

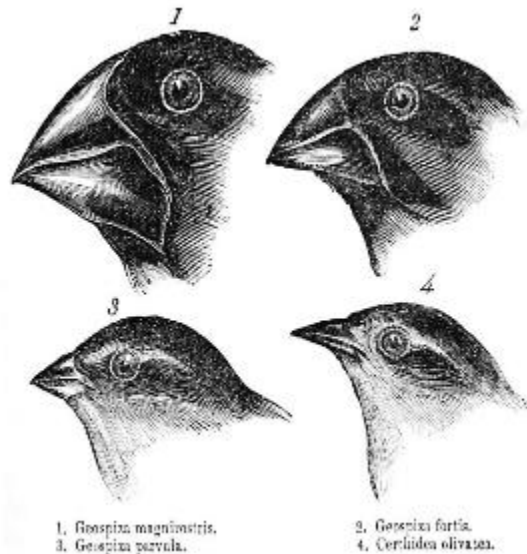
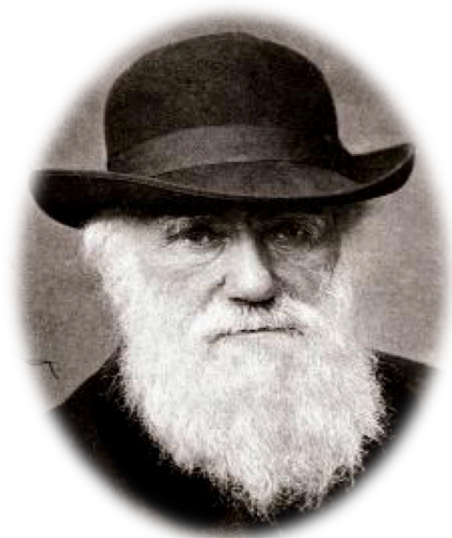


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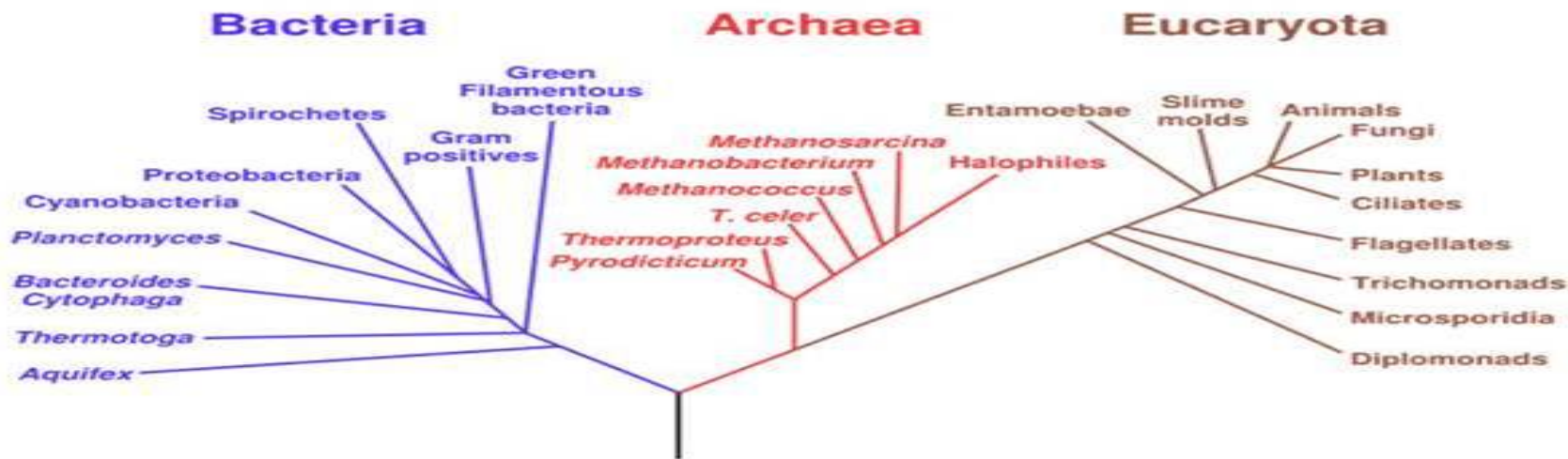
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# Evolution by Means of Natural Selection

