# EVOLUTION THROUGH NATURAL SELECTION

# Several Insights Led to Darwin's Theory

After his voyage on the *Beagle*, Darwin spent more than 20 years conducting research, thinking about how evolution occurs.

Though he had traveled the world, many things at home also influenced him.

# Several Insights Led to Darwin's Theory

- Some of these influences came from agriculture and breeders.
- Darwin noticed that domesticated plants and animals show variety their wild ancestors didn't have.

Through selection of certain traits, breeders could produce a huge amount of diversity.

# Several Insights Led to Darwin's Theory

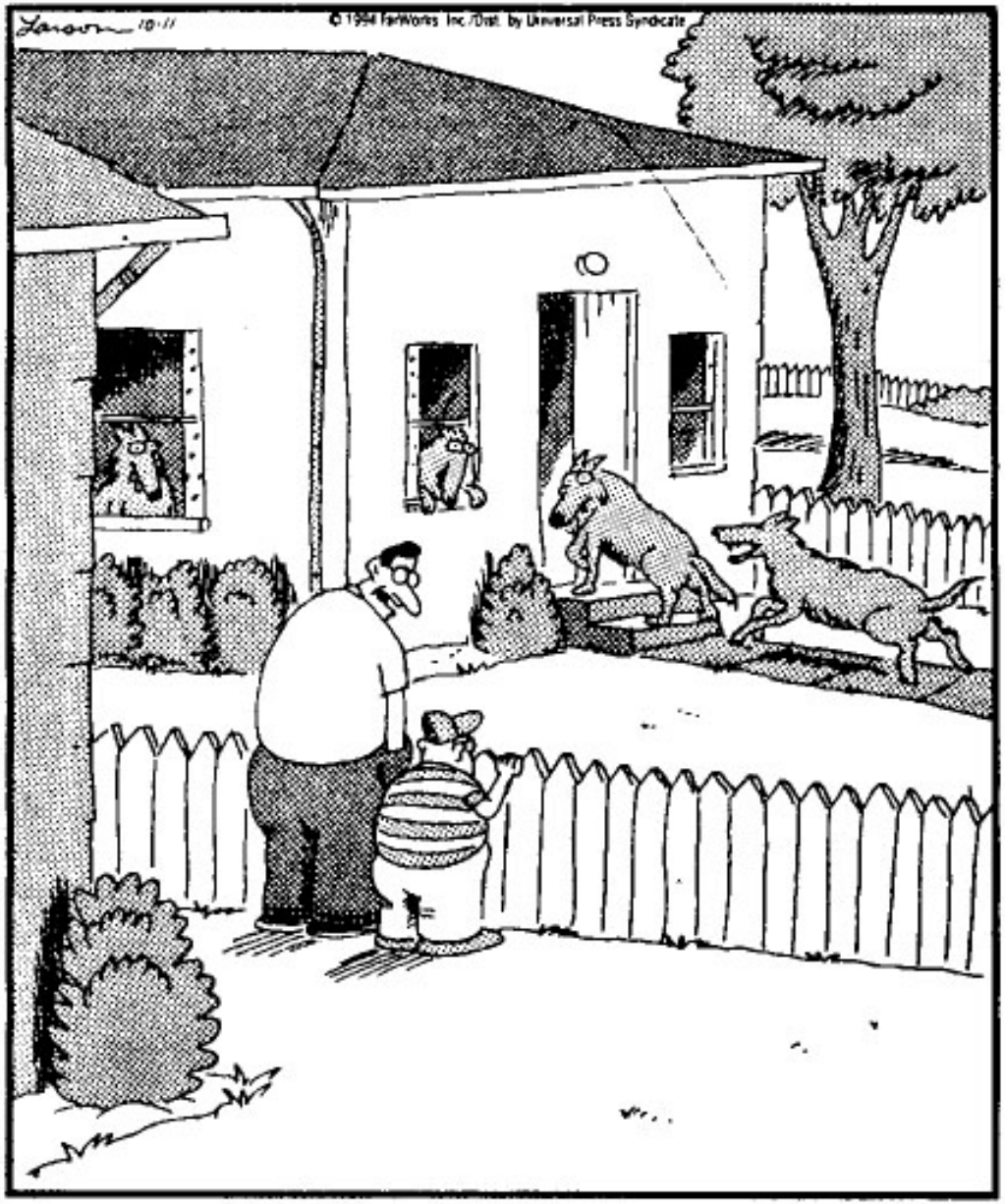
- To explore this idea further, Darwin started breeding pigeons.
- Darwin knew nothing about genetics, but noticed that certain traits in the pigeons could be selected for and passed down from parent to offspring.
- He realized that certain traits must be heritable.

# Several Insights Led to Darwin's Theory

Darwin used this line of thinking to come up with his theory of evolution through a mechanism that he called: natural selection.

For natural selection and thus evolution to occur in a population, 3 requirements (or tenets) were needed.

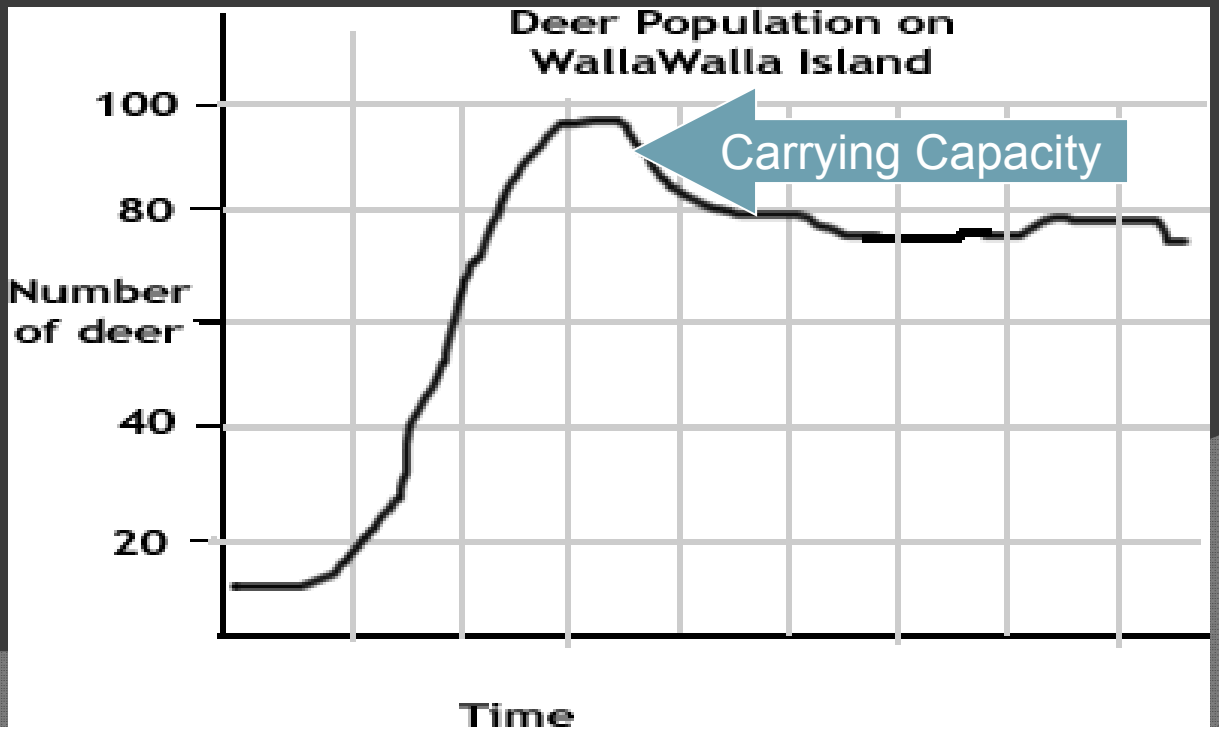
# Basic Tenets of the Theory of Evolution:




"I know you miss the Wainwrights, Bobby, but they were weak and stupid people — and that's why we have wolves and other large predators."

# The Tenets of Biological Evolution

1. Populations tend to produce more offspring than the environment can support.
   - This leads to a *struggle for existence* in which some individuals survive and some die.



# The Tenets of Biological Evolution

## 2. Natural Selection

The over-production of offspring leads to competition and survival of the individuals best suited to that *particular environment*.

Natural Selection refers to the idea that individuals who are better adapted to their environment tend to survive and reproduce more than less well-adapted individuals.

