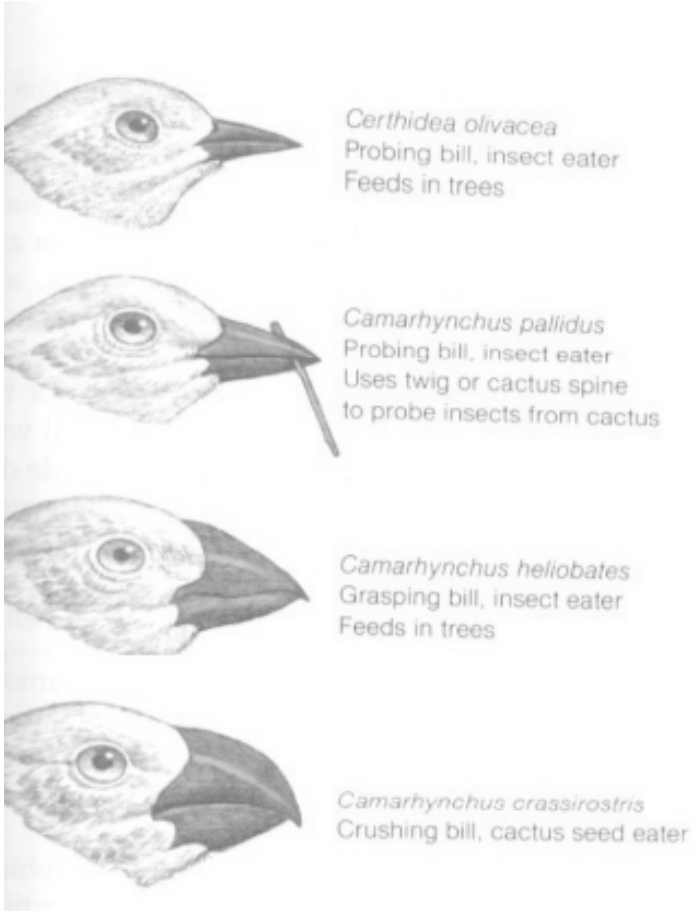
Darwin's Finches

While in the Galapagos, Darwin also studied small songbirds called finches. He studied their anatomy and feeding habits.

He saw that there were many varieties of beaks among the finches.

large beaks
small beaks
thin beaks
thick beaks

Finch Beak Size and Function

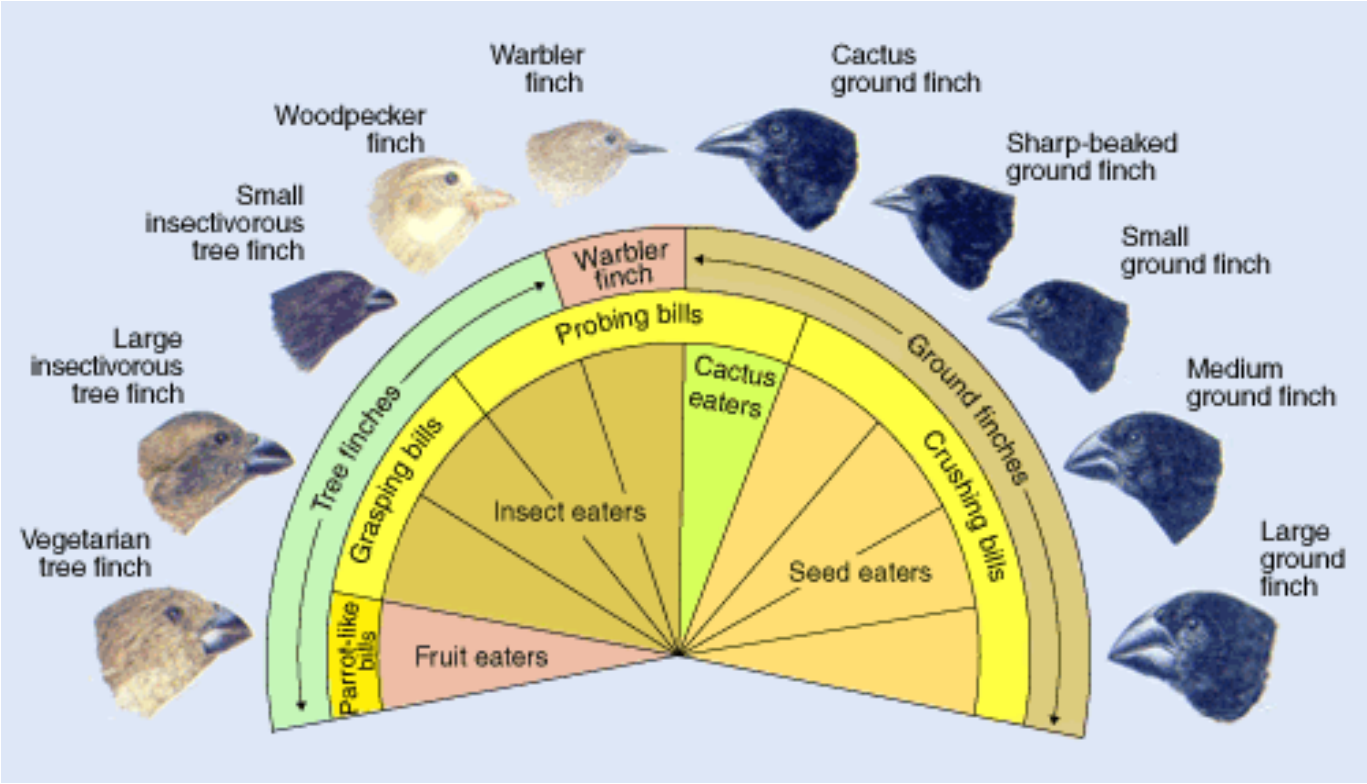


When back in England, Darwin arranged his finch specimens by the island they came from.

He realized that birds from the same island had similar beaks but birds from different islands had large variations

Can you suggest a reason for the variation by island?

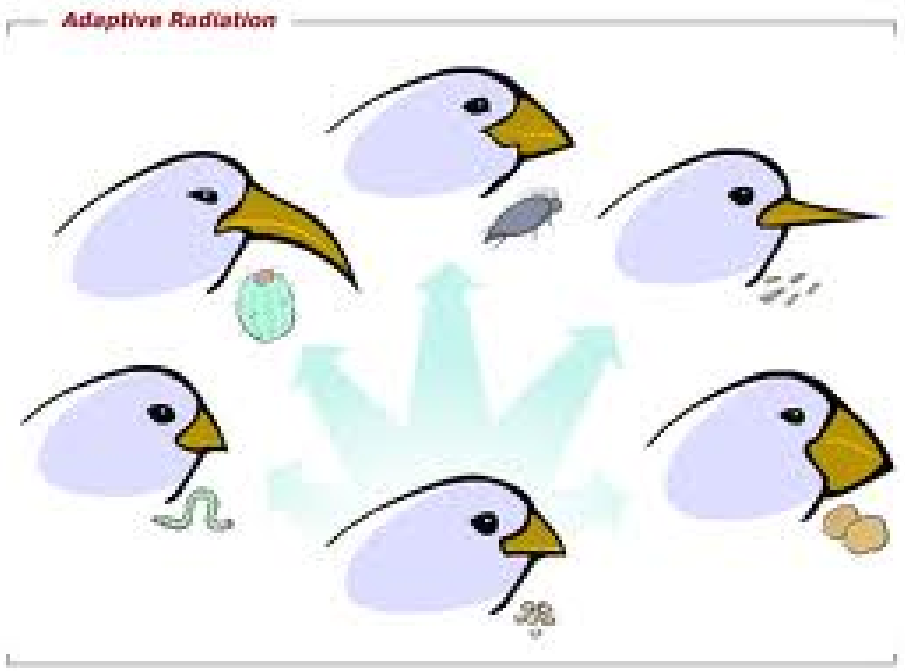
Finch Beak Size and Function



Finch Beak Size and Function

After further study it was shown that the South American Common Ground finch was the **common ancestor**, the species that existed before the others, of all the finches Darwin brought back from the islands.

Adaptive Radiation

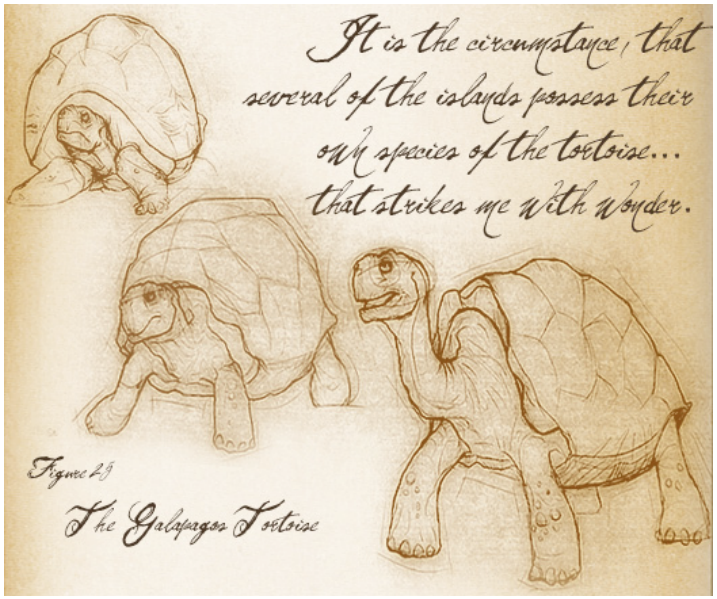


Darwin identified this kind of evolution as adaptive radiation.
One ancestor giving rise to many new modified populations.

Darwin's Notebooks

While in the Galapagos, Darwin studied all of the animals and plants there.

Darwin's notebooks were filled with his drawings and descriptions of everything he saw.



The full text of Darwin's observations, drawings and reflections during his voyage around the world available at:

Click here for The Voyage Of The Beagle by Charles Darwin.

Darwin's Return to England

Upon Darwin's return to England, his collections were hailed by the scientific community.

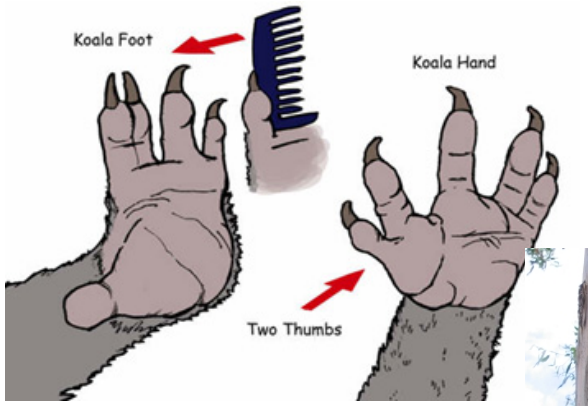
He immediately began to send out specimens to other scientists for examination while he began to piece together the evidence to determine the mechanism by which evolution happens.

Adaptations

As Darwin continued to study his specimens, he focused on **adaptation** He began to see that this was the driving force behind evolution.

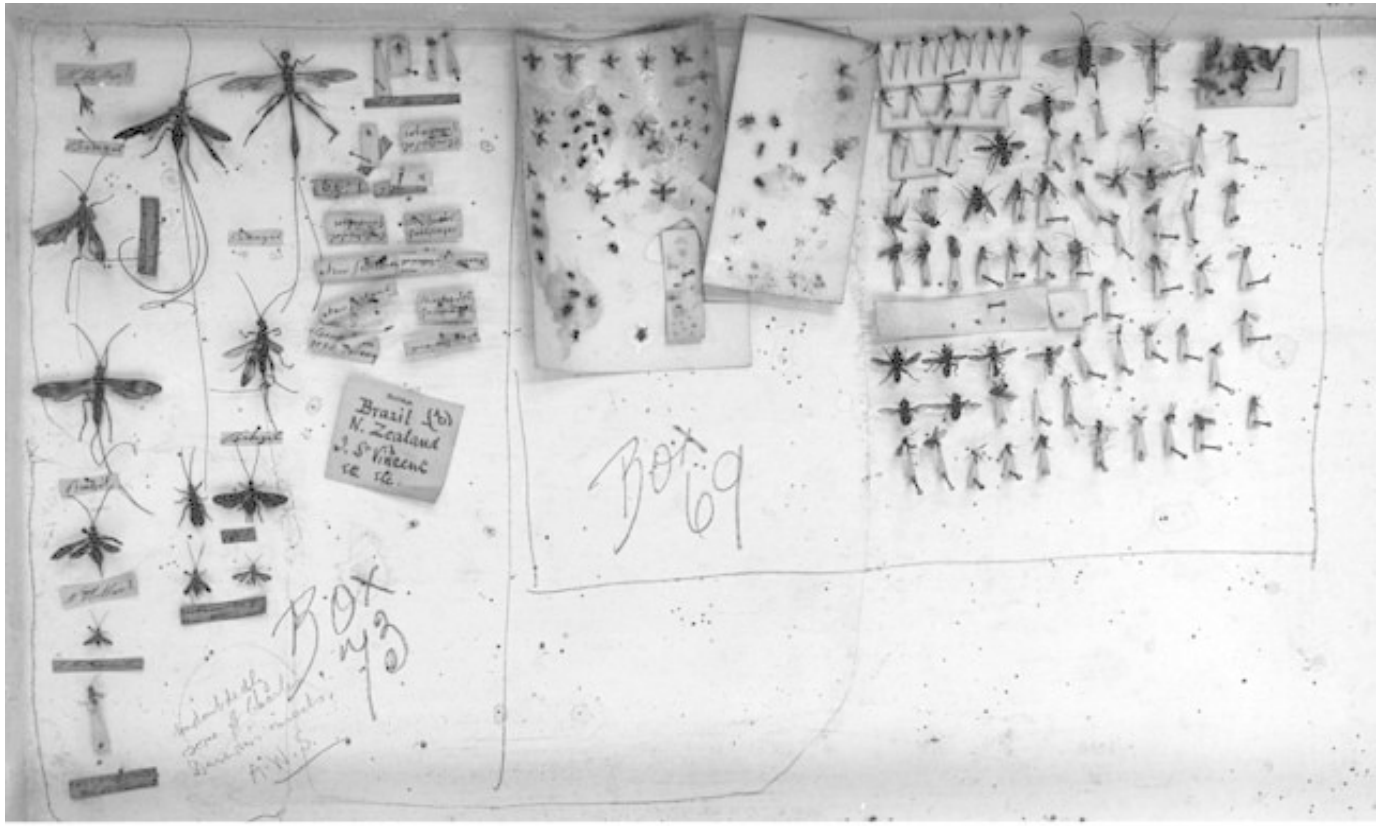
An **adaptation** is a trait - structure, function, or behavior - that makes a living organism better able to survive and reproduce in its environment.