## Phylogenetic Tree of Life





# Evolution by Means of Natural Selection



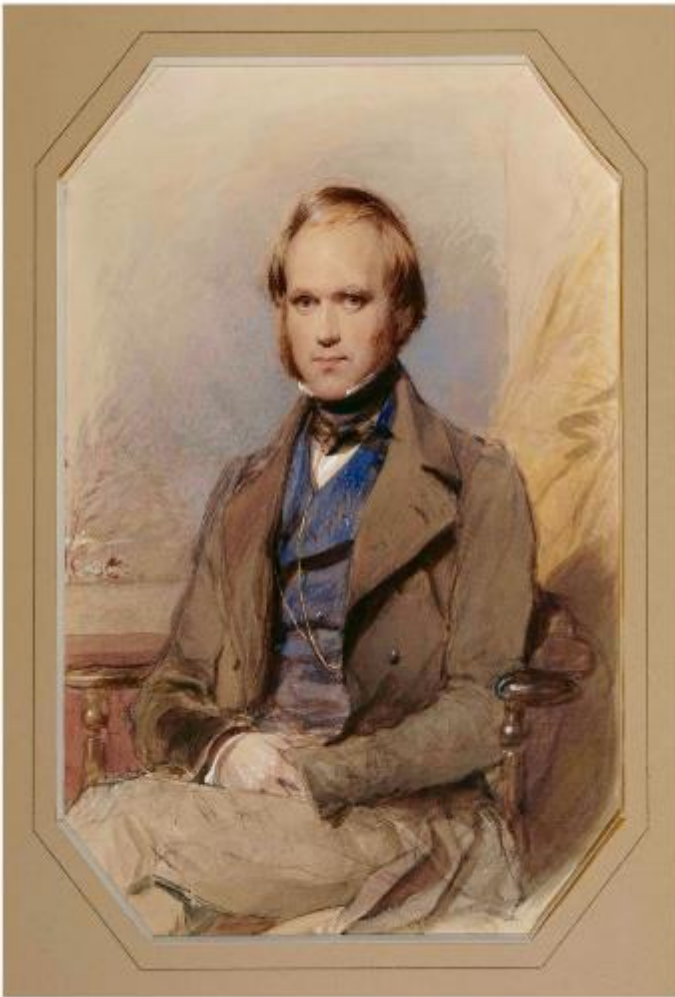
- In 1858, Charles Darwin and Alfred Wallace released a joint scientific paper which introduced the concept of evolution by means of natural selection.
- This paper, along with Darwin's subsequent publication, *The Origin of Species*, changed the way science and society explained events in our natural world.
- They were the first to describe *how* (the mechanism by which) new forms and species could arise or evolve - **natural selection**.

Radiolab [Darwinvaganza!](http://www.radiolab.org/story/91893-darwinvaganza)

<http://www.radiolab.org/story/91893-darwinvaganza>







Annie Darwin  
1841 - 51  
(portrait taken in 1849)

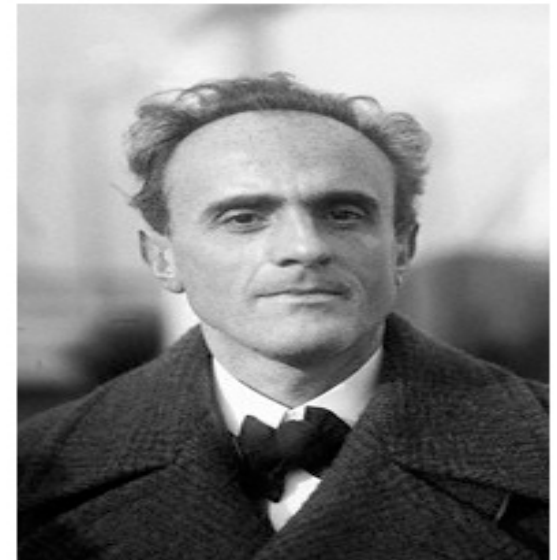
*Wedding Portrait of Charles & Emma Darwin 1840*  
*In this portrait, he is 30 years old and she is 31.*  
*They produced 10 children, 3 of which died in childhood.*



# Before the Theory of Natural Selection

- **Evolution** = Change in living things over generations.
- Long before Darwin & Wallace, scientists noted that evolutionary change appeared to happen.
- *The question was:* HOW do species evolve? What is driving the change?
- In the Radiolab episode "[Inheritance](#)," we learned what Jean-Baptiste Lamarck and Paul Kammerer thought was driving evolutionary change....

*Let's review the story.*



Paul Kammerer (1880 - 1926)

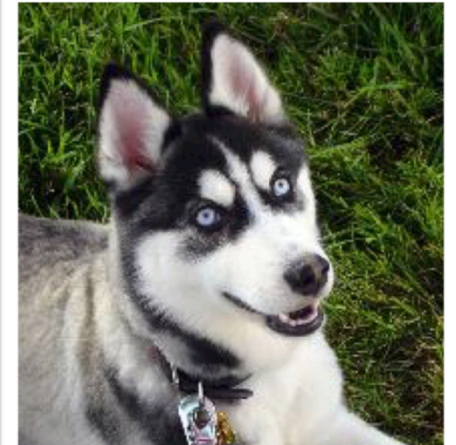
# Evolution & Artificial Selection



*Canis lupus* - Gray Wolf



*Canis lupus familiaris*  
-  
Domestic dog





**RADIOLAB**

*“The Taming  
of the Fox”*

*... and the entire Human Race.*

Podcast Episode:

[New Nice](#)



<http://www.radiolab.org/story/91696-new-nice/>





# Lap Dogs

Lapdogs are not a specific breed, but a general type of dog with a small size and friendly disposition.

Historically kept by individuals with leisure time.

A sweet-tempered companion animals with no working function.