# The Tenets of Biological Evolution

3. The ***variation*** in individuals in a population is controlled by their genes and is therefore ***inheritable***.

- The better ***adapted*** individuals ***pass on their traits*** to more offspring than the less well adapted.
- The results of natural selection therefore ***accumulate***.
- As one generation follows another, the ***characteristics of the species gradually change.***

# Darwin and Wallace

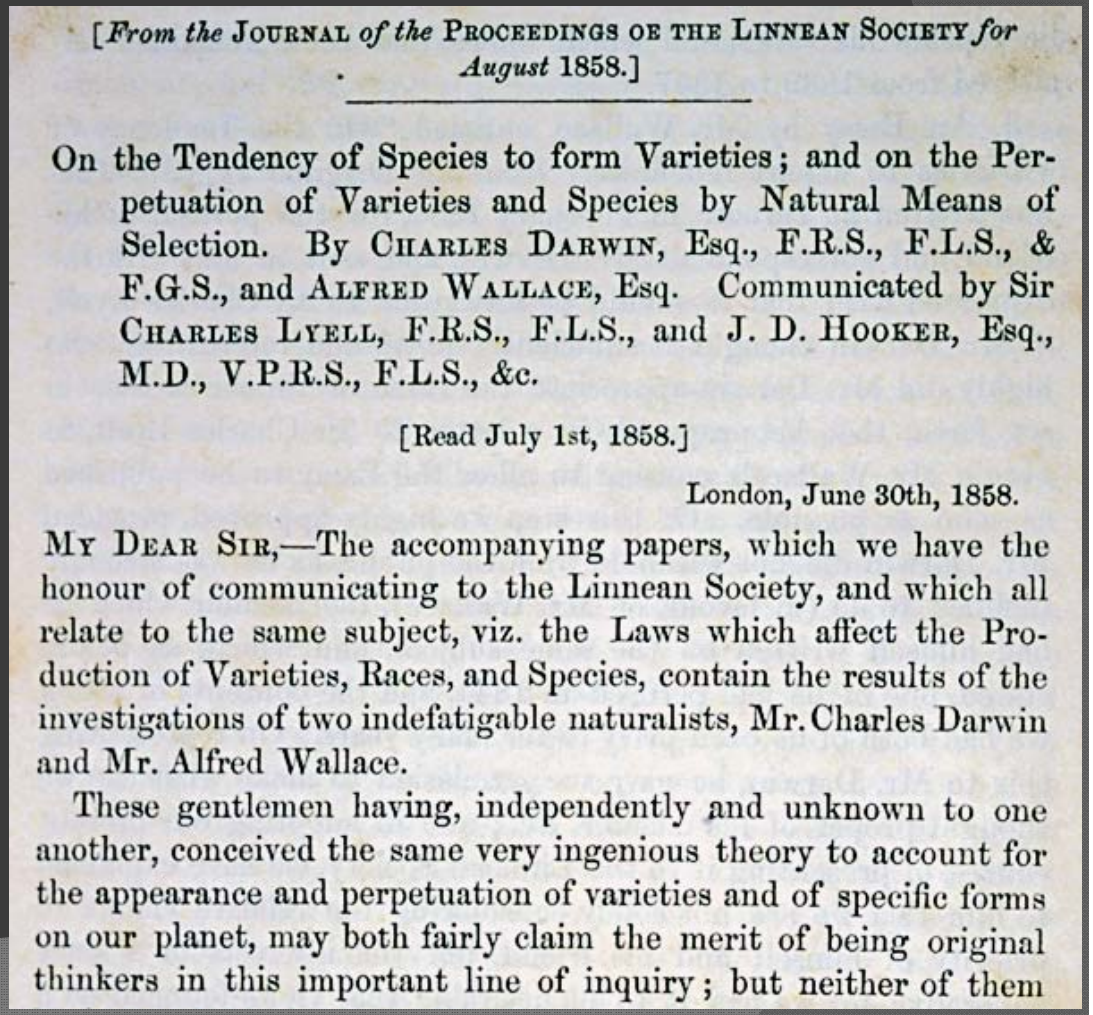
Darwin conceived his theory of evolution by natural selection in 1838 but spent the next 20 years conducting research to support it.

He was writing up his theory in 1858 when he received an essay from Alfred Russel Wallace describing basically the same idea.

# Darwin and Wallace

They decided to publish their theory together in July of 1958.

Wallace unfairly is often forgotten.



[*From the* JOURNAL *of the* PROCEEDINGS OF THE LINNEAN SOCIETY *for August* 1858.]

On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection. By CHARLES DARWIN, Esq., F.R.S., F.L.S., & F.G.S., and ALFRED WALLACE, Esq. Communicated by Sir CHARLES LYELL, F.R.S., F.L.S., and J. D. HOOKER, Esq., M.D., V.P.R.S., F.L.S., &c.

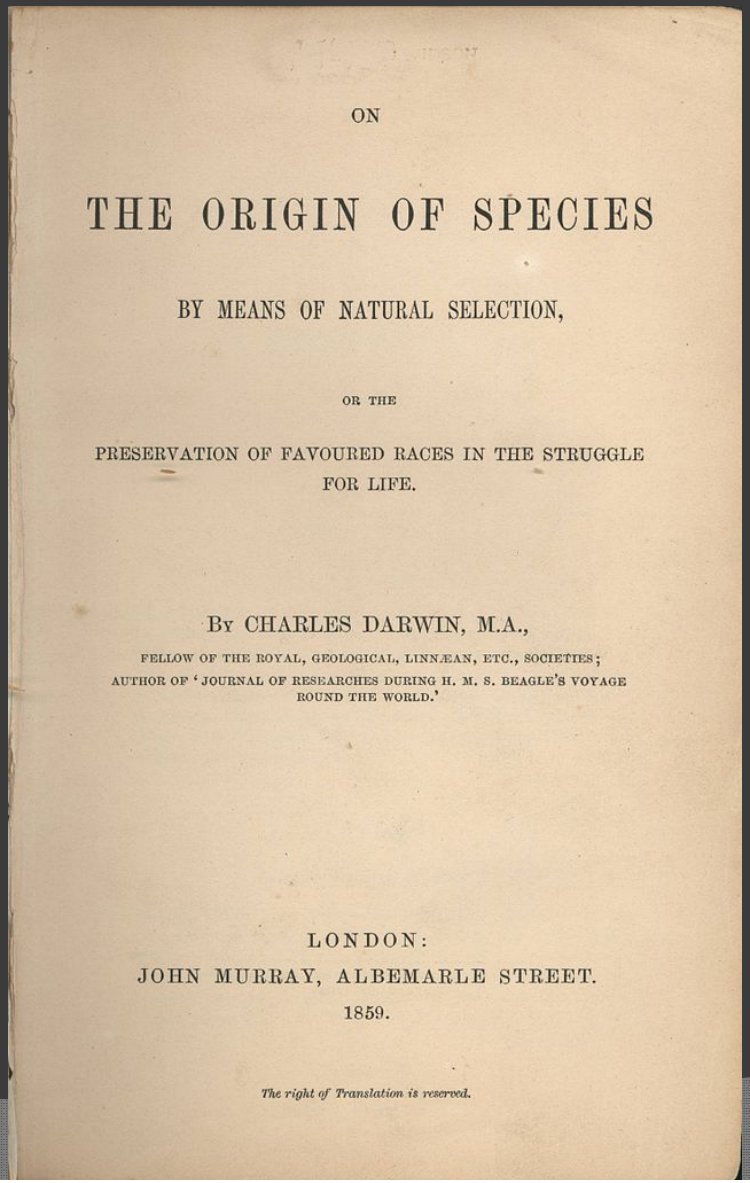
[Read July 1st, 1858.]

London, June 30th, 1858.

MY DEAR SIR,—The accompanying papers, which we have the honour of communicating to the Linnean Society, and which all relate to the same subject, viz. the Laws which affect the Production of Varieties, Races, and Species, contain the results of the investigations of two indefatigable naturalists, Mr. Charles Darwin and Mr. Alfred Wallace.

These gentlemen having, independently and unknown to one another, conceived the same very ingenious theory to account for the appearance and perpetuation of varieties and of specific forms on our planet, may both fairly claim the merit of being original thinkers in this important line of inquiry; but neither of them

# Darwin and Wallace



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.,

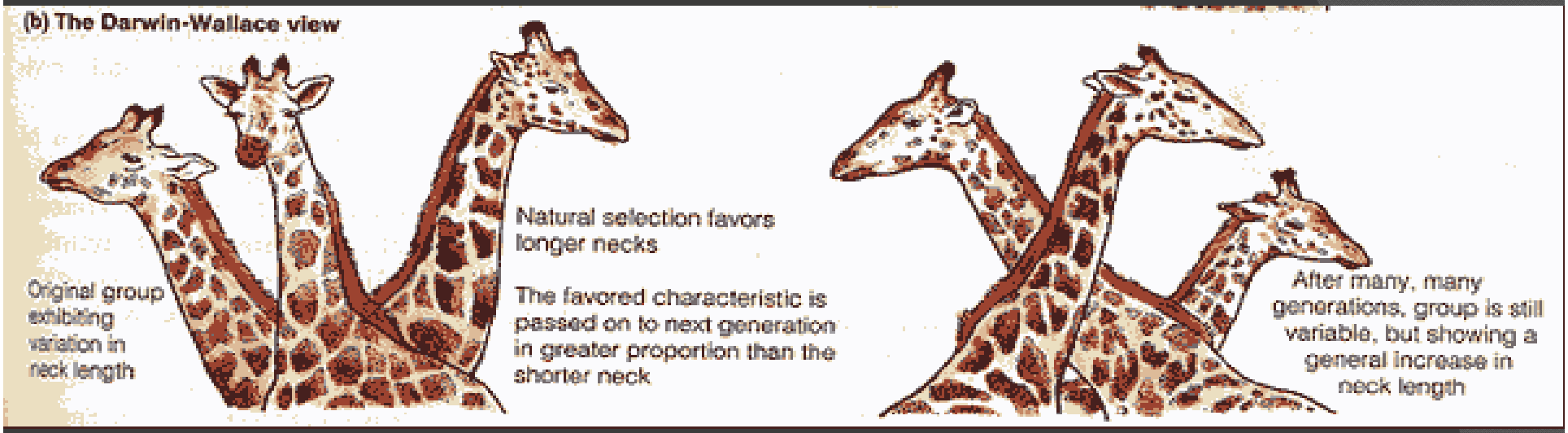
FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