Example:
A koala has two thumbs on each hand, which enables it to get a better grip when climbing trees.



Adaptation

One of Darwin's examples: insects that fed on flower nectar needed special organs to get to the nectar of the specific species of flowers that existed on the different islands. **Adaptation led to evolution and new species coming into existence.**



Darwin's Bug Collection from the Galapagos and South America

Origin of Species

Darwin had eventually outlined his theory of natural selection as the driving force behind evolution but he did not publish his findings immediately because he feared the public uproar it may have caused.

He began writing an essay entitled "On the Origin of Species by Means of Natural Selection" in 1844 but did not finish it until 1858 and published it a year later.

He only published it after reading the work of another naturalist, Alfred Russell Wallace, who had come to a similar conclusion about natural selection.

Click here to see a video of Wallace's collection

Darwin's Theories

From his work, Darwin developed two main theories:

1. **Evolution explains life's unity and diversity.**
2. **Natural selection is the cause of adaptive evolution.**

Unity & Diversity

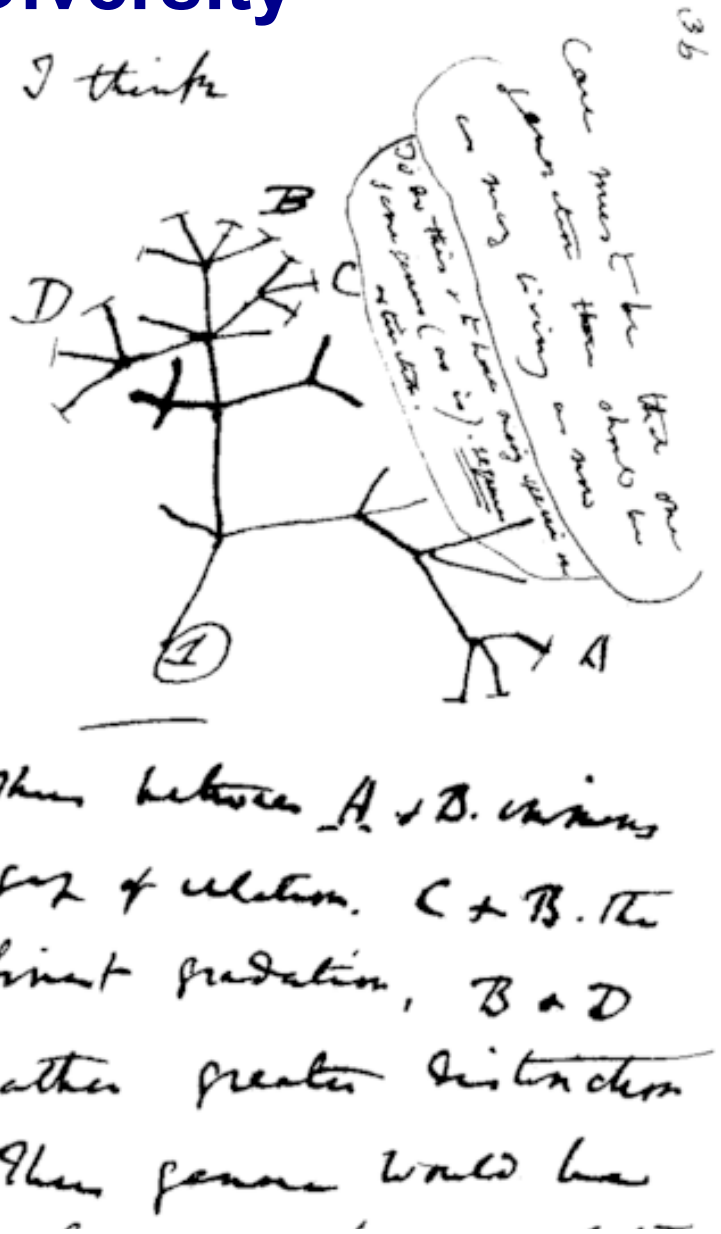
Darwin used the term "Descent with Modification", which was how he viewed the changes that took place in living things over time.

Darwin stated that all organisms were unified in that they all descended from a common ancestor that lived long ago.

Unity & Diversity

"I think case must be that one generation should have as many living as now. To do this and to have as many species in same genus (as is) requires extinction . Thus between A and B the immense gap of relation. C and B the finest gradation. B and D rather greater distinction. Thus genera would be formed. Bearing relation to ancient types with several extinct forms"

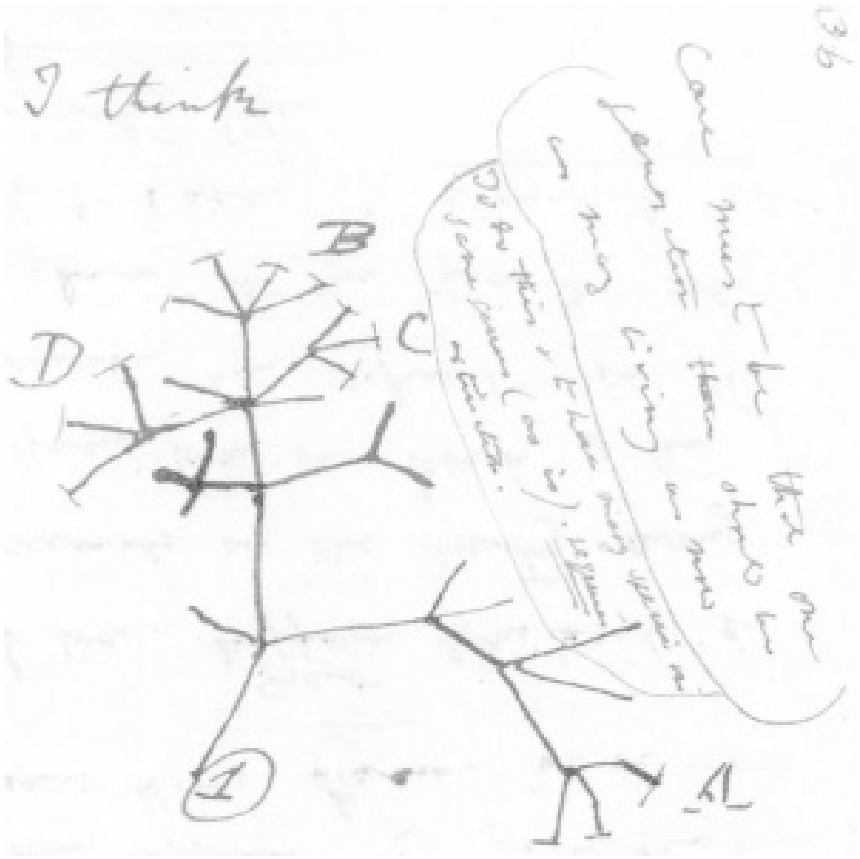
- Charles Darwin 1837 notebook. First drawing of the tree of life.



Unity & Diversity

As the descendants of this common ancestor spread to different habitats over millions of years, they accumulated adaptations that enabled them to be fit in their environment.

Darwin viewed life as a tree with a common ancestor found at the trunk and all the branches from it that represent the diversity of living organisms.



Natural Selection

Return to Table of Contents

Natural Selection

The following slides illustrate the different modes of natural selection and the effect it has on a **population.**

A population is the smallest unit that can evolve. We will see that individuals cannot evolve. They can only contribute their genes to the next generation of the population.

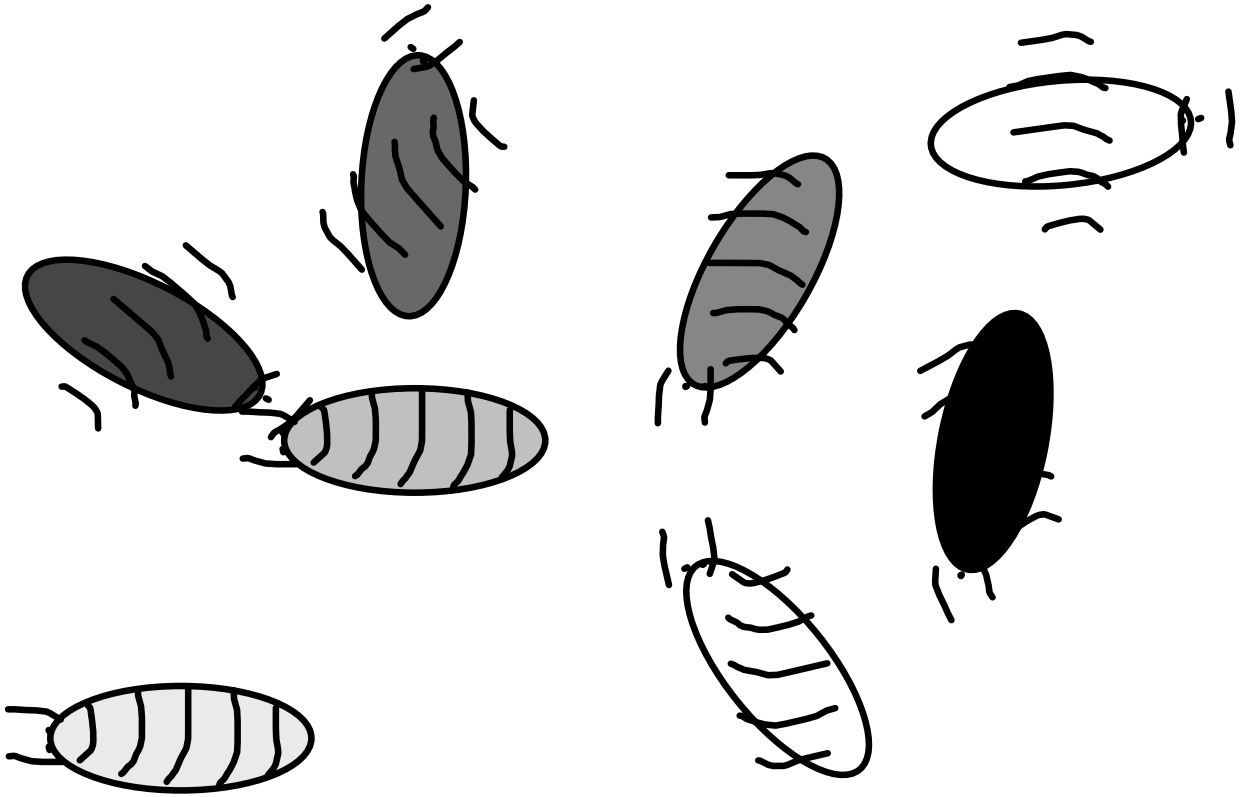
Roly Poly Selection

Armadillidium vulgare, known as pill bugs or roly polys, are a favorite snack of predatory birds. For this reason they tend to evolve to the color of the ground they inhabit for camouflage.

But how do they know the color of their background? The answer is they don't, they are bugs with very little brain power.