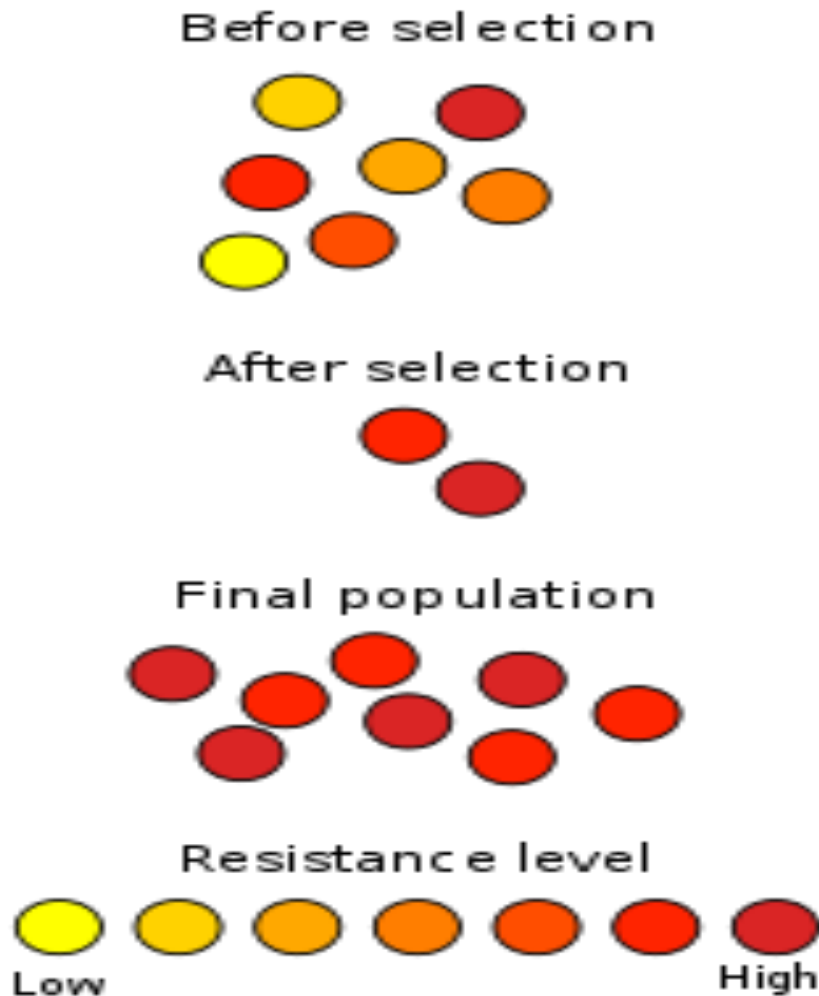
Many lapdogs are bred to retain puppy-like traits (*neoteny*). They resemble human babies: small, high forehead, short muzzle, large eyes.



Images:  
Portrait of [Princess Ekaterina Golitsyna](#) (1720-1761), Wiki;  
[Beauties Wearing Flowers](#),  
8th century China,  
Tang Dynasty;  
[Portrait of three lap dogs](#),  
Wikiwand; Sick little girl being comforted by lap dog Lulu, T. Port



# Antibiotic Resistance in Bacteria



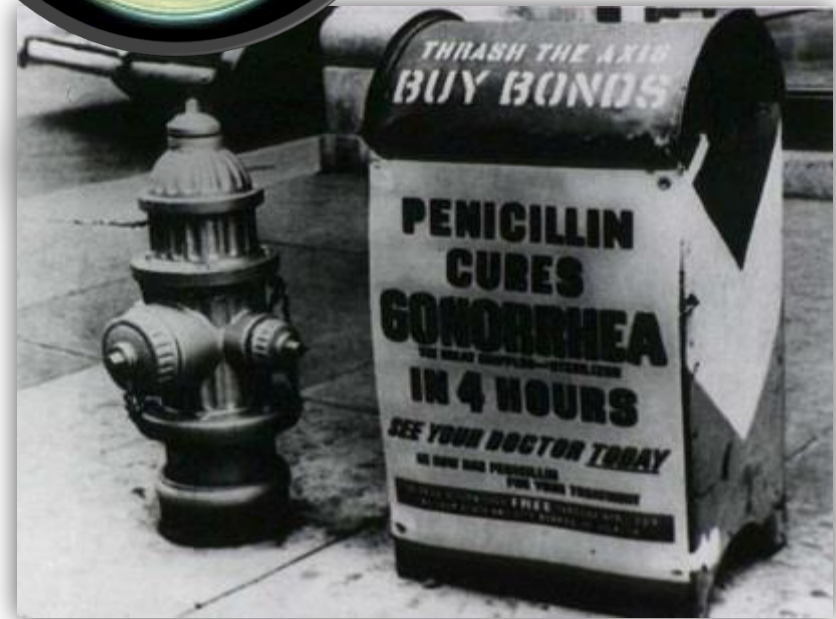
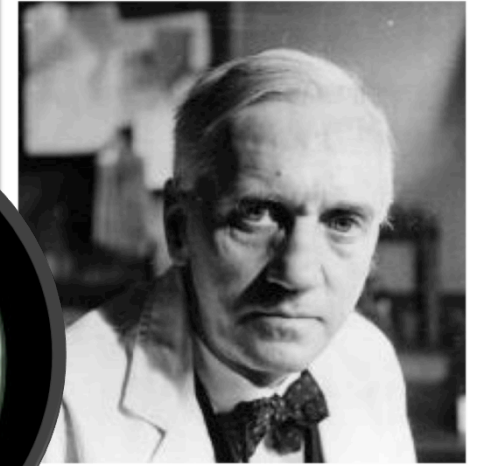
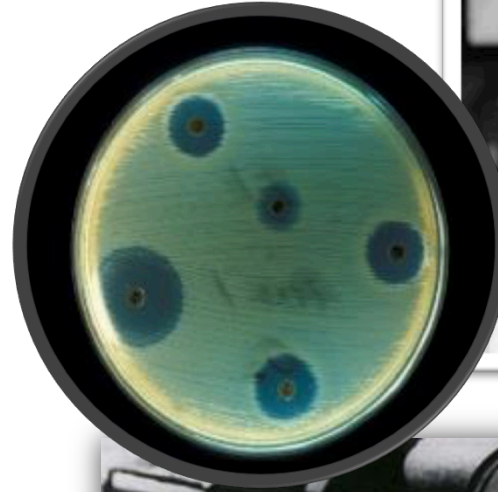
Resistance to antibiotics is increases though the survival of individuals that are immune to the effects of the antibiotic.