*The right of Translation is reserved.*

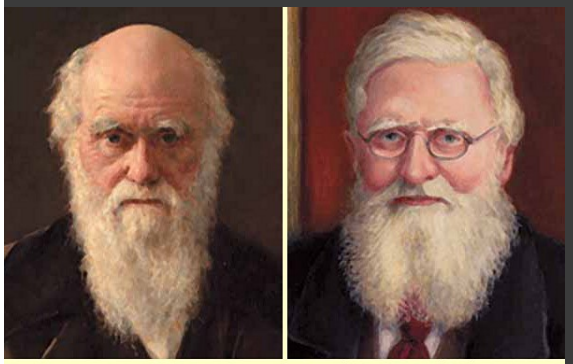
Darwin wrote a book on his observations a year later called, "*On the Origin of Species*".
It is now considered the foundation of evolutionary biology

# Revisiting Lamark




Darwin and Wallace's theory of Natural Selection would have explained the giraffe's long necks in the following way:

- An original group exhibited variation in neck length.
- Longer necks were more successful in the given environment.
- Longer necked giraffes were then able to reproduce more often than shorter necked giraffes and thus pass on their long neck genes to the next generation.
- After many generations, the population has a general increase in neck length.



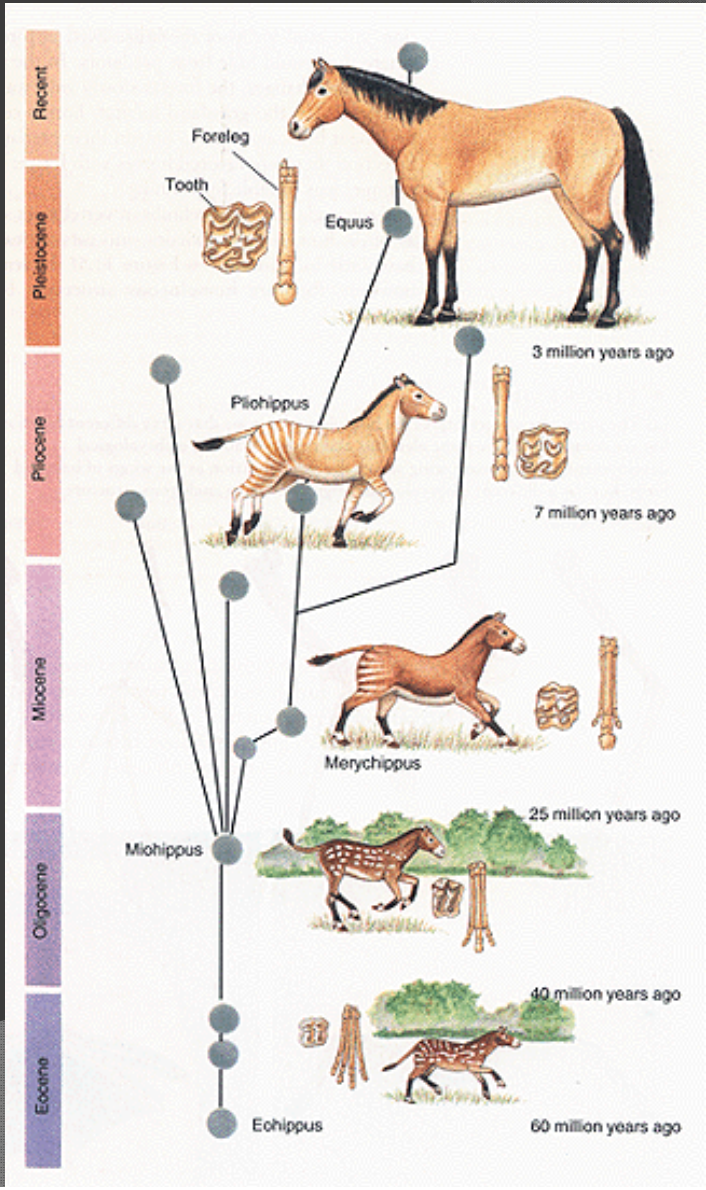
CHARLES DARWIN ALFRED WALLACE

# Revisiting Lamark

Even though the giraffe's neck is extremely long, it has only seven neck vertebrae, the same number that people and most other mammals have.

# Evolution and Populations

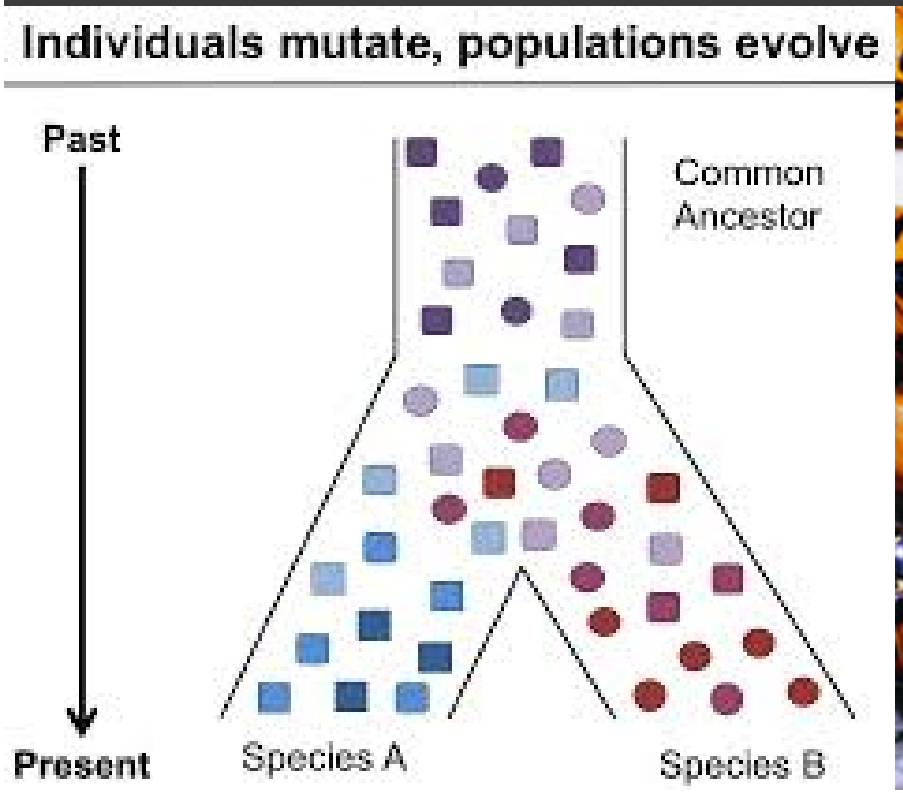
- It is important to note that biological evolution refers to populations and not to individuals and that the changes must be passed on to the next generation.
- In practice this means that evolution is a process that results in heritable changes in a population spread over many generations.



# Evolution and Populations

In other words:

Populations evolve not individuals.




# Our Evolving Definition of Evolution:

The **accumulation** of **changes** in the **heritable** traits of a **population**.

Evolution describes the changes in the **variation** in the genes of a species over time.