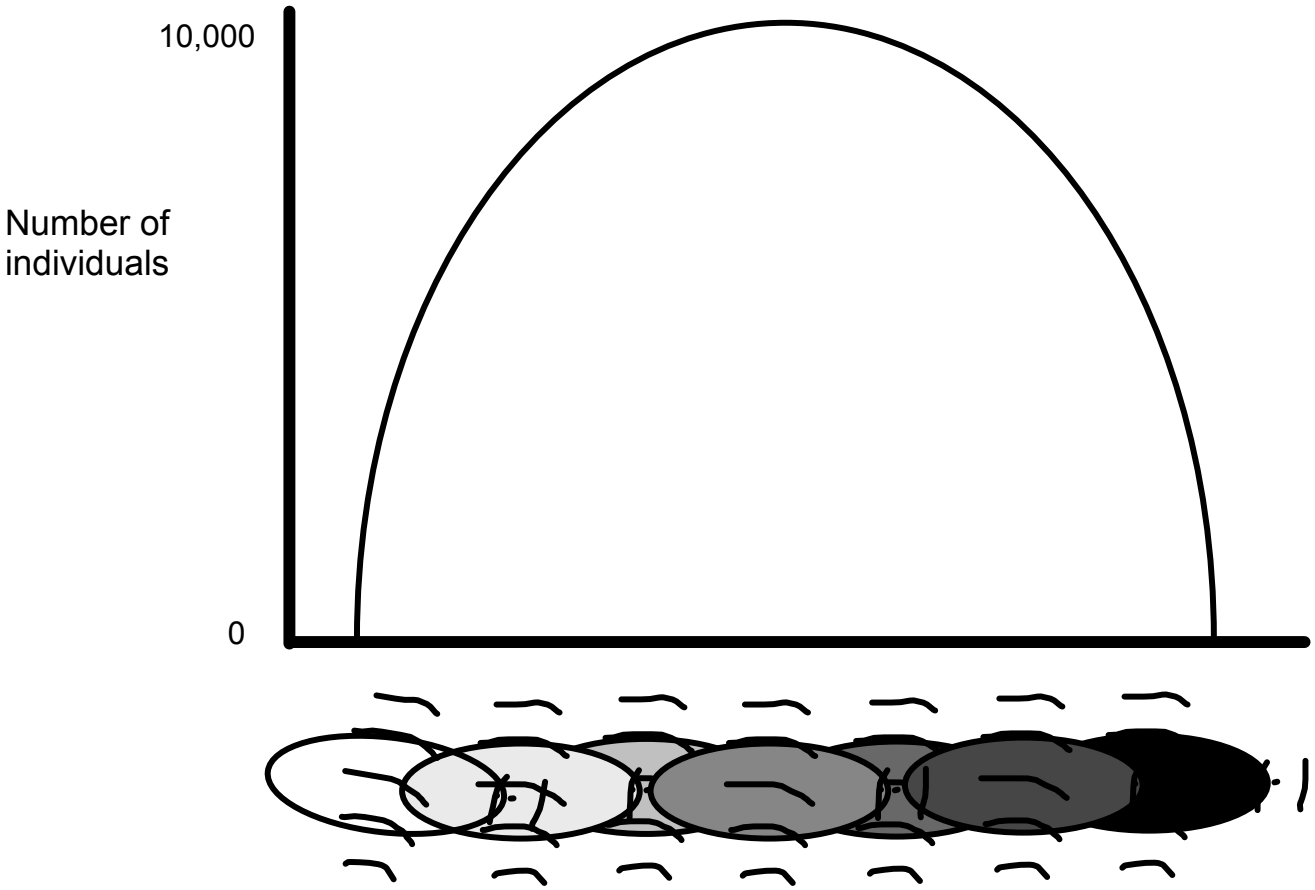
Roly Poly Selection

Let's consider a fictitious population of roly polys that migrate to a new area. This population has a gradient of shades that run from white to black.



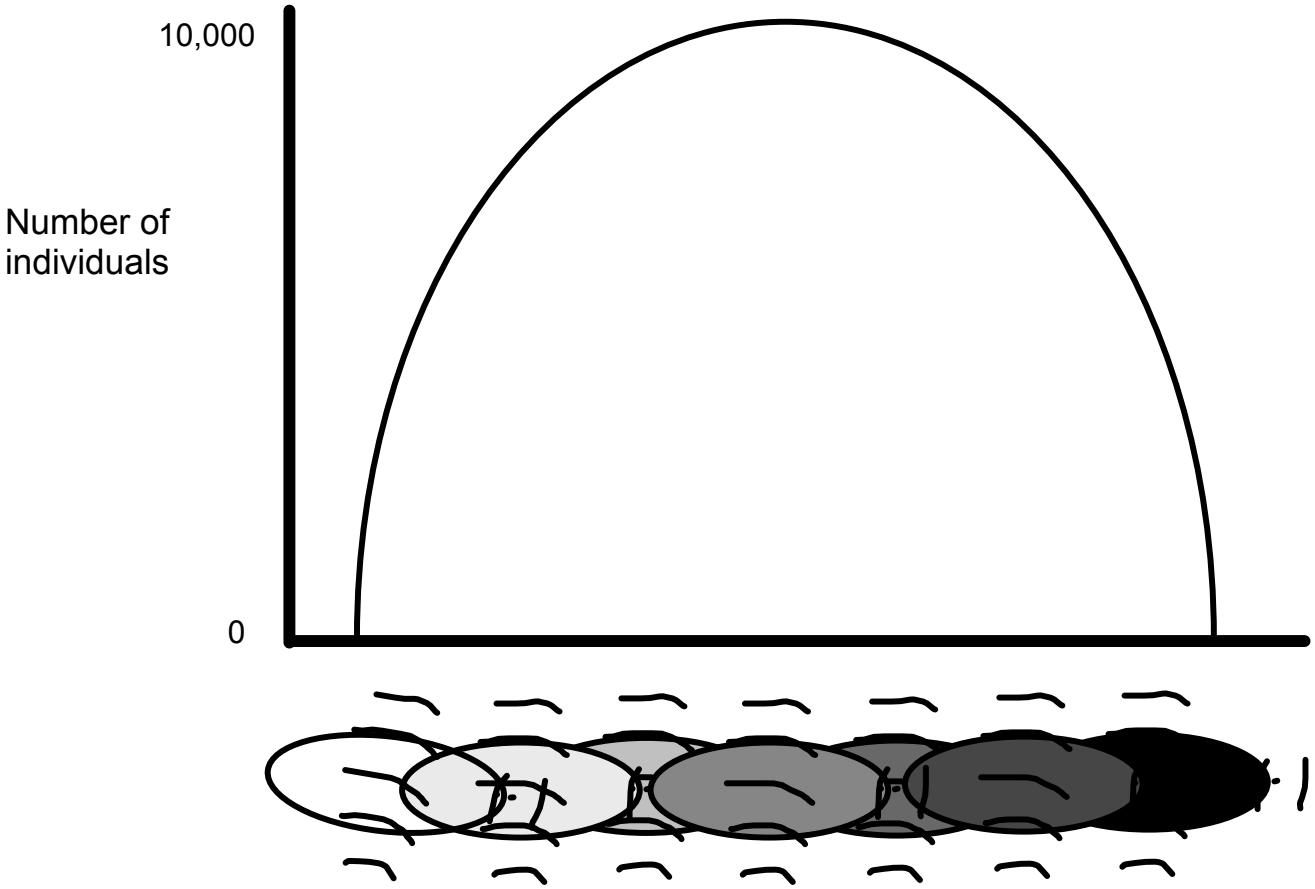
Roly Poly Selection

A scientist studying the population randomly samples the individuals and creates a graph that shows distribution of shade



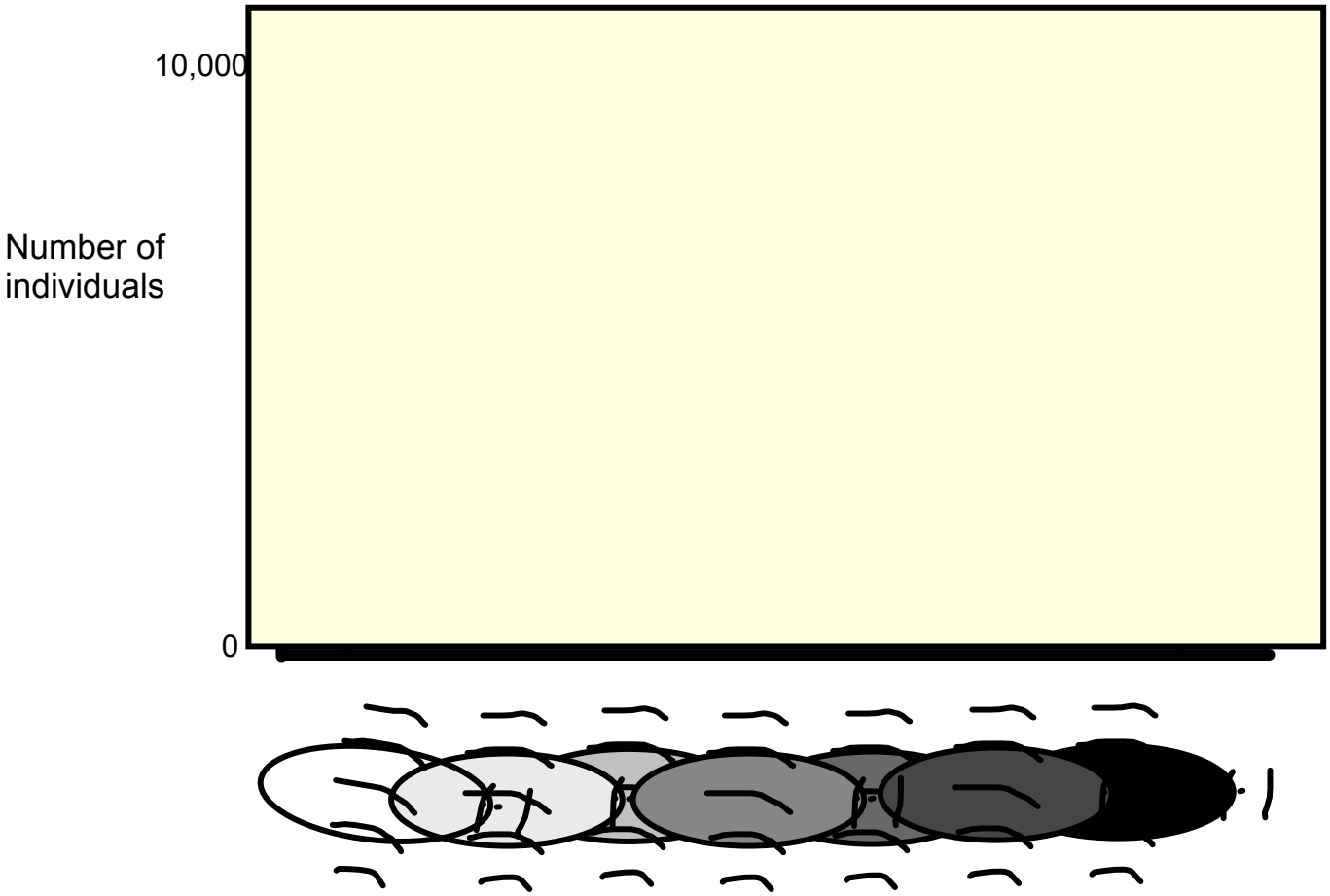
Roly Poly Selection

Imagine that this population has moved to an area where the soil is fertile and black. What would happen to this curve if we resampled the population 5 years later? There are many hungry birds that live in this area. Draw your prediction.