Offspring of those antibiotic resistant bacteria inherit the resistance, creating a new population of resistant bacteria.

# Discovery of Antimicrobial Agents

## Penicillin

- **Alexander Fleming** (1881 - 1955), a Scottish biologist and pharmacologist, observed bacterial staphylococci colonies disappearing on plates contaminated with mold.
- Fleming extracted the compound from the mold responsible for destruction of the bacterial colonies.
- The product of the mold was named penicillin, after the *Penicillium* mold from which it was derived.
- Nobel Prize in Physiology of Medicine in 1945.



Images: *Penicillium* mold, [PHIL #8396](#);  
*Staphylococcus aureus* on antibiotic test plate, PHIL #2641;  
Poster attached to a mailbox offering advice to [World War II](#)  
servicemen, 1944, NIH



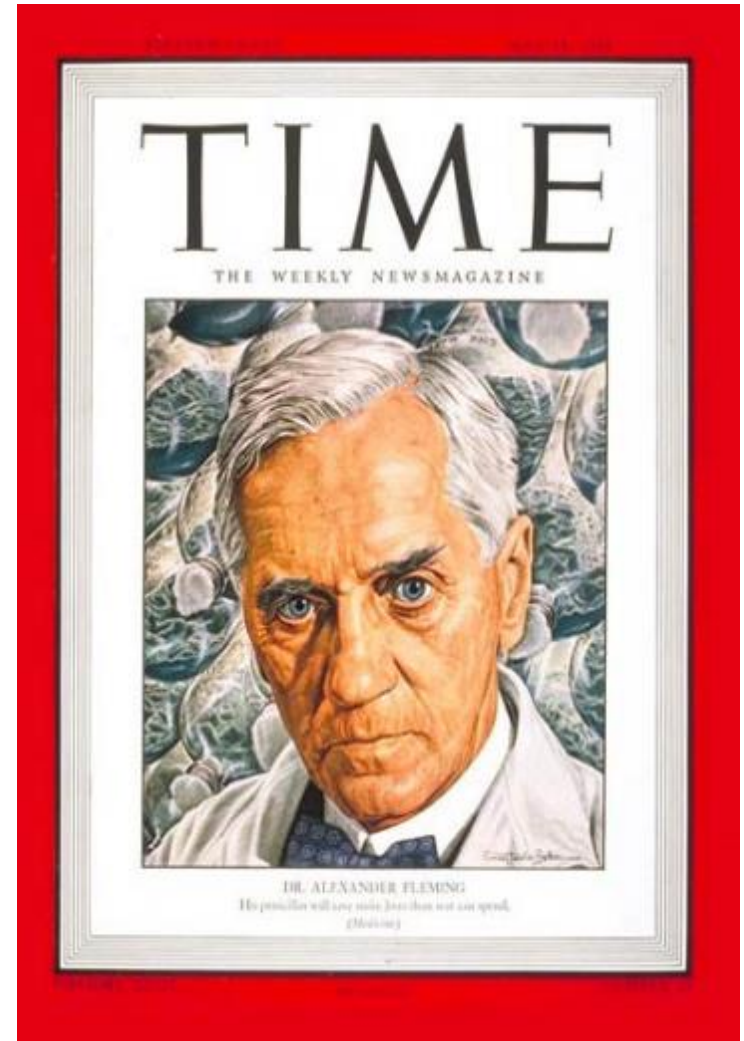
# Discovery of Antimicrobial Agents

## Antibiotic resistance

- In 1944, height of WWII, Alexander Fleming was featured on the cover of Time magazine, with the subtitle:

***"His penicillin will save more lives than war can spend."***

- About the same time that Fleming's face appears on Time magazine, a Stanford researcher publishes that he has found 5 different strains of *Staph* that do not respond to penicillin...The first sign that the *Staph* population has responded to penicillin, by developing resistance.
- This began the "arms race" of development of new antibiotics in response to antibiotic resistance. A few examples:
  - Streptomycin 1943 (resistance 1948)
  - Methicillin 1960 (resistance 1961)
  - Clindamycin 1969 (resistance 1970)
  - Ampicillin 1961 (resistance 1973)
  - Carbenicillin 1964 (resistance 1970)
  - Piperacillin 1980 (resistance 1981)
  - Linezolid 2000 (resistance 2002)



Listen to Radiolab episode  
["Staph Retreat"](#).

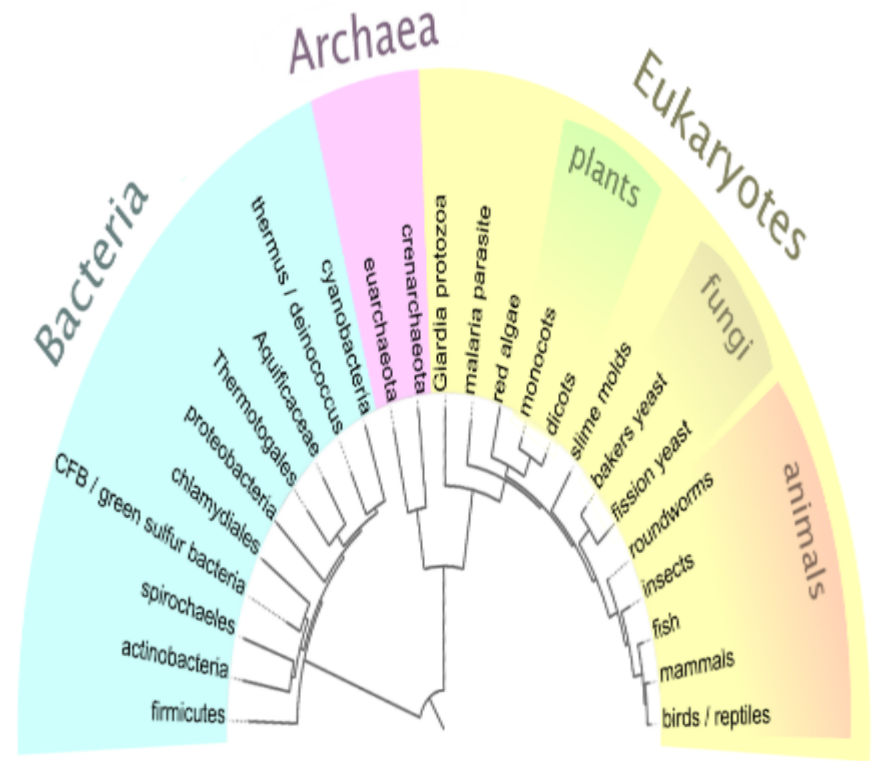


# What Is Evolution?

Biological evolution = change in heritable traits of a population over successive generations; descent with modification.

Today's species are related to each other through common descent (ancestors that they share) and are products of evolution over billions of years.

Over very large stretches of time, evolutionary processes explain the origin of new species, occasionally the elimination of existing species and ultimately the vast diversity life on our planet.



**VIDEO:**  
**Evolution: It's a Thing**

from Crash Course Biology

# What Is Natural Selection?

Natural selection is what drives evolution.

It's the process in nature by which the organisms best adapted to their environment survive and are better able to transmit their genetic characteristics to the next generation.

Individuals not as well adapted to their environment tend to be eliminated.

**Natural Selection is the Process**  
**Evolution is the Outcome**

Natural selection, in a nutshell:

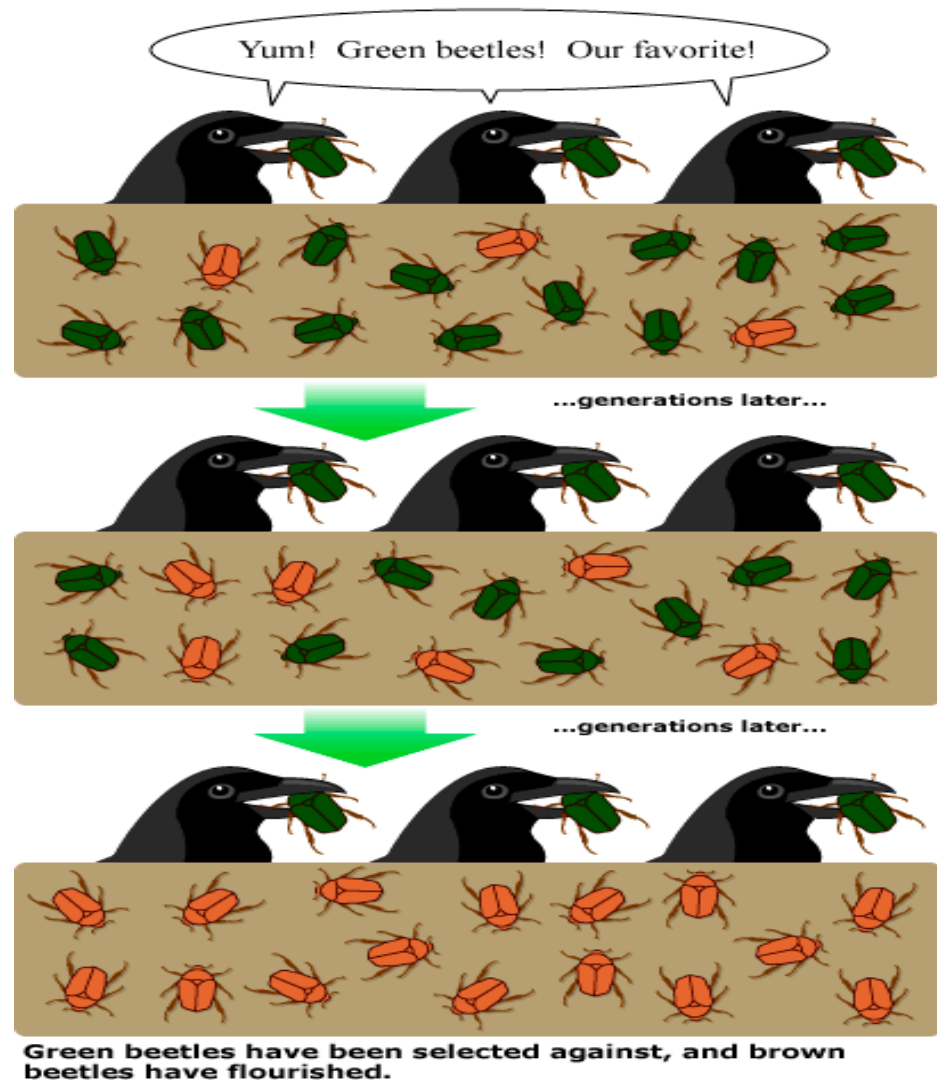


Image: University of California Museum of Paleontology's [Understanding Evolution](#).

# Key Concepts of Evolution by Natural Selection

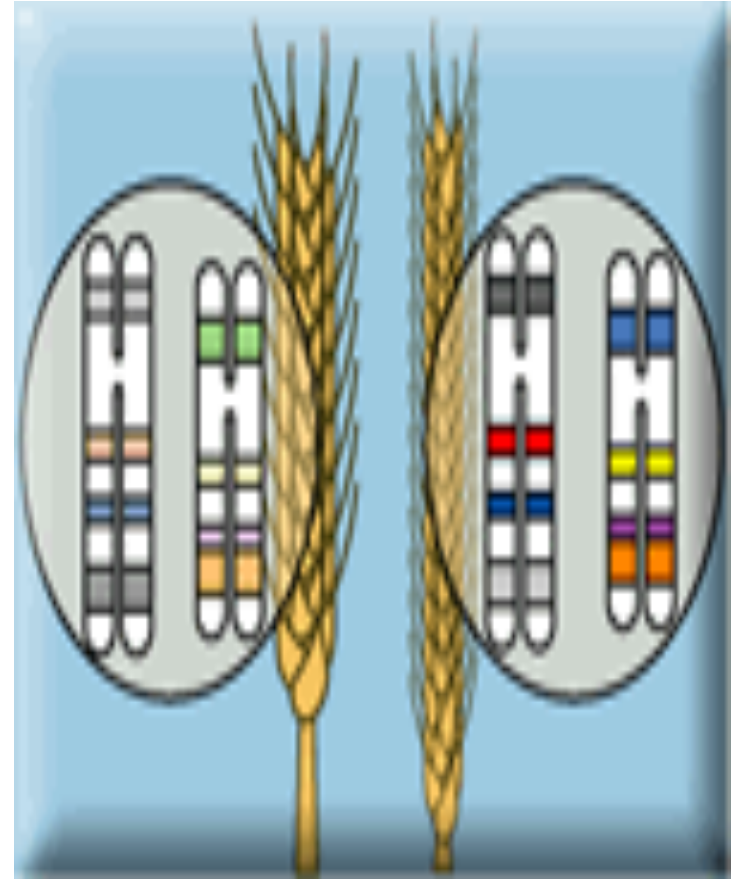
1. Population size is limited by the environment.

2. Genetic Diversity:

- Populations of individuals are genetically diverse.
- Even members of the same species have characteristics that vary from one individual to the next.
- Many of those differences can be inherited.

3. Environment is the combined influences of both *physical* and *biological* limiting factors.

- *Biological limiting factors* include disease, competition, predation.
- *Physical limiting factors* are abiotic, like drought, fire, flood.