- These changes are the result of:
  - Mutations
  - Natural selection
  - Chance

# How Does Variation Arise?

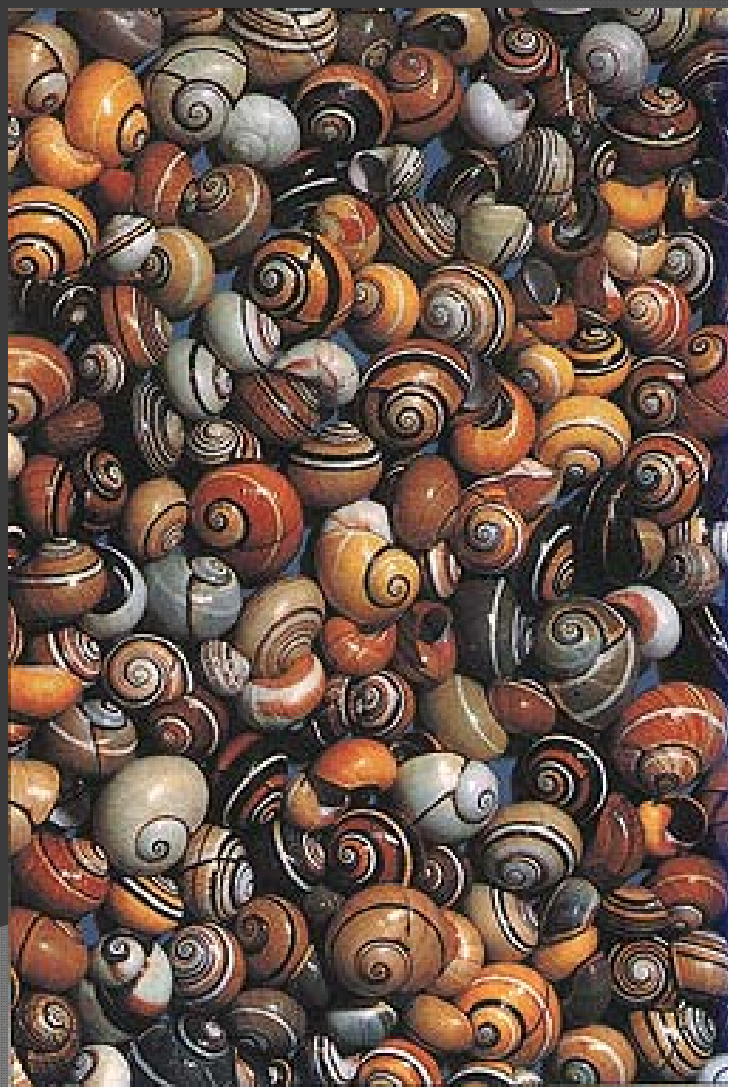
In the DNA:

-Sexual Reproduction

-Mutations

In the Environment:

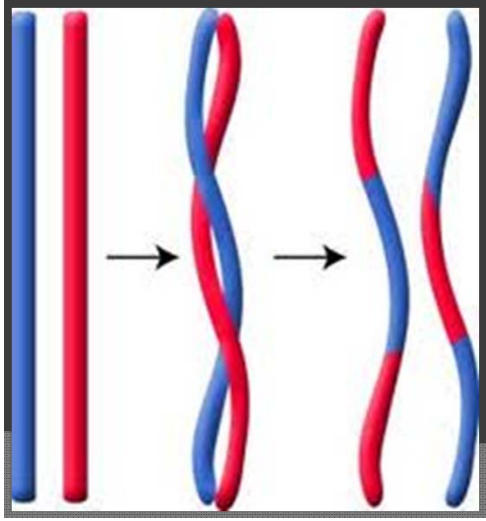
-Genetic Drift

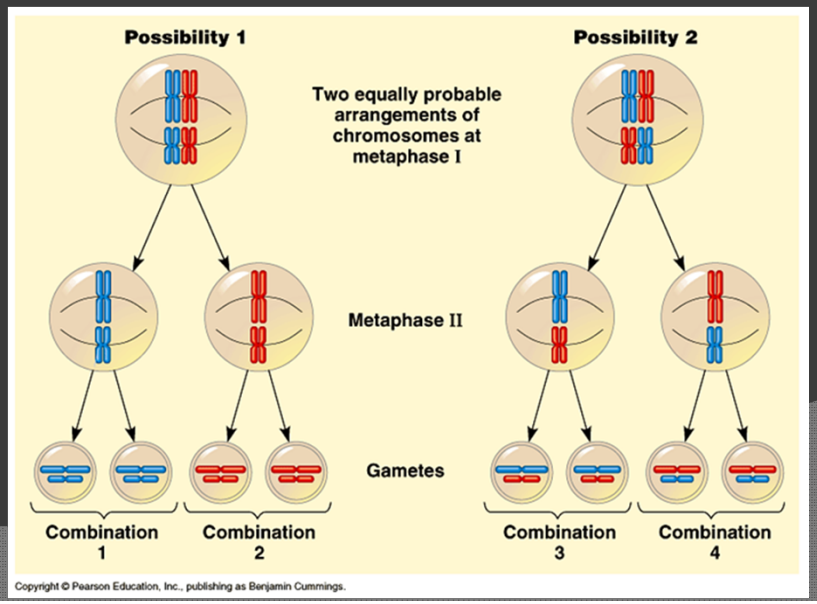


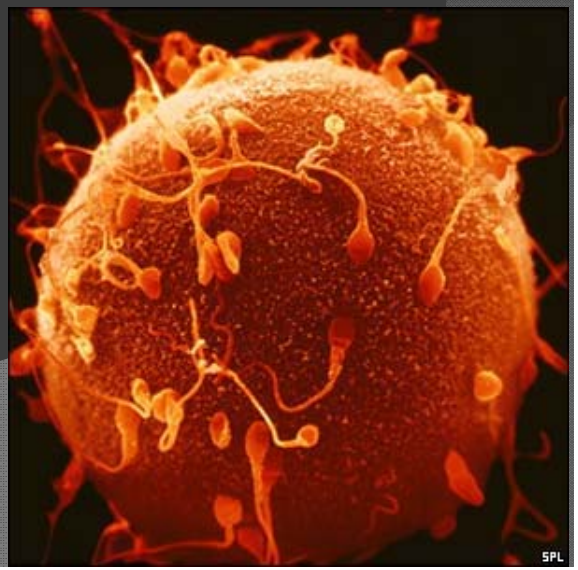
# How Does Variation Arise?

## Sexual Reproduction

- Role:
  - Promotes variation in a species through meiosis and fertilization which is essential to natural selection.



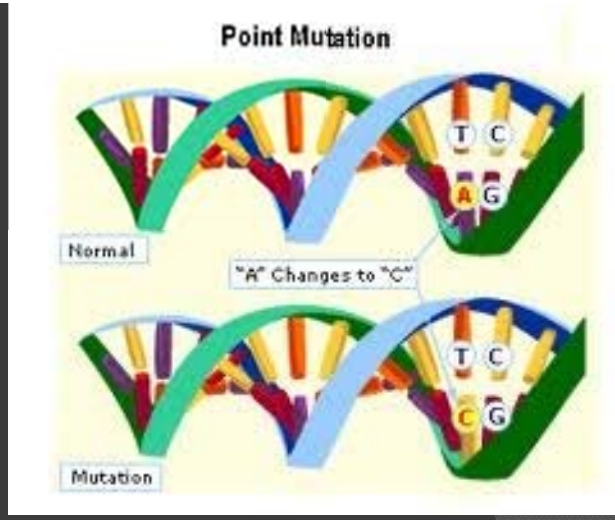


# How Does Variation Arise?

## Mutations:

- Changes in the base pair sequence of DNA.
- Most are neutral or harmful to the organism, but some have positive effects.
- Note: In an organism that sexually reproduces, the mutation must occur in a gamete (sex cell) if it is to be passed on to offspring, and thus contribute to the evolution of that organism.

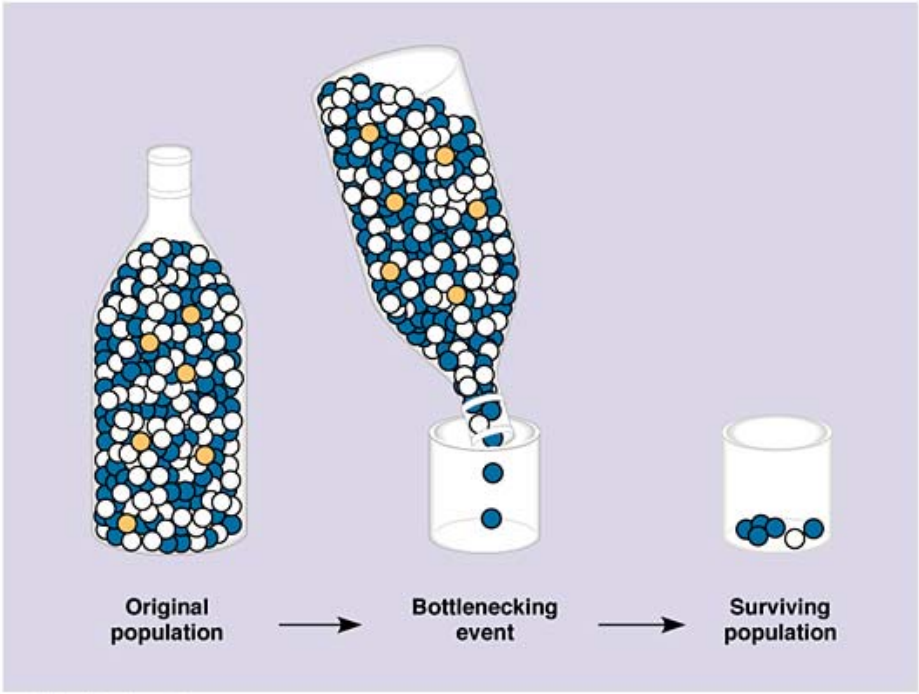



A mutation has caused the garden moss rose to produce a flower of a different color.

# How Does Variation Arise?

## Genetic Drift:

- Sometimes the frequency of a gene in a population is determined **by chance** and not by whether it gives the individual an advantage in the environment.
- This is known as genetic drift.