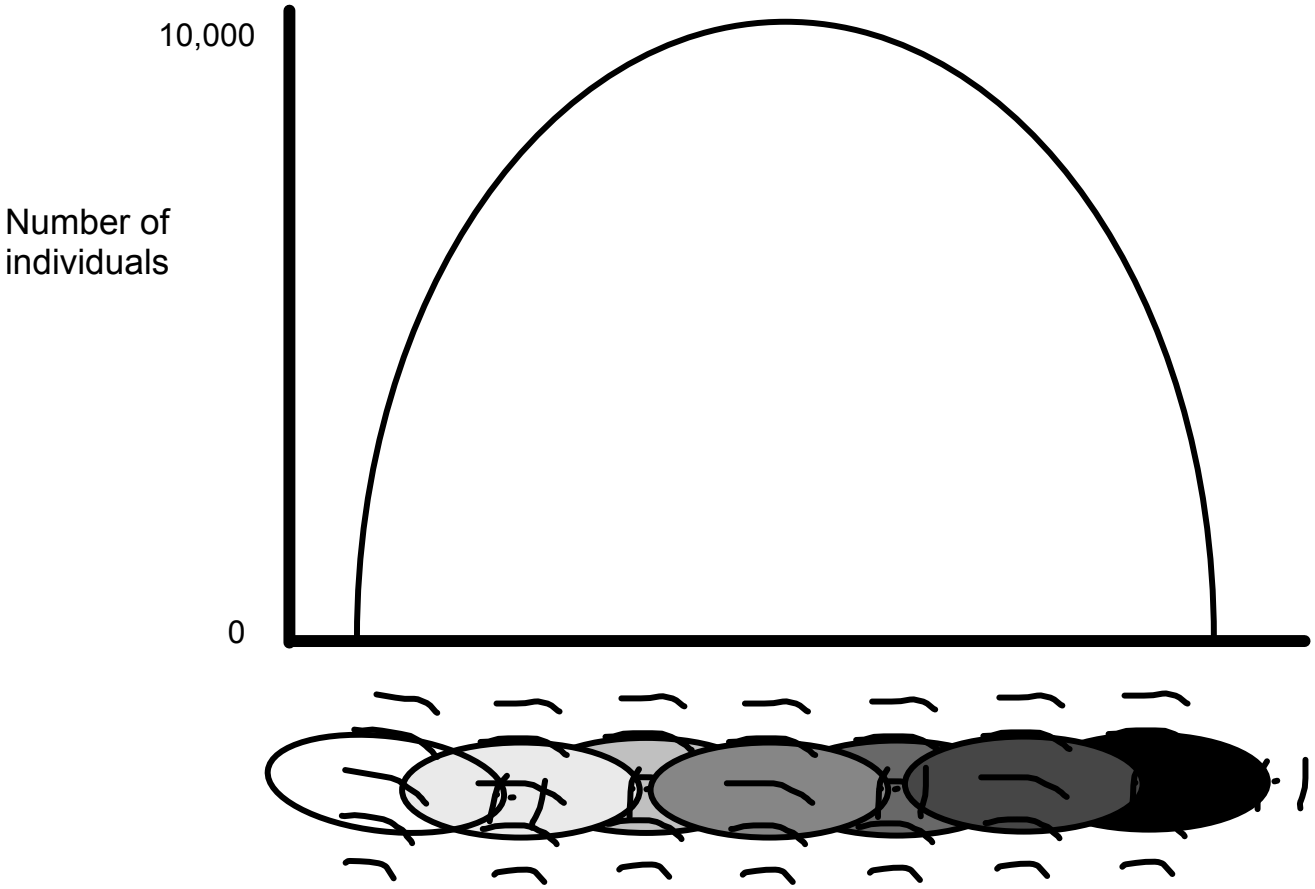
Roly Poly Selection

This is what the scientist observed. Birds ate mostly the lighter colored. In other words, the environment favored the camoflaged darker roly polys. This is called **directional natural selection**.



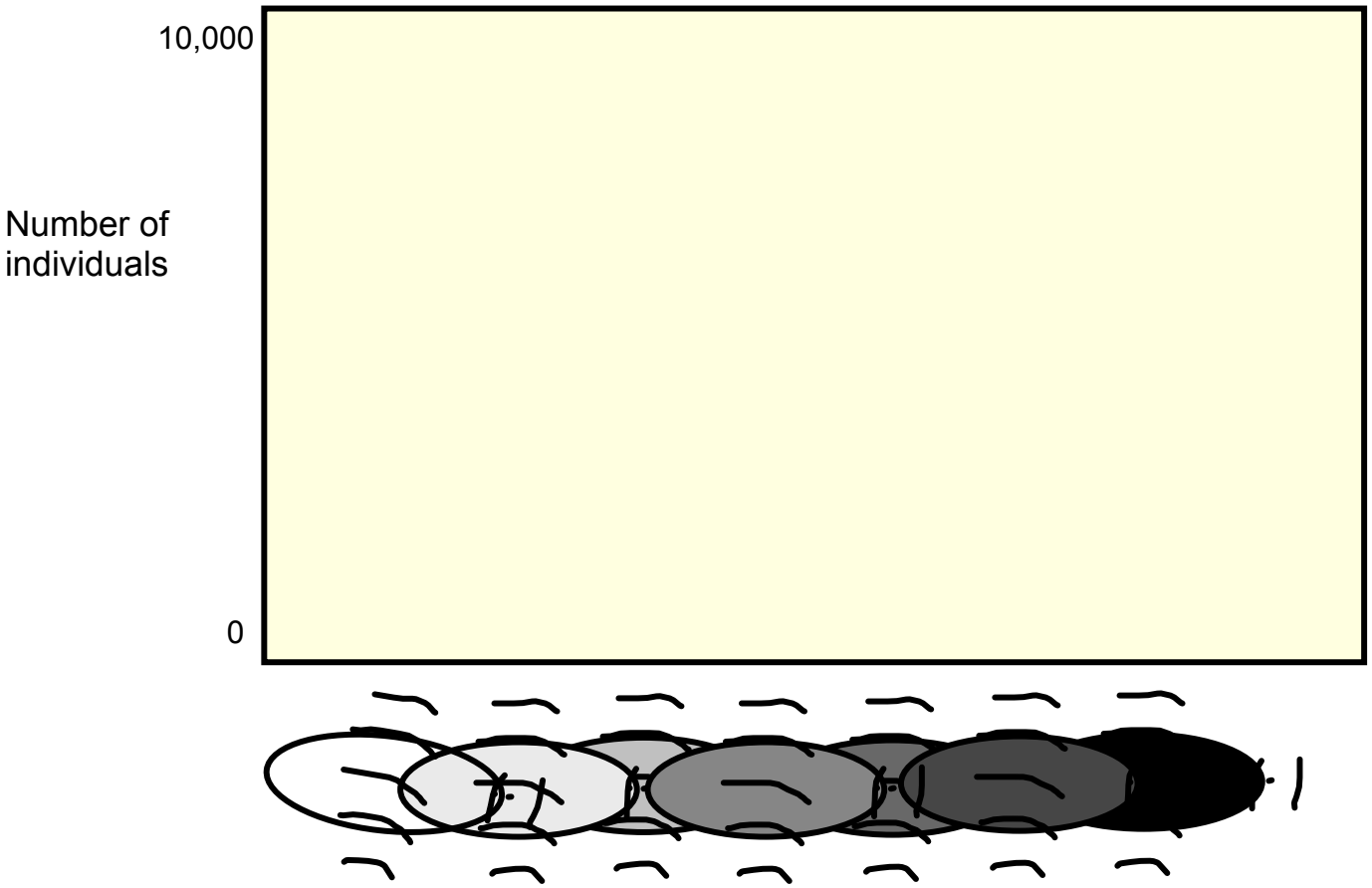
Roly Poly Selection

Now imagine this poulation has moved to an area that has ice on the ground year round (remember, fictitious). What would be the outcome? Draw your prediction.



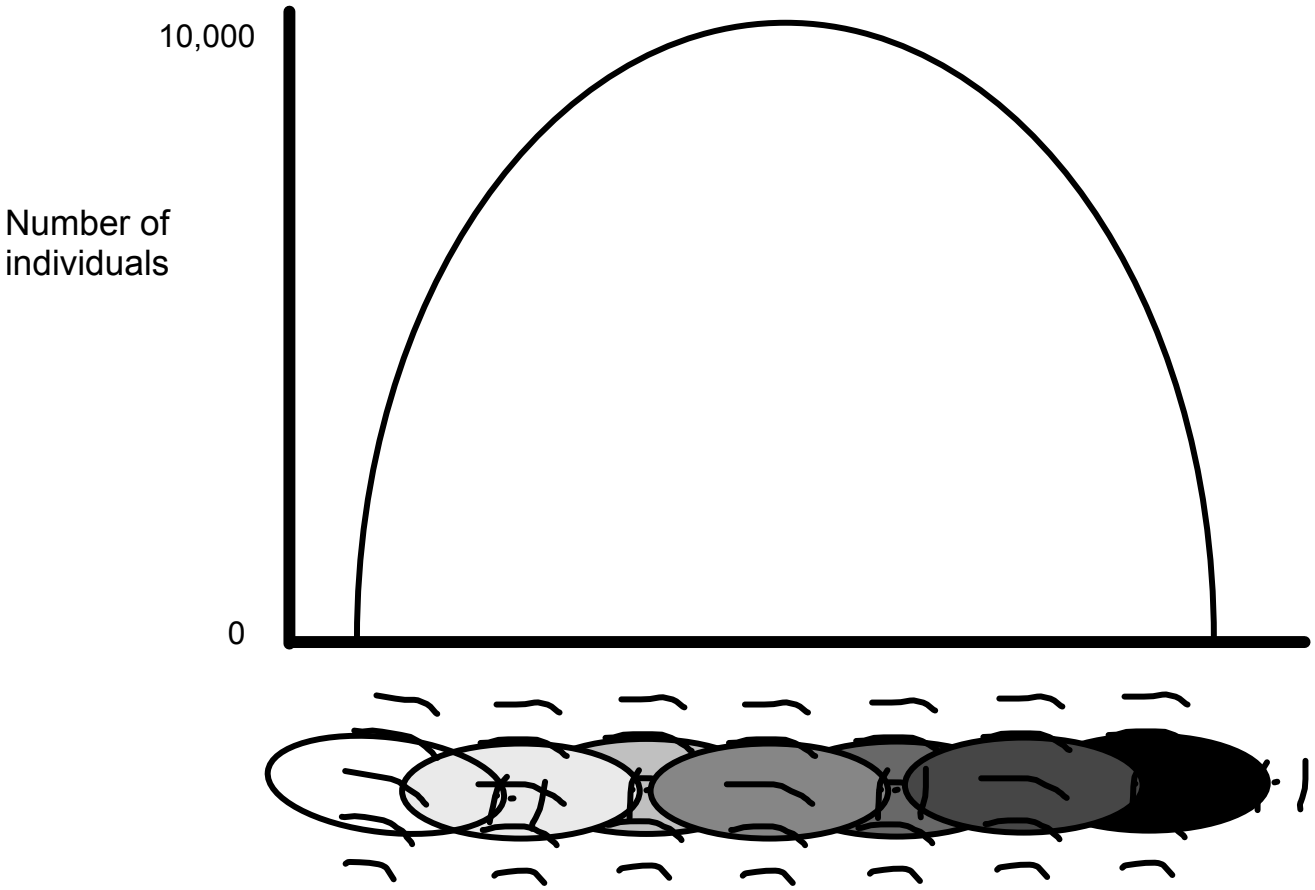
Roly Poly Selection

This is what the scientist observed. Birds ate mostly the darker colored. In other words, the environment favored the camoflaged lighter roly polys. Again, **directional natural selection** occured.



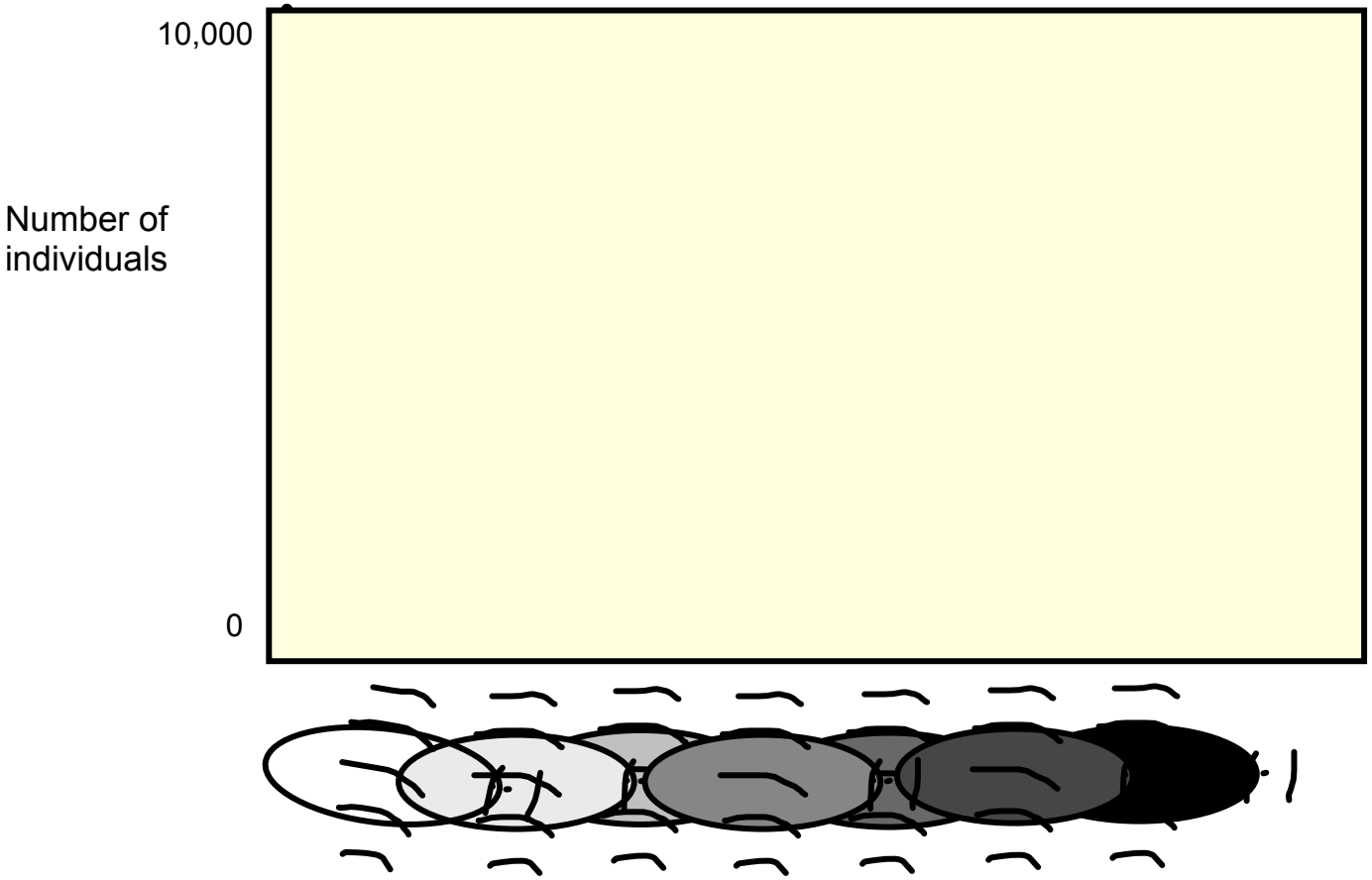
Roly Poly Selection

Now imagine this population has moved to an area where it is snowy in the winter and fertile soil in the summer. What would happen to the populations color distribution?