# Key Concepts of Evolution by Natural Selection

## 4. Relative Fitness:

- In any given environment, some individuals have traits that put them at an *advantage* over individuals who do not possess those traits.
- When environmental factors **decrease** an individual's *reproductive success*, the organism is "*selected against*" by nature.
  - Genes of these individuals will be reduced or eliminated from the gene pool. These individuals are less adapted to their environment, *less fit*.
- When environmental factors **increase** an individual's *reproductive success*, the organism is "*selected for*" by nature.
  - Genes of these individuals will increase in frequency in the gene pool. These individuals are more adapted to their environment, *more fit*.



**Q:** What does "fitness" mean in the context of natural selection?



# Key Concepts of Evolution by Natural Selection

## 4. Relative Fitness:

- In any given environment, some individuals have characteristics that put them at an advantage over individuals who do not possess those characteristics.

## 5. Population Shift:

- In any given environment, individuals who have advantageous characteristics will generally be healthier, live longer, and leave more offspring than individuals who do not have those useful traits.
- The population will, over time, contain more and more individuals with the advantageous traits, and fewer individuals who do not possess them.



# Evolution of Mimicry

Check out this  
[Video of the Orchid Mantis](#)!

How does its appearance help it catch prey and avoid predators?

Consider how, over time, a population of preying mantis' could be "shaped" by natural selection to look like a flower.



# The Power of Natural Selection Over Time

## Reproductive Isolation

Over time, natural selection can make sub-populations within a species genetically different enough so that they are no longer able to reproduce with each other, creating separate species (reproductive isolation).

Sexually reproducing organisms are only considered to be of the same species if they can mate and produce fertile offspring together.



Mules are sterile hybrids of horses and donkeys, two separate species with interspecific (between species) sterility.

The liger is a hybrid between a male lion and a female tiger. Ligers exist only in captivity because the habitats of lions and tigers do not overlap in the wild. Ligers typically grow larger than either parent species.

Most ligers suffer from embryonic fatality or premature death, and those that survive are often sterile.





# The Selfish Gene

*Whoever Passes on the Most Genes Wins!*

The organisms that live long enough to produce more reproductive offspring "win", since they will be represented in higher numbers of the next generation.

Individuals that can locate, harvest and utilize the resources from their environment the most efficiently, while minimizing the influence of limiting environmental factors acting upon them, will be the most successful in continuing their genes to the next generation.



The Neanderthal was a species of human in the genus *Homo*, closely related to modern humans. Neanderthals became extinct between 41,000 and 39,000 years ago. This coincides with the start of a very cold period in Europe, about 5,000 years after *Homo sapiens* reached the continent.

Images: [Skeleton & restoration model of Neanderthal](#), Wiki; [Head and Shoulders Model of Male Neanderthal](#), Wiki.



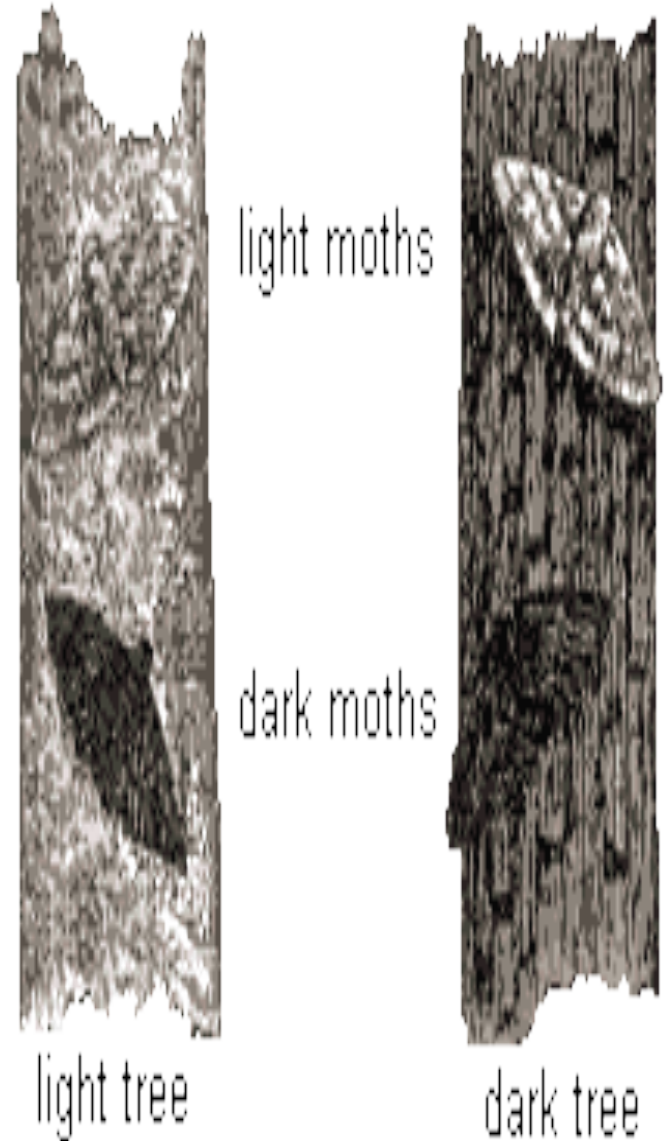
*Classic Example of Natural Selection*  
**The Peppered Moth**

***England, before the industrial revolution***

*(before ~ 1760)*

Most peppered moths were light grey in color, closely matching the lichen-covered trees in their environment.