# How Does Variation Arise?

Variation is random, because the processes that lead to variation:

-Crossing Over

-Independent Assortment

-Fertilization

-Mutations

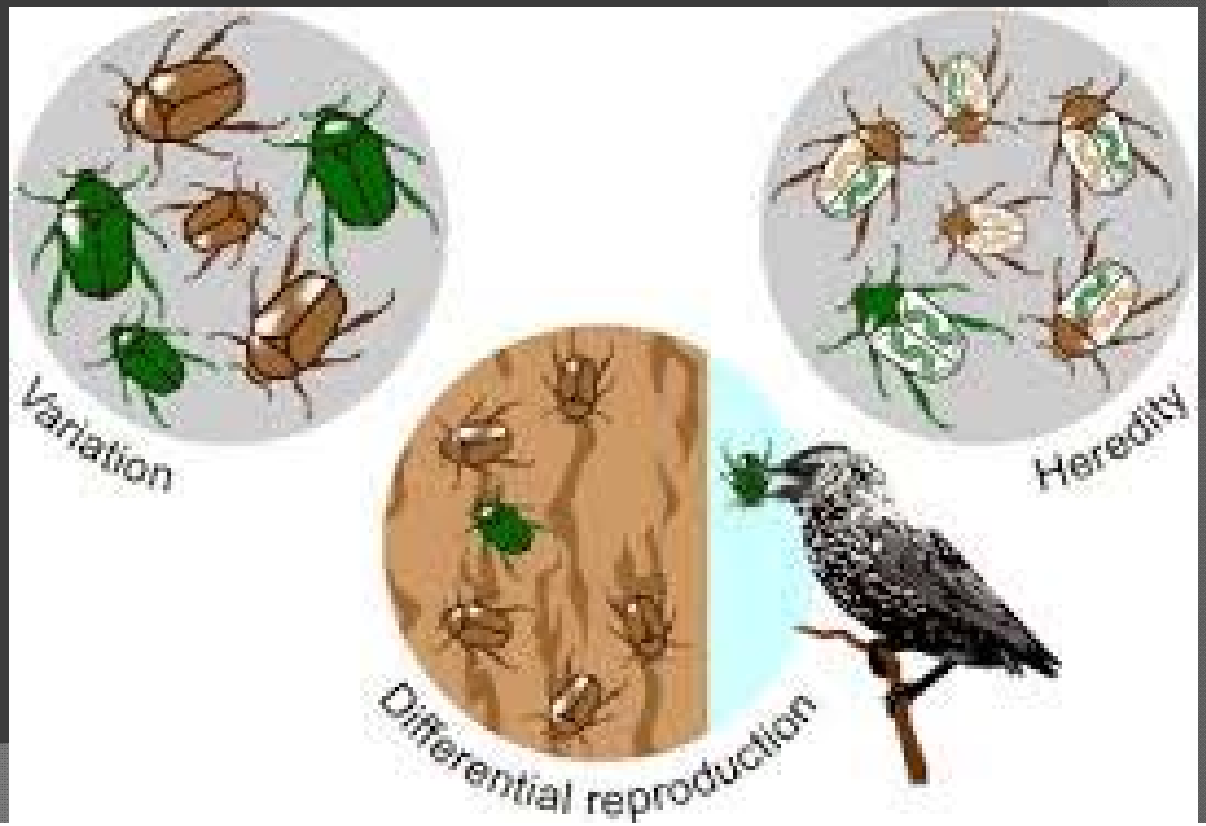
are all random.

# How Does Variation Arise?

This does not mean that evolution is random. Far from it!

This is because the selection process is far from random.

Variation is random, natural selection is not.



# Differential Survival

Because natural selection is not random, this leads to what is known as differential survival, which refers to a difference in the chance that an organism will survive to reproduce.

# Differential Survival

The result of differential survival is that the individuals best adapted to a *specific* environment will survive to reproduce.

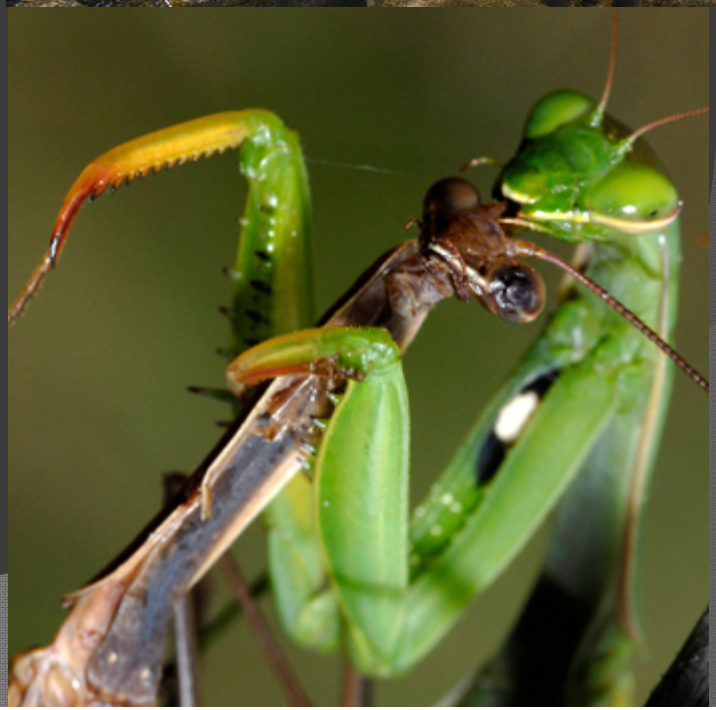
- They will get the most food
- find the best shelter
- not be eaten by other species.
- find a mate
- reproduce and care for their offspring

# Differential Survival

Remember it is ultimately **reproducing** that matters.

Once an organism passes on its genes, its biological “purpose” in life is done.

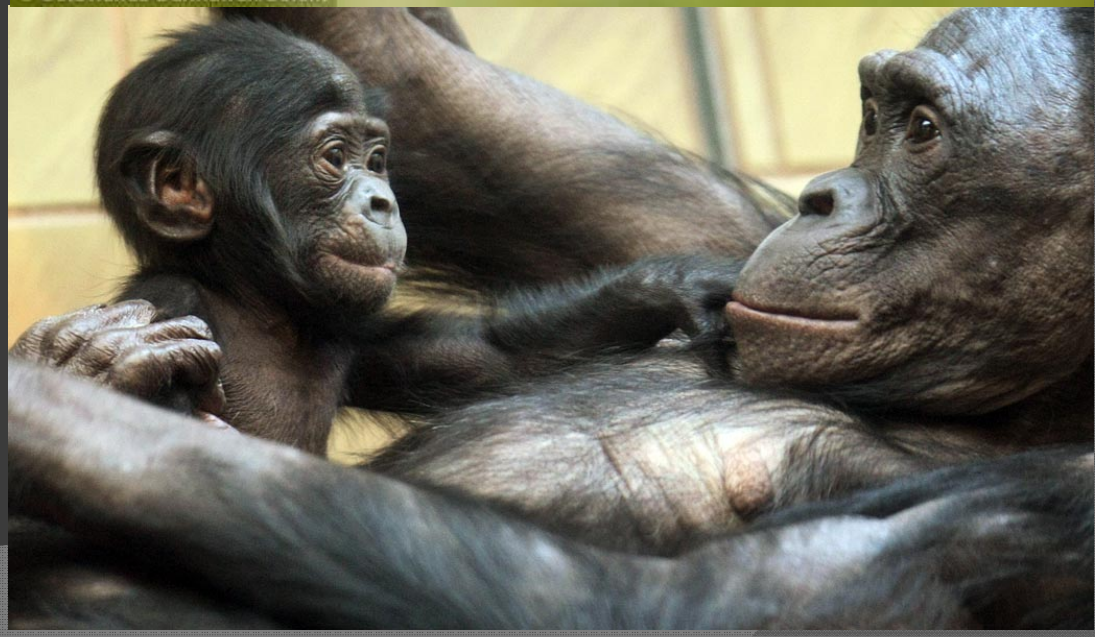
This is why many creatures die after mating.



# Differential Survival

Of course those are creatures whose offspring can survive on their own after being born.


Some offspring need parents around to help them grow and develop!