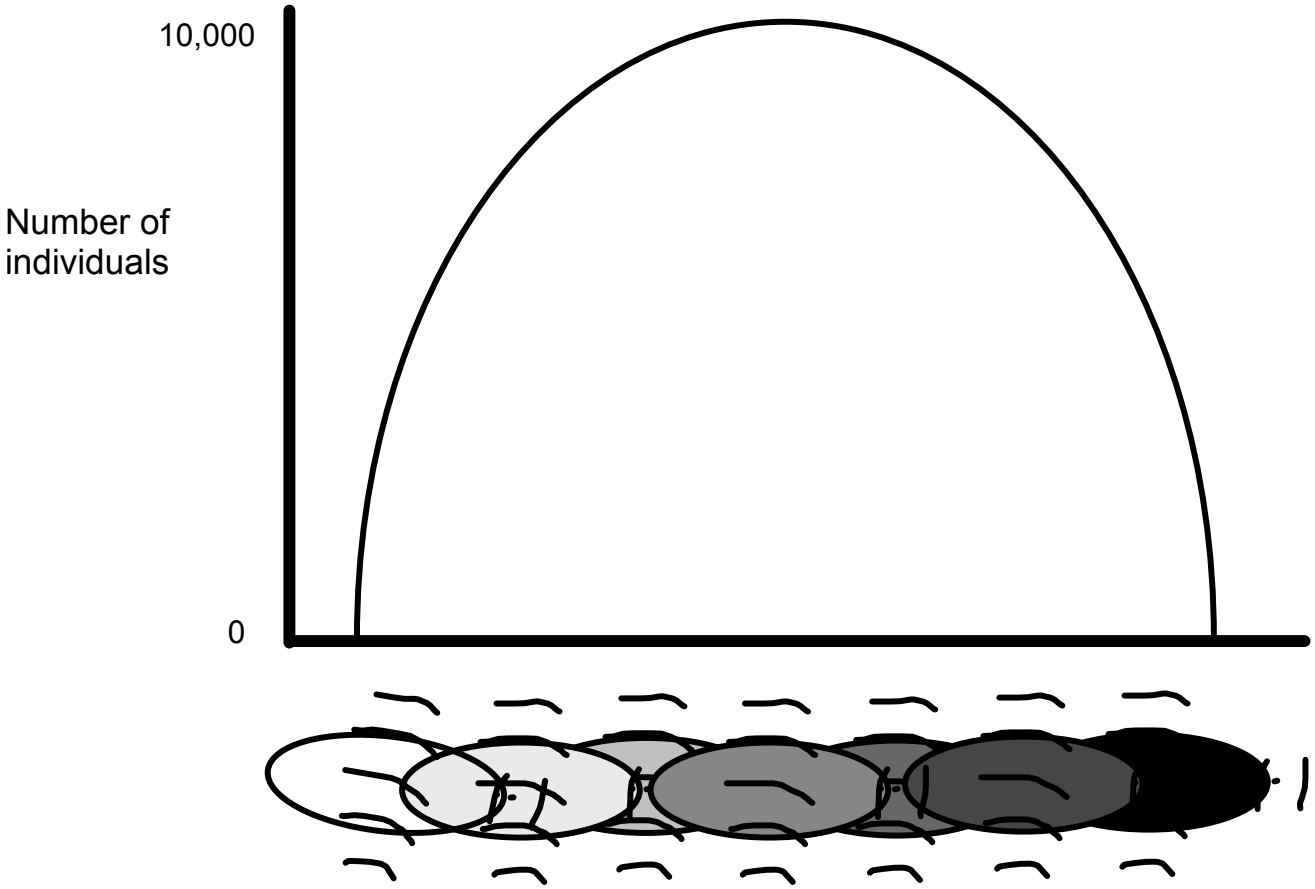
Roly Poly Selection

This is what the scientist observed. In the summer the dark were protected, in the winter the light were protected. through out the year the grey ones were visible so they were eaten year round. This is called **disruptive natural selection**.



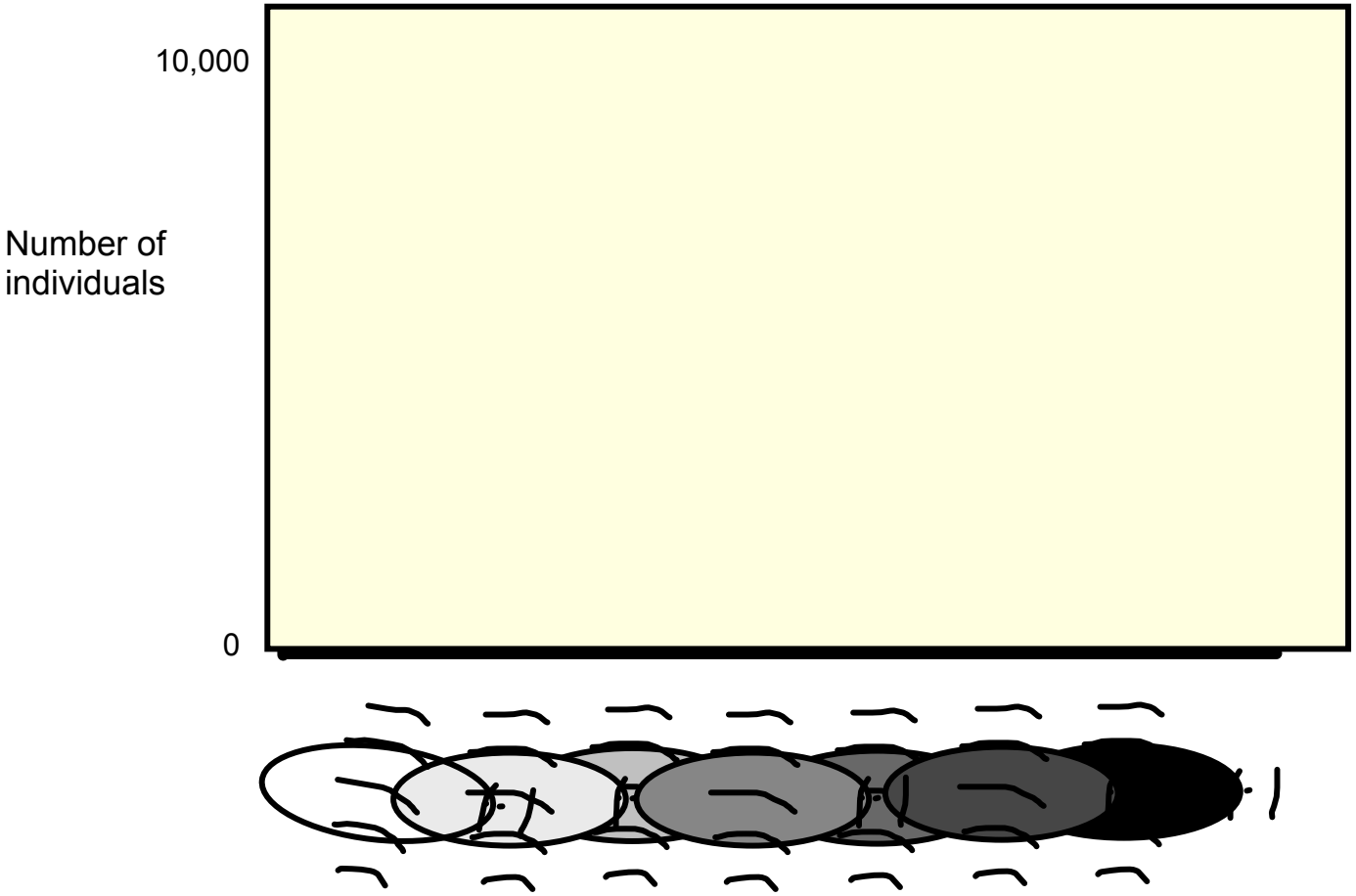
Roly Poly Selection

Now imagine this population has moved to an area where there is grey sedimentary rock all year. What will happen to the distribution? Draw your prediction.



Roly Poly Selection

This is what the scientist observed. The grey were protected year round and the darker and lighter ones were more easily seen by the hungry birds. This is called **stabilizing natural selection**.



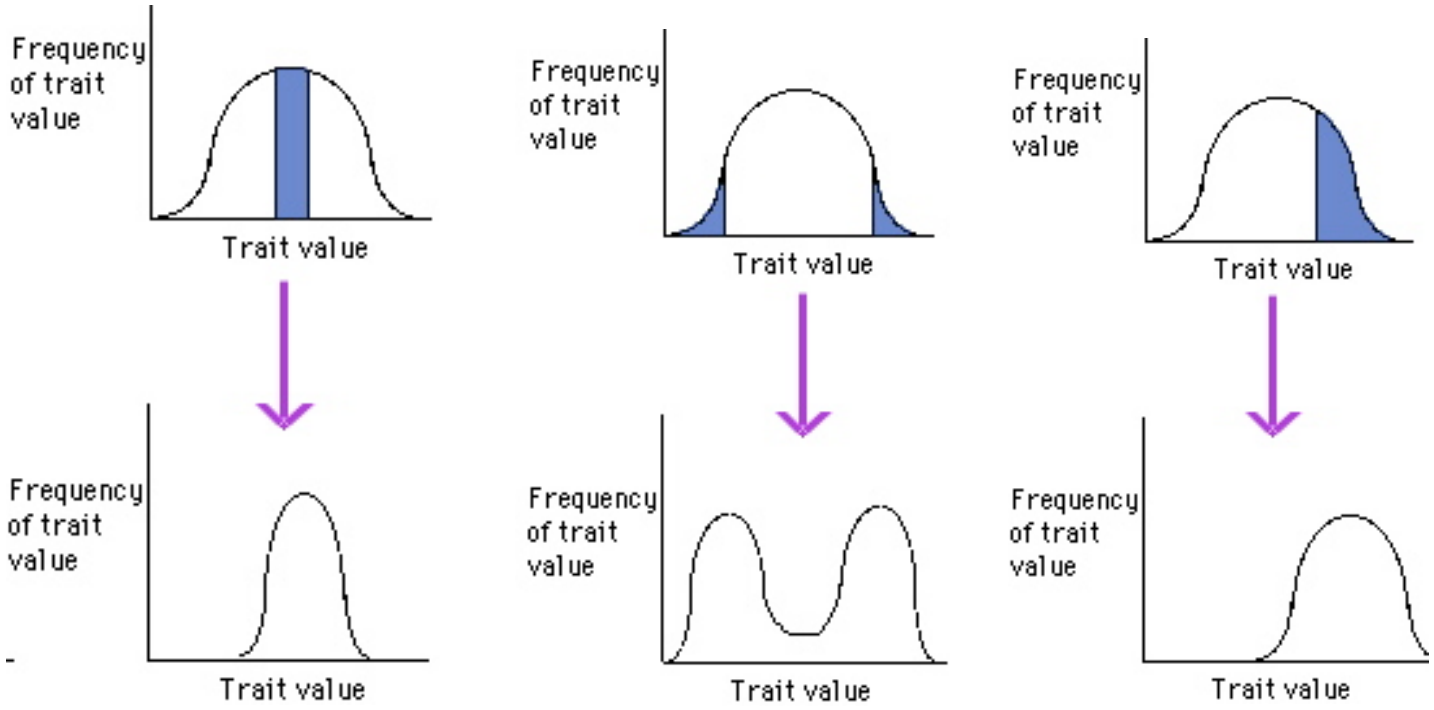
Natural Selection

In each subsequent generation, environmental factors play a role in which organisms are selected for or against. Those organisms that have the adaptations to better fit in the environment have increased fitness and have a better chance to survive and reproduce.

Increases in the frequencies of favored traits in a population from one generation to the next modifies the gene pool.

All of the genes in a population at any given time are referred to as the **gene pool** of that population.