Genetic variation in the moth population resulted in some very dark colored moths, but when these dark moths landed on lichen-covered trees, they were easy targets for predators.



# The Peppered Moth

## *Industrial revolution*

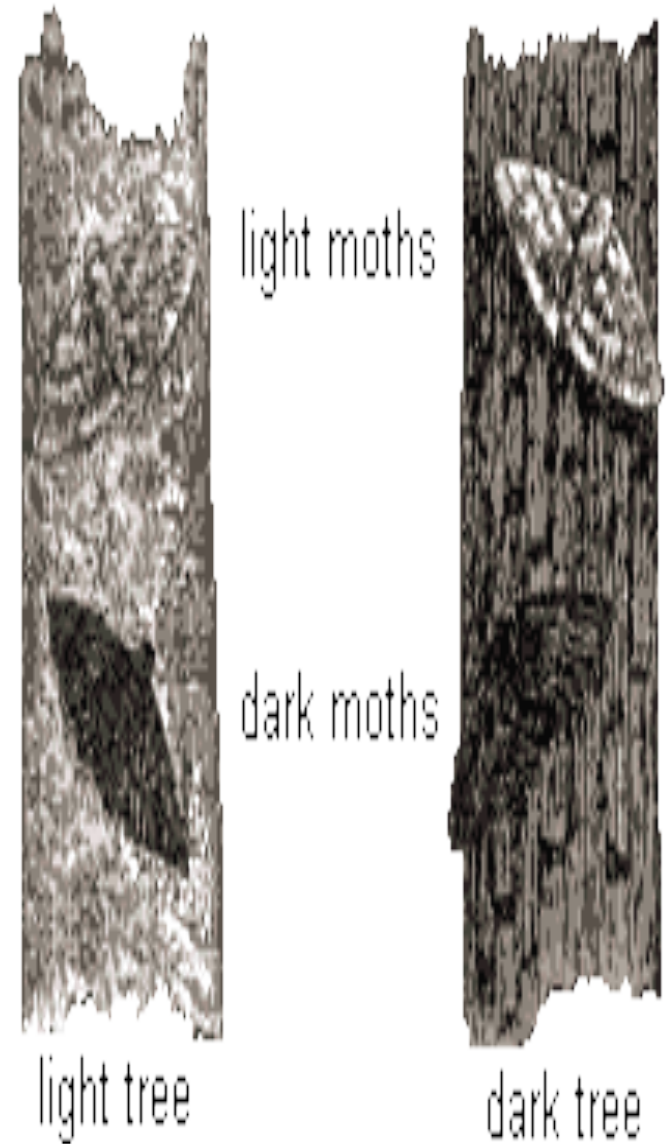
*(after ~ 1760)*

Pollution killed the lichens on trees and darkened the bark.

When moths landed on these trees, the dark colored ones were harder for predators to spot and they more often survived and reproduced.

Over generations, the environment continued to favor darker moths, and they progressively became more common.

By the late 19<sup>th</sup> century, 98% of the moths near cities were black.

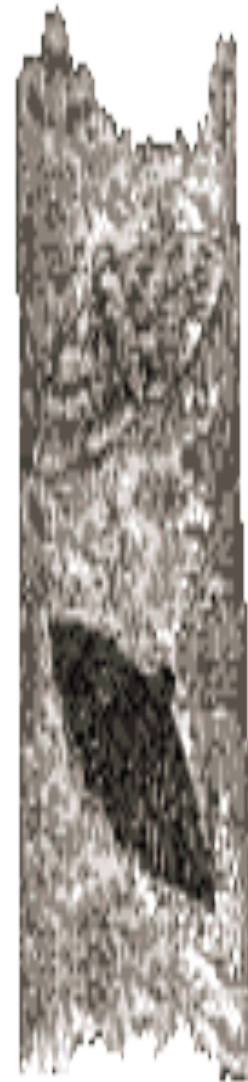


# The Peppered Moth

## *More recently*

Modern air pollution controls have reduced the air pollution, and the lichens have grown back, making trees lighter in color.

Again, natural selection favors lighter moth varieties so they have become the most common.



light moths

light tree



dark moths

dark tree

Images: [Biston betularia betularia typica](#), the white-bodied peppered moth. & [B. betularia betularia carbonaria](#), the black-bodied peppered moth, Wiki.

# Lab Activity



- In today's exercise, you will be asked to assume the role of a bird that is facing competition for food your own **conspecifics** (members of your own species).
- Other students will take on the role of your competitors.
- Each "bird" in the competition will be asked to collect seeds from the environment using the "beak" supplied.
- The number of seeds collected over the allotted time will determine your success.
- Those "birds" that retrieve the most seeds will be considered more fit for their environment than their competitors and therefore most likely to pass on their genes.