# Speciation

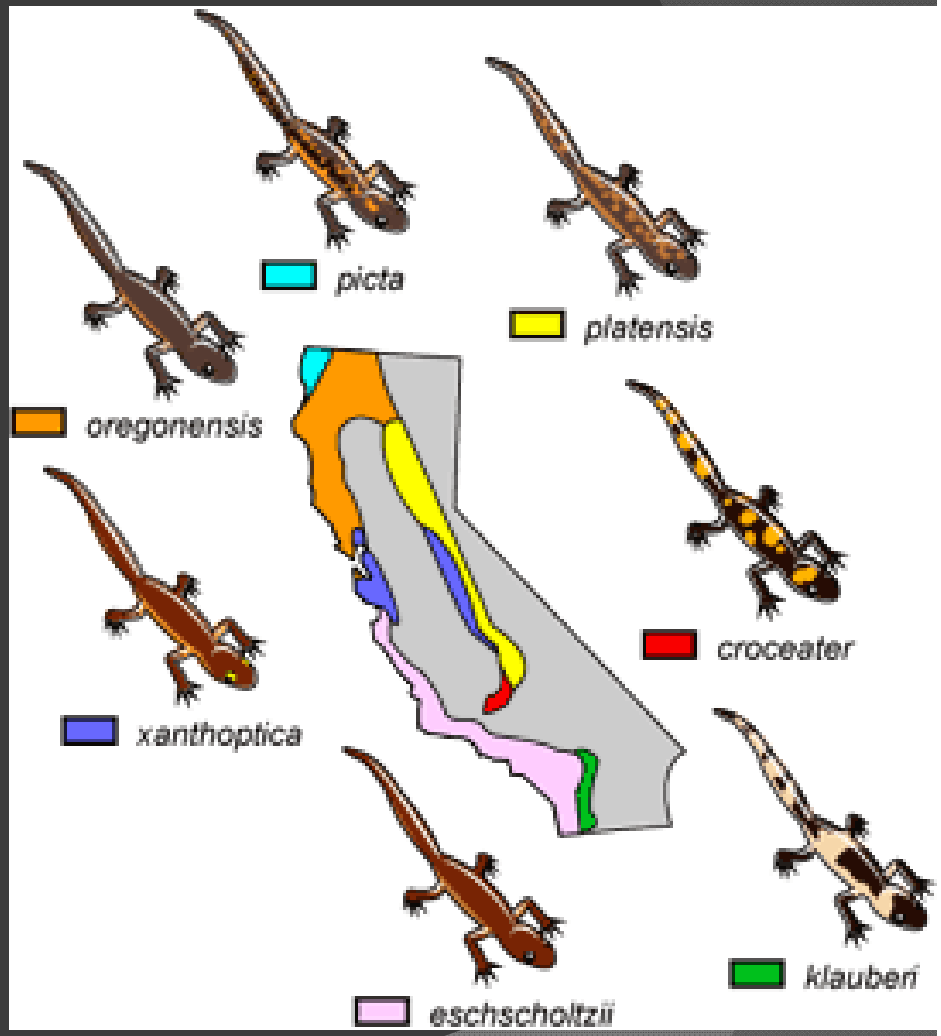
- If environments change (either gradually or suddenly), what traits are considered the "best adapted" may also change.

- This process can lead to changes in the species.

# Speciation

- When two populations of a species are in different environments they cannot interbreed.

- If the selection pressures are different in these respective environments, these populations will eventually become different species (speciation).



# Speciation

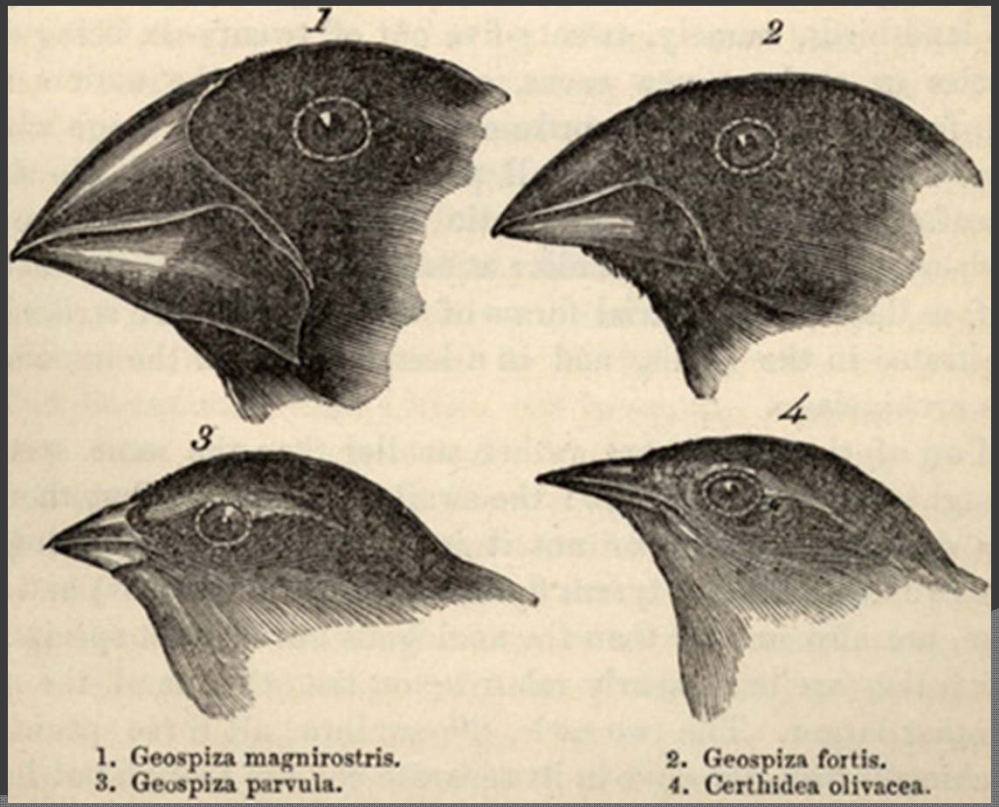

Example:

The eastern meadowlark (*Sturnella magna*) and the western meadowlark (*Sturnella neglecta*) have very similar body shapes and coloration.

- Their ranges overlap in the middle of the country.
- Considered different species:
  - Songs are different
  - Behavioral differences that prevent interbreeding.

# Speciation

When Darwin visited the Galapagos he noticed each island had a different species of finch that was well adapted to the environment of that island.



# Speciation

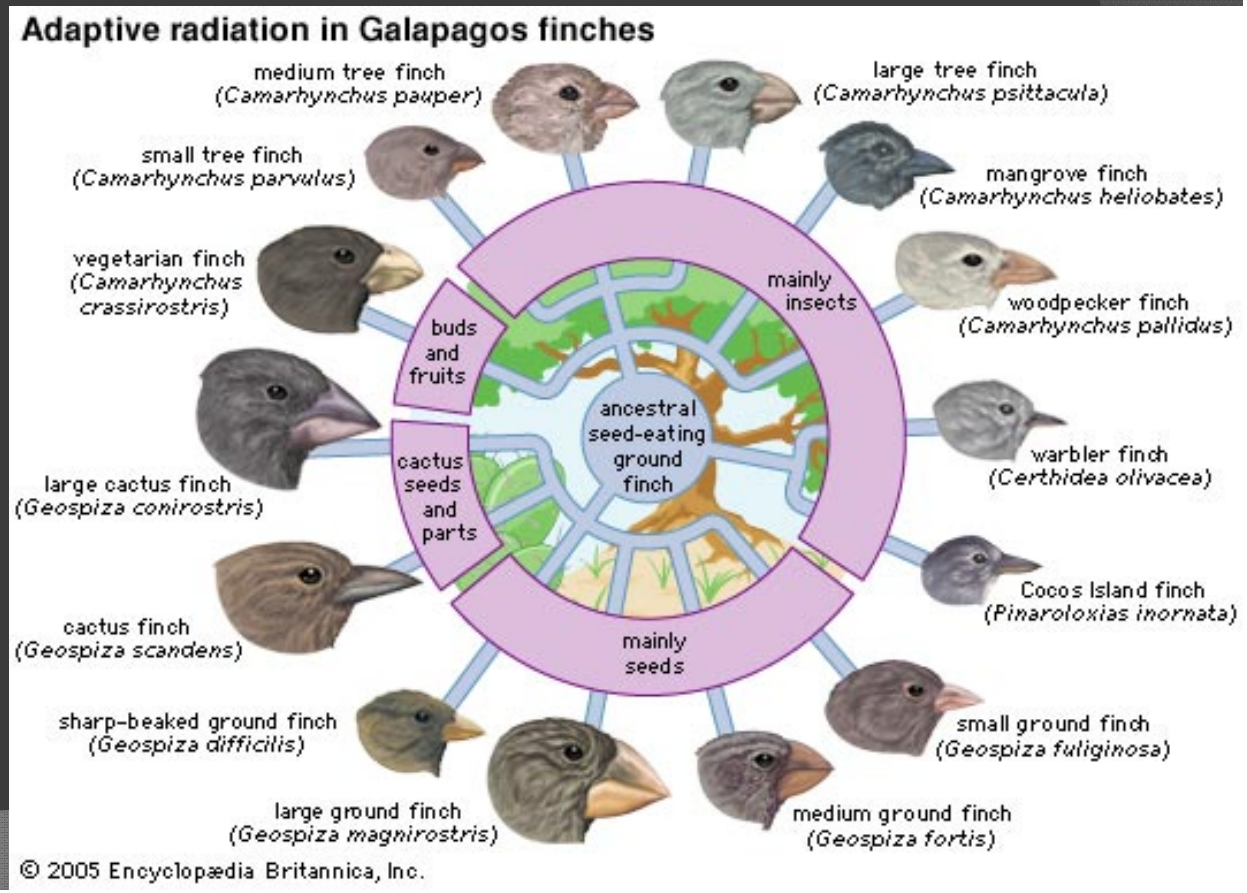
For instance on islands that only had plants with hard seeds, the finches on that island had smaller beaks used for cracking the seeds.