Natural Selection



Stabilizing

Disruptive

Directional

Natural Selection

The following is a video about natural selection. The information within the video will be used to complete an activity. You should take notes on the important points.

Click here to watch a video on Natural Selection

Click here for the printout of the activity.

Teacher Note: Procedure 1-3 should be done first in class, then the video should be watched in class. The rest of the procedure and questions should be finished as homework or during the remainder of the class period.

Mutations & Hardy-Weinberg

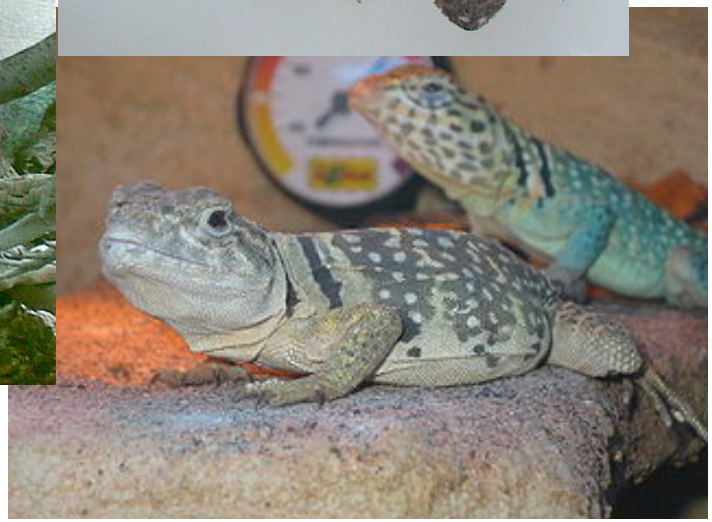
Return to Table of Contents

Mutations

Mutations are how new alleles are introduced within a population. Small changes in the genetic code that produce favorable traits will survive in a population. Those mutations that produce unfavorable traits will perish with the individual that carries them.

Mutations

Mutations that cause new traits are the driving force behind evolution. Without them there would be no new variation for natural selection to create adaptations.

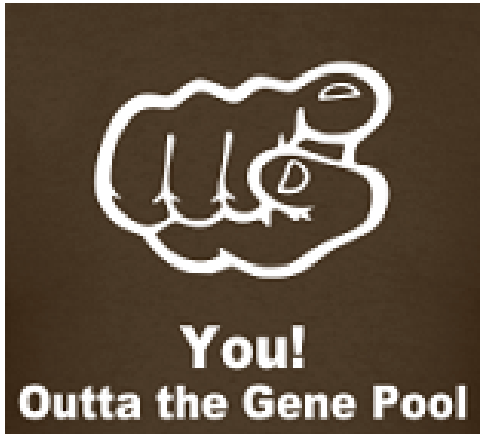


Population Genetics

A population's gene pool consists of all the genes in all individuals in that population.

Each variation of a gene has a **gene frequency** in the population. The gene frequency is the ratio of a particular allele to the total of all other alleles of the same gene in a population.

This frequency can be measured and then compared to its frequency in past or future generations. **If there is a change in gene frequency of the gene pool then the population is evolving.**



Non Evolving Populations

All of the examples given so far are of evolving populations because that is what we are trying to prove: populations evolve.

However, a good scientist knows that you have to look at the **Null Hypothesis (H_0)** as well as your hypothesis (H_1).

The null hypothesis is the opposite of your hypothesis.

Non Evolving Populations

In this case, we are saying that our hypothesis is:

H_1 = Populations evolve by descent with modification as proposed by Charles Darwin.

Our null hypothesis:

H_0 = Populations do not evolve by descent with modification as proposed by Charles Darwin.

Non Evolving Populations

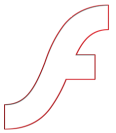
Looking back at the evidence that has been presented for our hypothesis, try to imagine what the conditions would have to be in order for a population to not evolve.

Remember, our contention is that if a gene pool changes the population has evolved. So how could you have a gene pool that **does not** change?

Try to come up with a list within your groups.

Sorry, this element requires Flash, which is not currently supported in PDFs.

Please refer to the original Notebook file.



Hardy-Weinberg Theorem

We use the Hardy-Weinberg Theorem to show what a non-evolving population would look like. It states that the parameters that would have to exist in order to stop a population from changing the frequency of genes in the gene pool. There are five parameters.

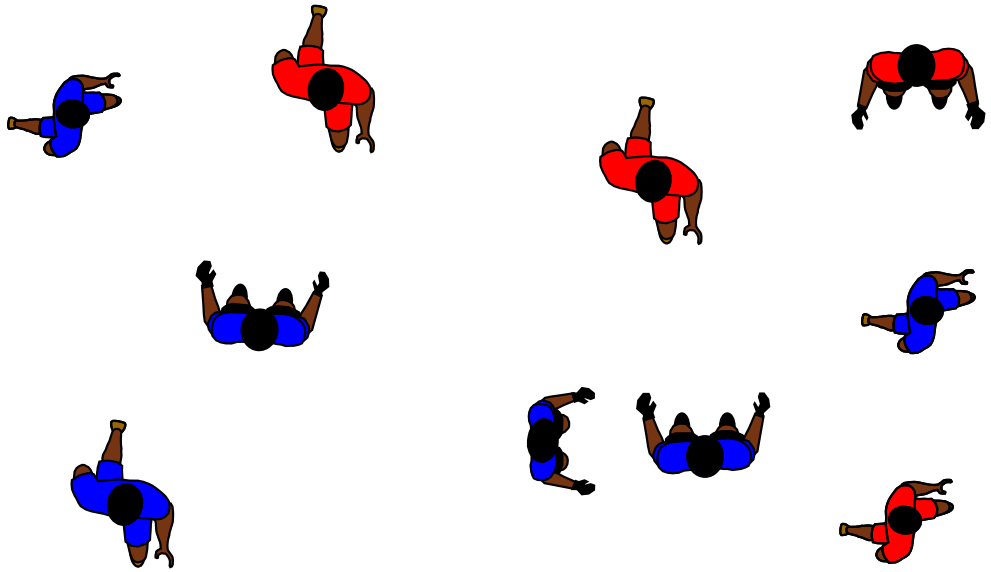
Condition #1: Large Population

Populations must be extremely large - in real life, populations tend to be smaller. They are localized in groups. The reason for the large size of the population is to ensure no genetic drift occurs and causes the gene frequencies to change.

.....in real life, this cannot hold true.

Condition #1: Large Population

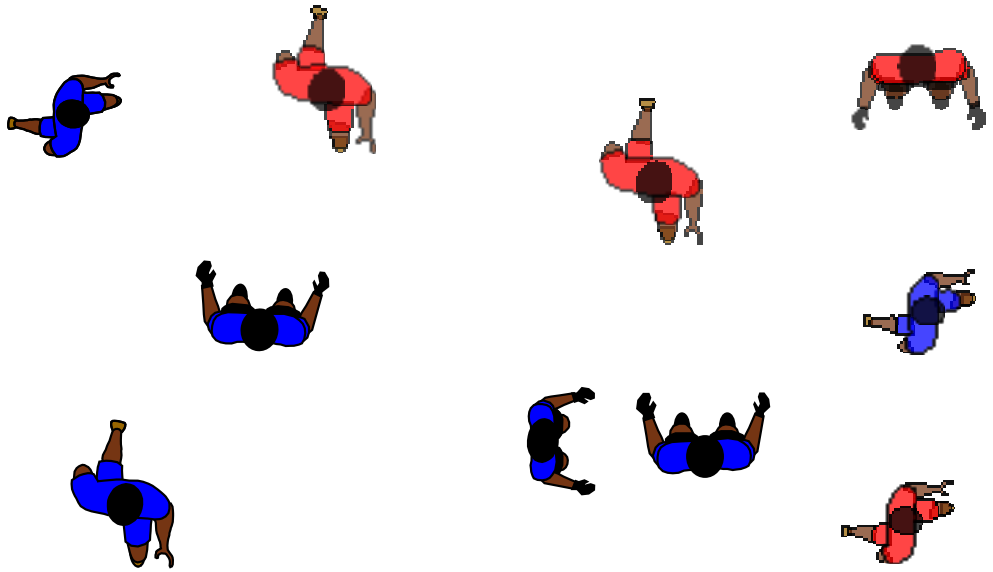
Imagine this pool of soccer players represents a small population.



60% Blue 40% Red

Condition #1: Large Population

Unfortunately lightning strikes the field and randomly kills 5 of the players. The gene frequency has been changed so the population has evolved.



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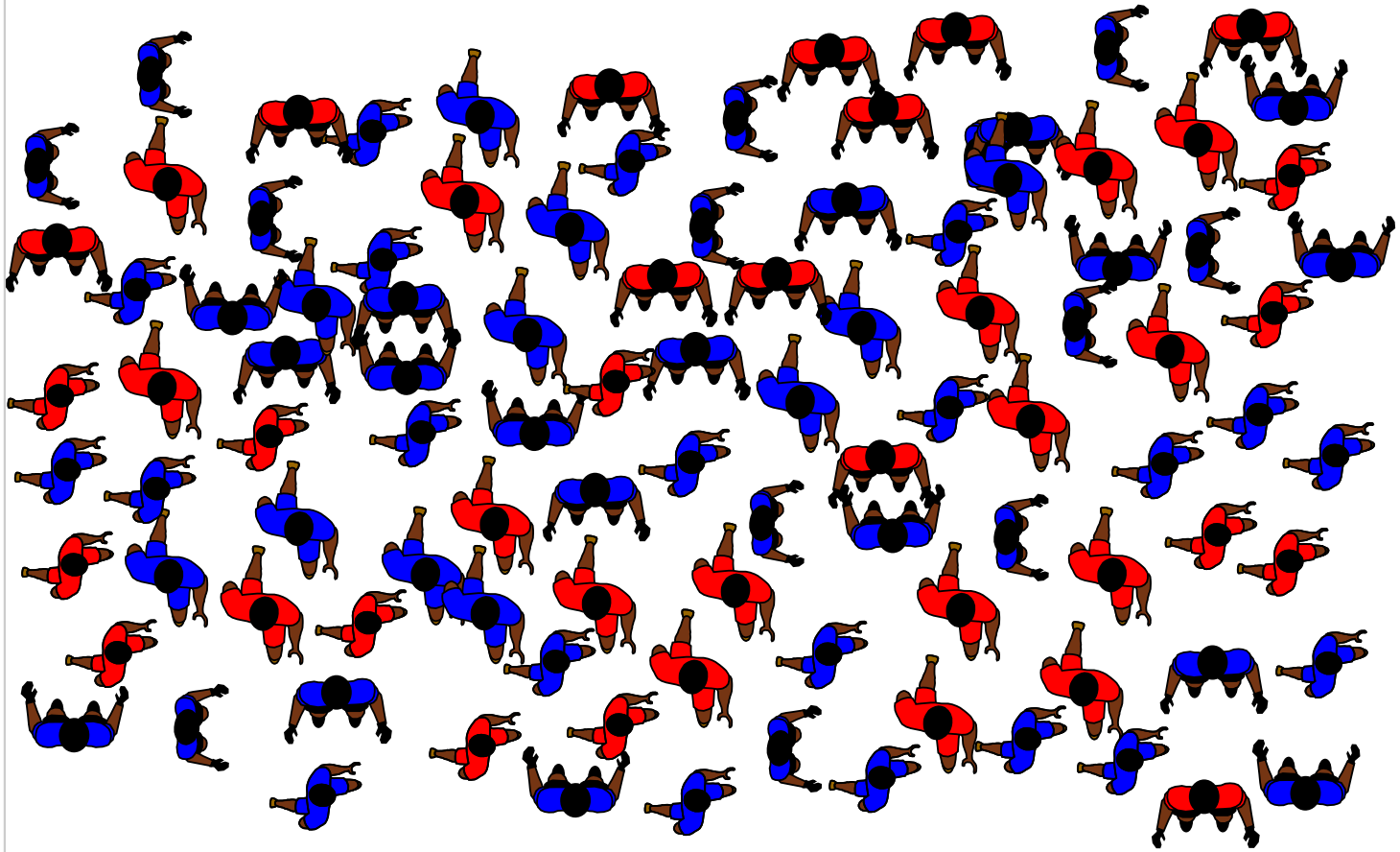
Condition #1: Large Population