# Speciation

On islands that had lots of insects, he found finches with sharp and narrow beaks that were well adapted for digging out grubs from trees and the dirt.

# Speciation

All in all, it is estimated that it took approximately 500,000 years for these 14 species to evolve from the one common ancestor on the South American mainland.

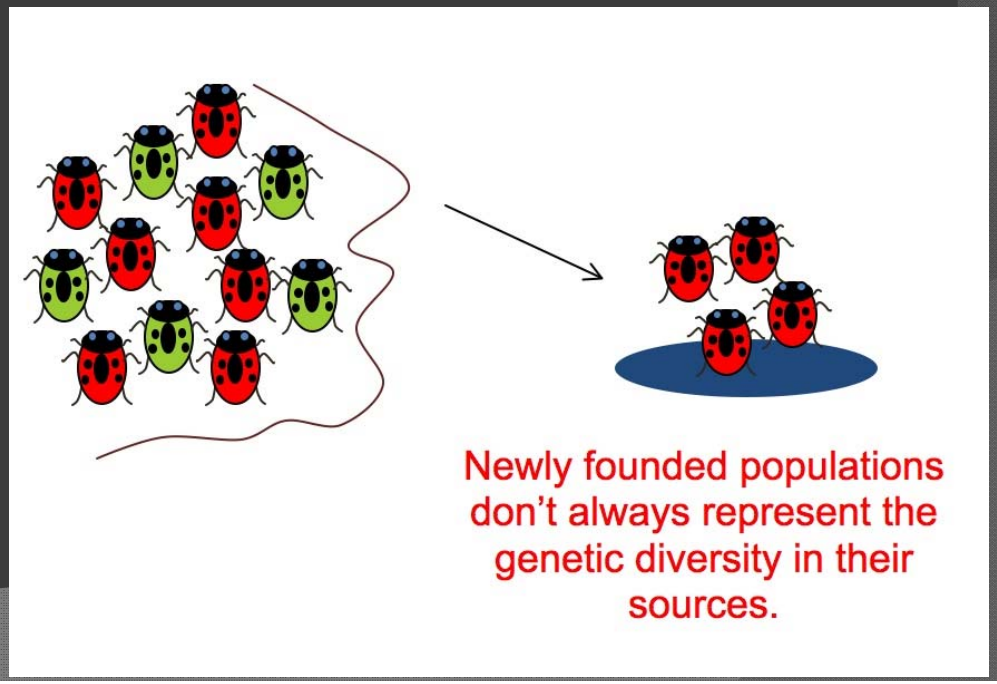


# Speciation

How do animals and plants even get to islands from the main land?

Birds and insects may fly, but plants and animals get to islands most likely from tropical storms that carry them there.

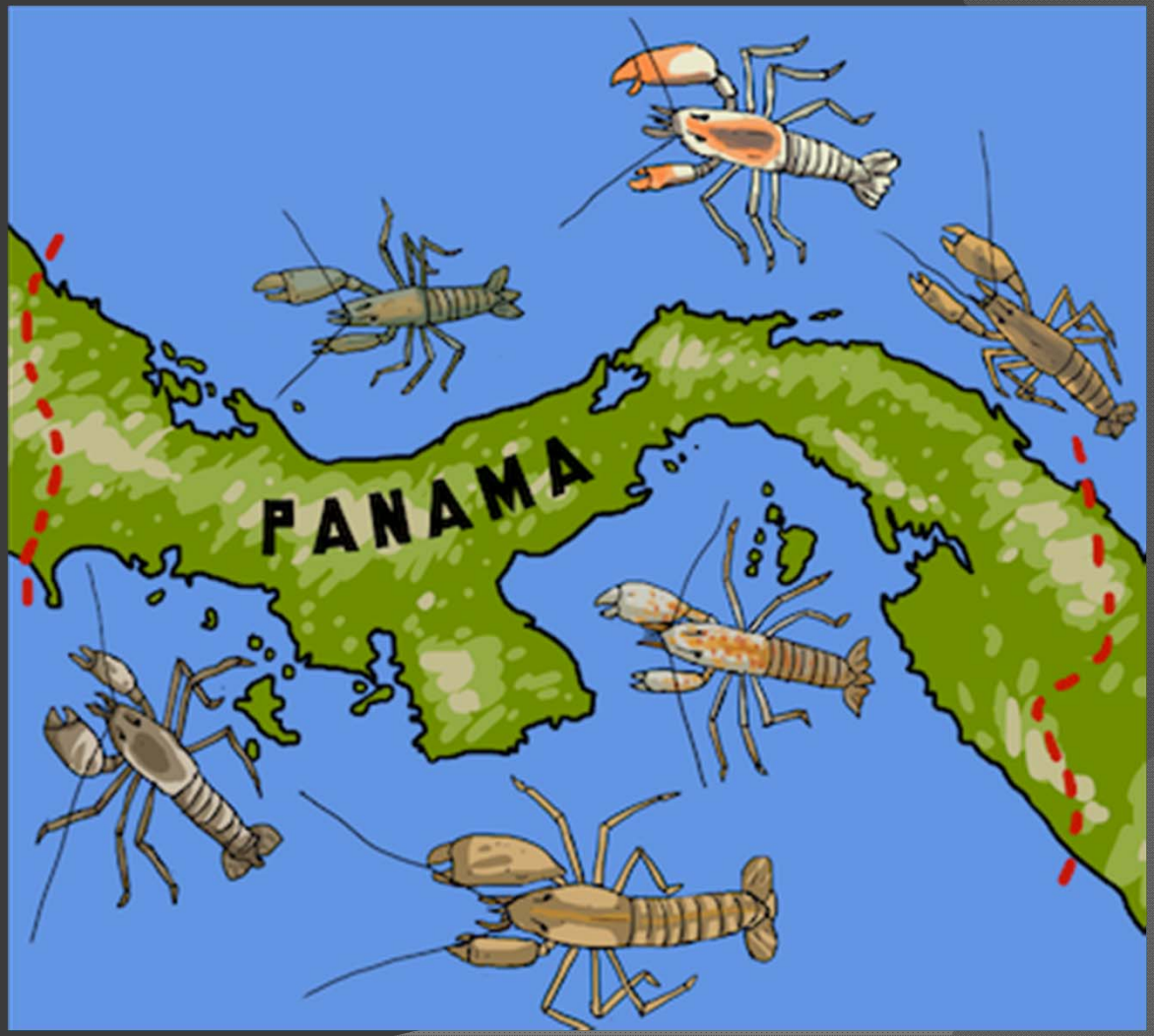
This is known as the Founder Effect.



In the summer of 1995, at least 15 iguanas survived Hurricane Marilyn on a raft of uprooted trees. They rode the high seas for a month before colonizing the Caribbean island, Anguilla. These few individuals were perhaps the first of their species, *Iguana iguana*, to reach the island.

# Speciation

There are many types of speciation, but allopatric speciation is where a geographical barrier separates two populations and prevents interbreeding.