These soccer players represent a significantly larger population



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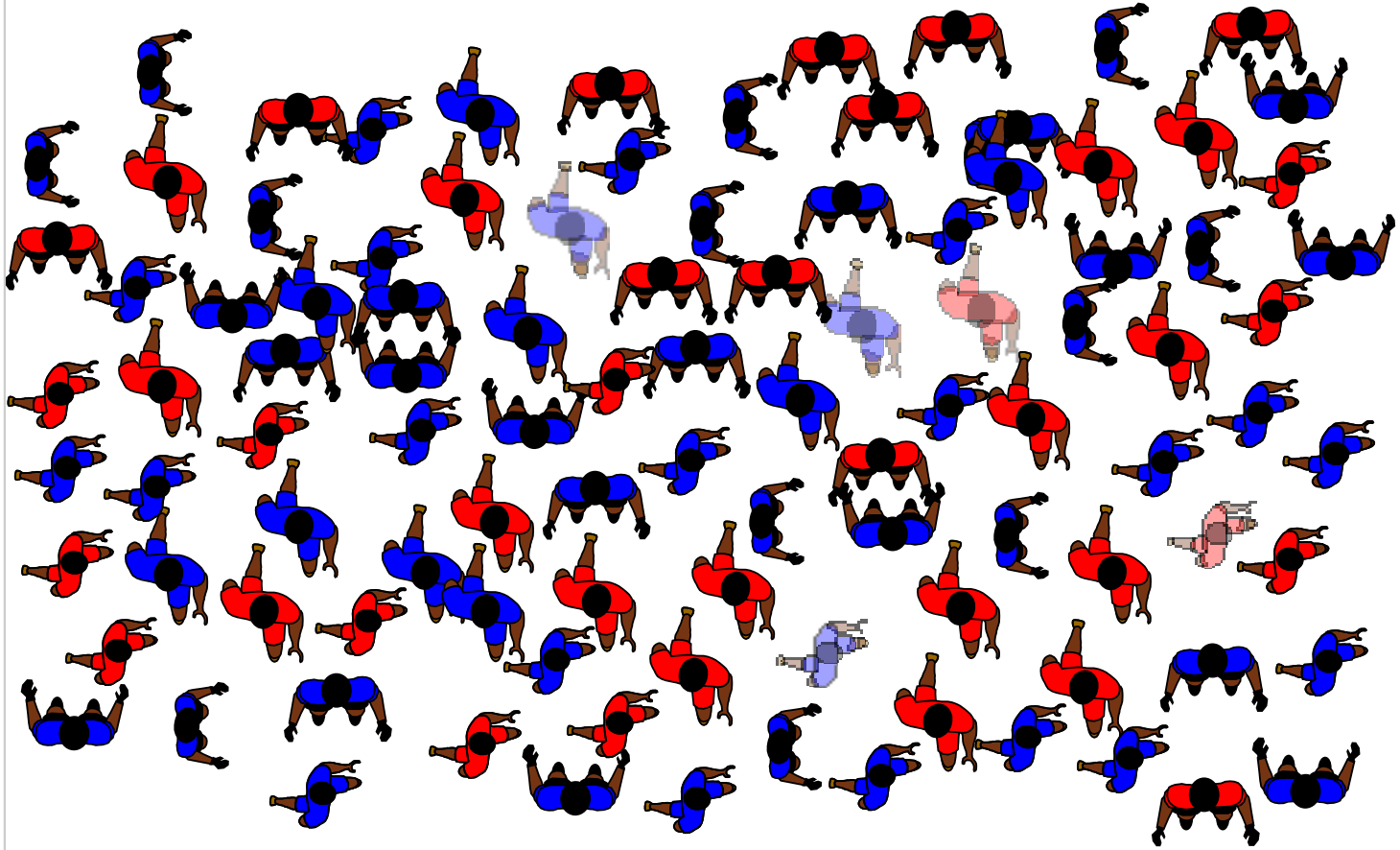
Condition #1: Large Population

If 5 players are randomly killed in this population there is much less of a chance that it will effect gene frequency. The larger the population the less it is affected by environmental events.



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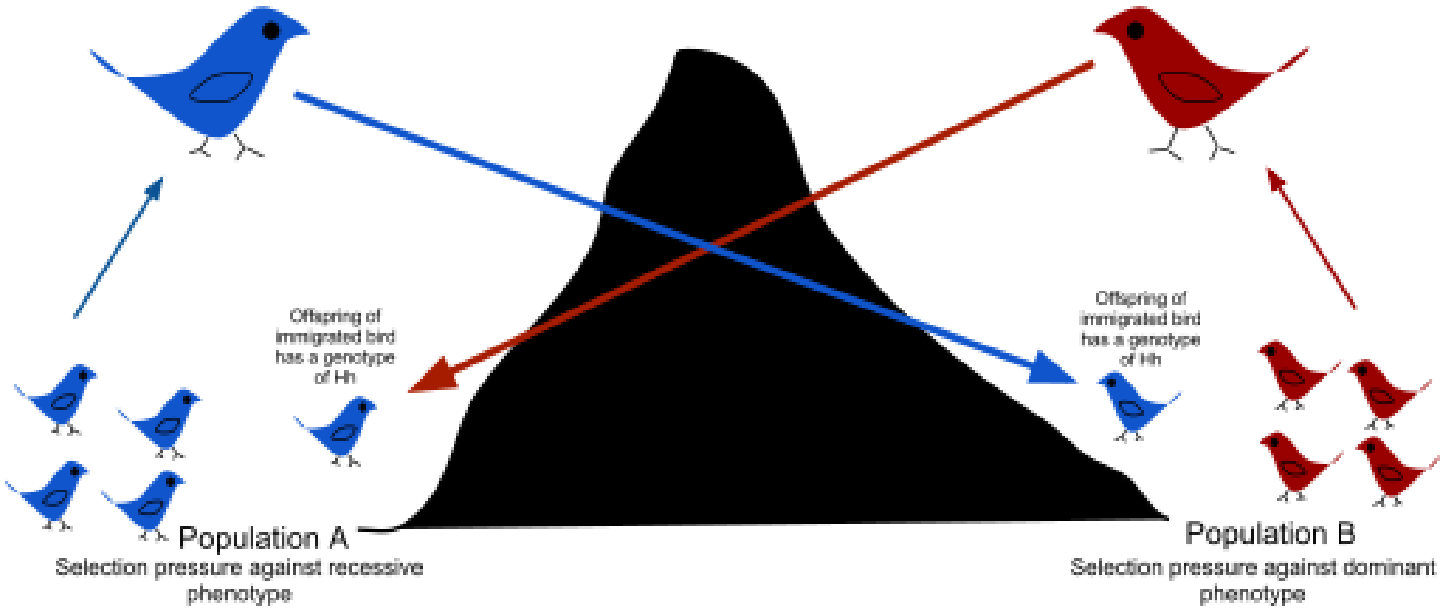
Condition #2 - No Gene Flow

No gene flow can occur in a population working within Hardy-Weinberg Equilibrium. Migration can not be occurring. In real life, you cannot stop organisms from migrating in and out of different populations. Real life populations do not have fences around them. You cannot stop theintroduction of or taking away of genes (gene flow) in a population from happening.

.....in real life, this cannot hold true.

Condition #2 - No Gene Flow

In this example of gene flow: one of the birds from population A immigrates to population B and vice versa. Through mating they incorporate genes into the other population.



Condition #3 - No Mutations

Unfortunately, there is no way to ensure**no mutations** occur in a population. Species have built-in mutation rates that help them gain and keep genetic variability.

Mutations are caused by many factors in the environment. Simply being exposed to the sun can cause mutations to occur.

.....in real life, this cannot hold true.

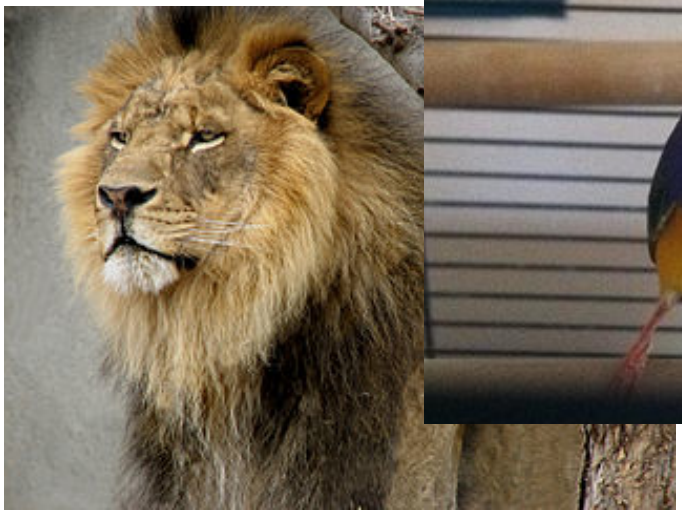
Condition #4 - Random Mating

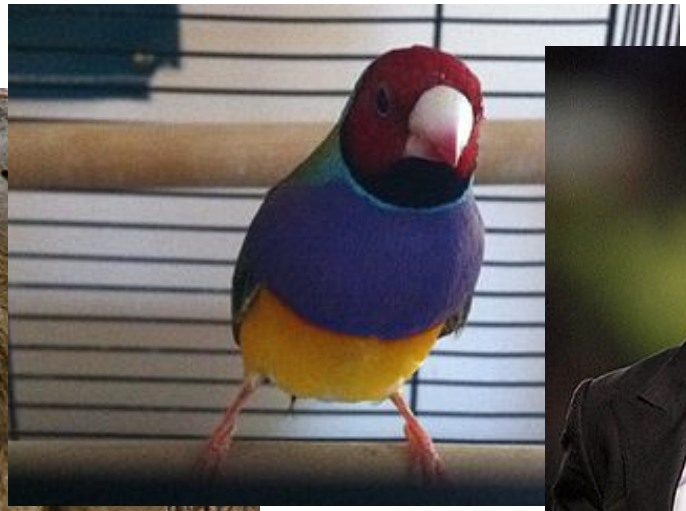
In Hardy-Weinberg Equilibrium, **mating must be random**. This is the mating of individuals regardless of any physical, genetic, or social preference. In other words, the mating between two organisms is not influenced by any environmental, hereditary, or social interaction. Hence, potential mates have an equal chance of being selected.

.....in real life, this cannot hold true.

Condition #4 - Random Mating

Most organisms CHOOSE their mates. It is almost always the female that chooses. For example, males in the animal kingdom tend to be more ornate than females. Having ornate features sends a signal to the female that this male has good genes, and he is a good partner for producing offspring. Therefore, the female will mate with the male who is most attractive.





http://topnews.in/people/david-beckham

Condition #5 - No Natural Selection

No Natural Selection - in real life how can you stop the environment from choosing the best fit and best adapted organisms? You can't...

There is no way to stop the environment from changing. There will always be floods, drought, volcanos, infections , fire, deforestation, competition, climate change, ...

.....in real life, this cannot hold true.

Hardy-Weinberg Equation

Click here for a review of the Hardy-Weinberg Equation

If further review is needed, please see NJCTL's first year biology course.

Evolution and Population Genetics First Year Course

Hardy-Weinberg Equation

Hardy-Weinberg Equilbrium can be calculated using the following equation:

$$p^2 + 2pq + q^2 = 1$$

where:

p^2 = frequency of the homozygous dominant genotype
(p= frequency of dominant allele)

2pq = frequency of the heterozygous genotype.

q^2 = frequency of the homozyzygous recessive genotype
(q= frequency of recessive allele)

and: $p + q = 1$

The Peppered Moth

One of the most studied examples of Natural Selection and adaptation is the *Biston betularia* (aka the Peppered Moth).

Watch the following video to see the history of this species and why it is a great example of natural selection taking place in a population.

Click here for a video of Evolution of the Peppered Moth

Click here for a Peppered Moth evolution simulation activity print out

Evidence for Evolution

Return to Table of Contents

Scientific Evidence for Evolution

Darwin was able to draw upon evidence from different disciplines in the scientific community to formulate his theories. These included:

1. **Homology**: certain characteristics in related species have an underlying similarity even though they may have different functions.

2. **Biogeography**: Recall that Darwin made many observations on the geographic distribution of species. This is referred to as biogeography.

3. **The fossil record**: By comparing changes in fossils in different layers of rock corresponding to different periods of Earth's history, we can see changes that have taken place.

Homology

Homology is defined in biology as a fundamental similarity in structure or behavior because of common descent, a common developmental origin.

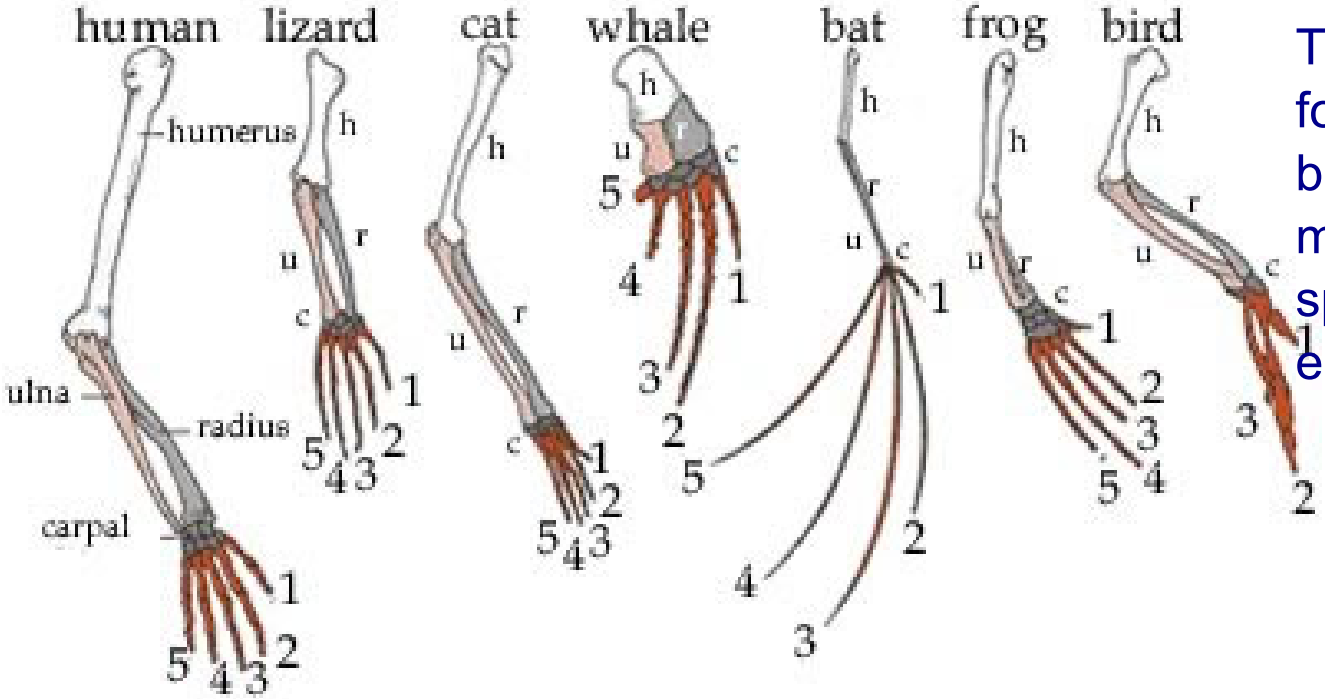
Homology includes:

- homologous structures
- vestigial structures
- comparative embryology
- molecular homology.

Homologous Structures

Darwin noticed that animals have similar body plans and structures.

For example, forelimbs of different animals are made of the same exact bones but modified in shape and size. These are what is known as **homologous structures**.



The bones in the forelimbs all became modified to the special needs of each organism

Vestigial Structures

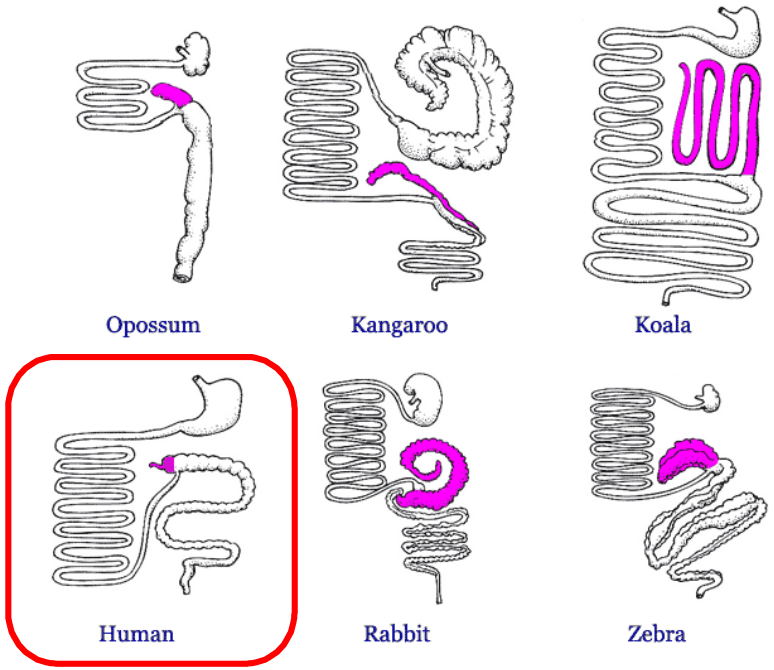
Vestigial structures are bones or organs of an organism which have lost function and atrophied (shrunk) through time.

The body part had a function in an ancestor, but through modifications and evolution the body part is no longer useful.

An example would be vestigial wings in flightless birds.

A vestigial organ : the human appendix

What is now the human appendix was once an extra pouch to help digest food back when our ancestors were herbivores and ate mainly plant material.



Since then, man has developed into more of an omnivore (eating both meat and plants) so the pouch lost both its function and its original structure related to digestion; however, it does contain lymphatic tissue and does contribute slightly to the immune system. That being said, one can live without their appendix as there are many other organs that contribute major roles to the immune system.

Comparative Embryology

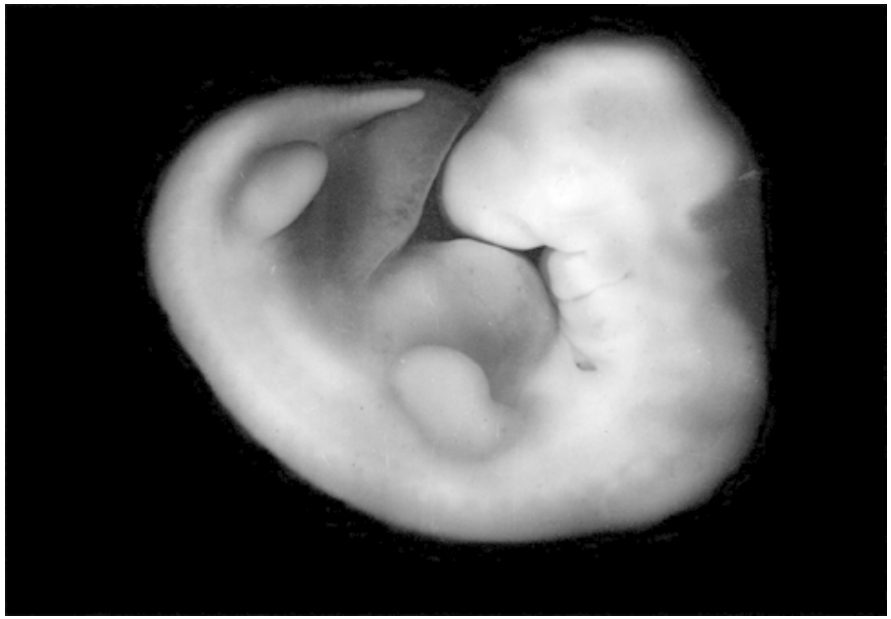
Comparative Embryology is the study of structures that appear during the development of different organisms.

Closely related organisms have similar stages and structures in their development. This gives evidence for evolution and common ancestry.

Human embryonic development

Early on in embryonic development, humans possess features that our evolutionary ancestors had.

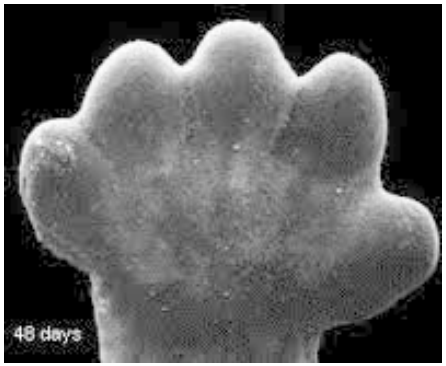
The older the embryo gets, the more it loses these ancient features because they develop into a more modern feature.



Progression of human embryonic development

Apoptosis (programmed cell death) occurs within the webbing to allow for the development of fingers and toes. This also causes a tail to be reabsorbed and gill slits to become structures of our face and neck.

48 day old human hand with webbing



Fetal hand after apoptosis.

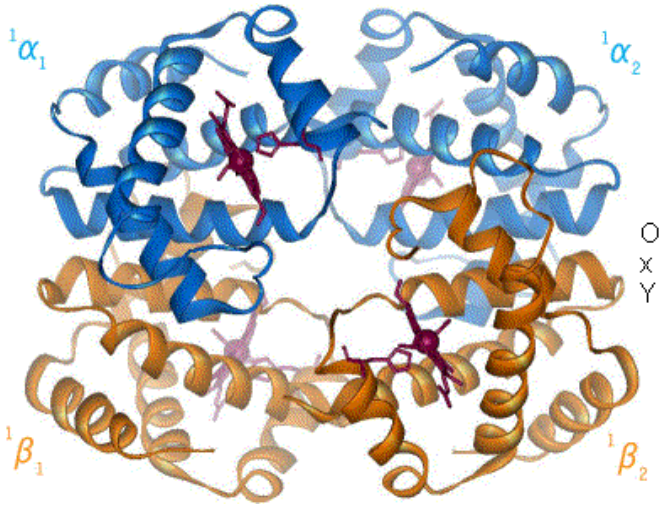
Molecular Homologies

In Darwin's time comparison of molecules was impossible, but now scientists are able to compare species at the microscopic level.

This is a model of a hemoglobin molecule. Many animals including humans, monkeys, mice, fish, birds, worms, bugs and thousands more use a version of this molecule.

The different versions can be compared to see how closely related organisms are.

Less difference = more relation



Biogeography

Biogeography is the geographical distribution of species.

Darwin observed that the species on the Galapagos resembled the species on mainland South America with observable differences in physical features and behavior. He could**compare geography with biology** to make inferences about this observation.

What inference would you make about this observation?

Click to compare your inference with Darwin's

Fossils

During Darwin's time, the science of geology (Earth science) was making advancements that allowed naturalists (biologists of the time) to estimate the age of bones and other remnants of past life being found by explorers.

These early **fossils** began to tell a story about the history of Earth an its inhabitants.

Fossils

"November 26th - I set out on my return in a direct line for Monte Video. Having heard of some giant's bones at a neighbouring farmhouse on the Sarandis, a small stream entering the Rio Negro, I rode there accompanied by my host, and purchased for the value of eighteen pence the head of an animal equalling in size that of the hippopotamus. Mr Owen in a paper read before the Geological Society, has called this very extraordinary animal, Toxodon, from the curvature of its teeth."

-Charles Darwin, The Voyage of the Beagle

Darwin's Toxodon skull sent to England from South America. It has been classified as an ancestor of the modern day rhinoceros.

The Growing Fossil Record

Since Darwin's time, the fossil record has increased by thousands of times its size, providing a clearer picture of evolution's history. It continues to grow.

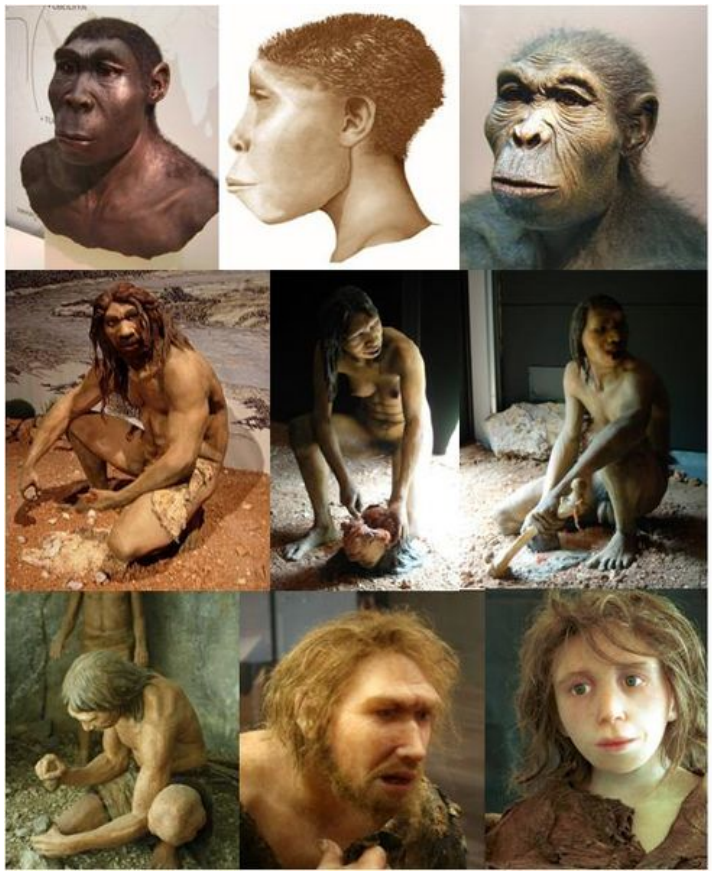
Researchers studying fossils from northern Kenya have identified a new species of human that lived two million years ago.

BBC News, 8 August 2012

http://www.bbc.co.uk/news/science-environment-19184370

The Growing Fossil Record

The fossil record has made it apparent that the key to Darwin's Tree of Life is the ability to pass information from one generation to the next of millions of years. This is the process of **heredity**.



A small sample of models of known hominids (human classification)based on recovered fossils:

- Homo habilis
- Homo ergaster
- Homo erectus
- Homo antecessor
- Homo heidelbergensis
- Homo neanderthalensis
- **Homo sapiens sapiens**: **modern humans, we are the only surviving hominid!**