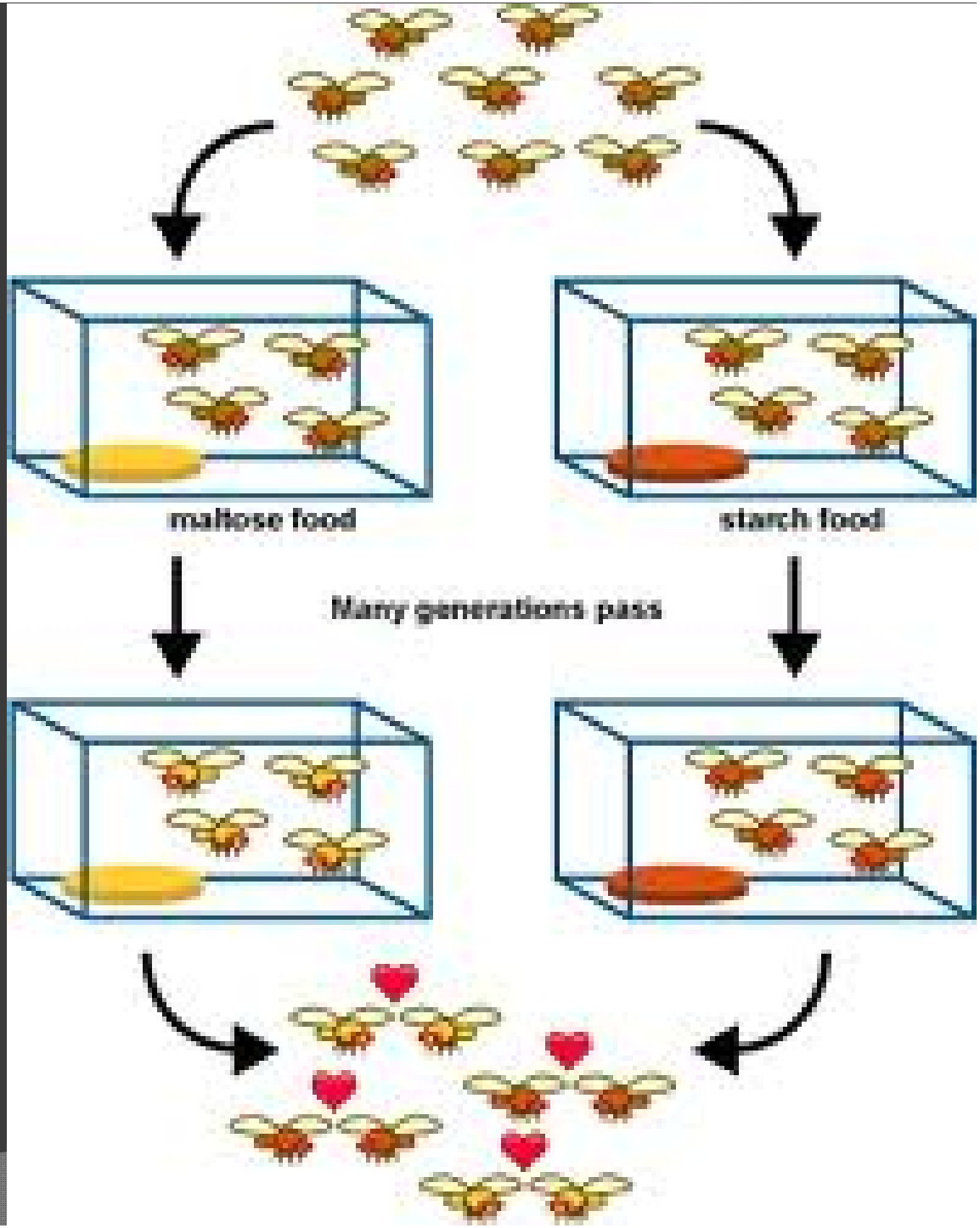


# Allopatric speciation of squirrels in the Grand Canyon



# Speciation

**We've even demonstrated speciation in the laboratory.**



# Extinction

Environments are constantly changing and if a species cannot adapt, they may go extinct.

The faster an environment changes, the less time a population has to adapt to these changes.

# Extinction

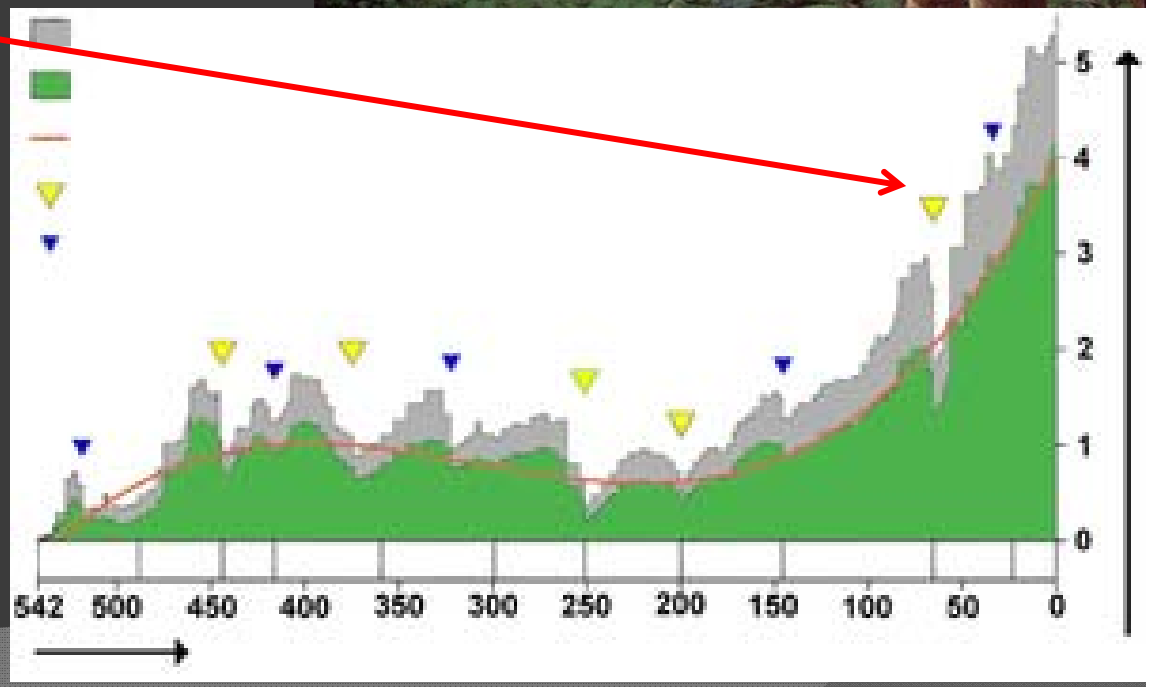
Ex. Dinosaurs

- Couldn't adapt to colder climate
- Their place was taken by mammals (homeothermic-warm blooded)
- Not all dinosaurs went extinct. Some also evolved to become warm-blooded birds.

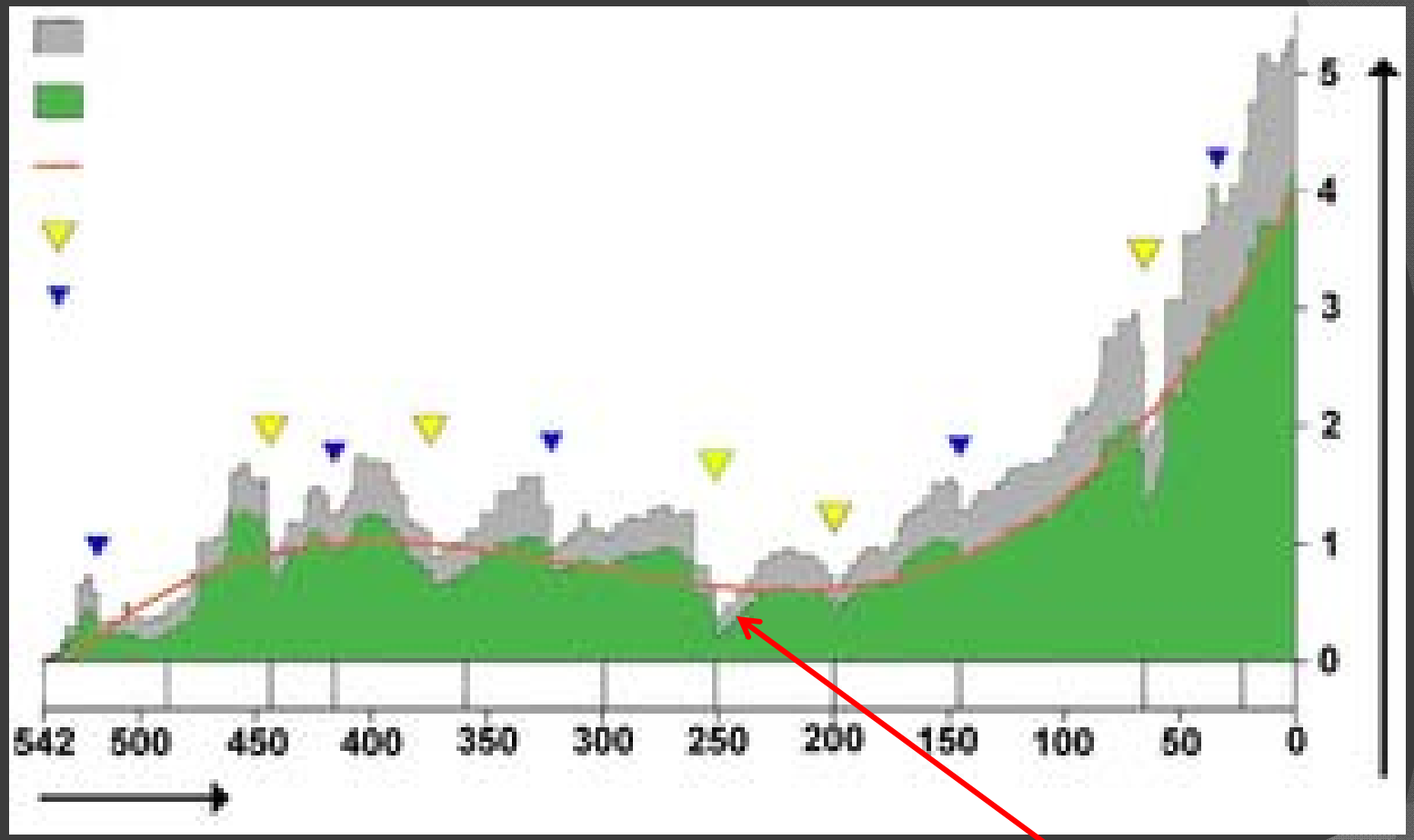
# There have been 5 major extinction events during the history of life on Earth.

*Some 99.9% of all species that have ever lived on Earth are now extinct.*

The Cretaceous-Tertiary Extinction (65.5 MYA) is probably the most well known, as it killed off all non-avian dinosaurs. 75% of all species went extinct.



# Extinction




This wasn't even the largest though. That honor goes to the Permian-Triassic Extinction (251 MYA) which caused the extinction of 96% of all marine species and 70% of all land species.

# Are We in the Midst Of a Sixth Mass Extinction?

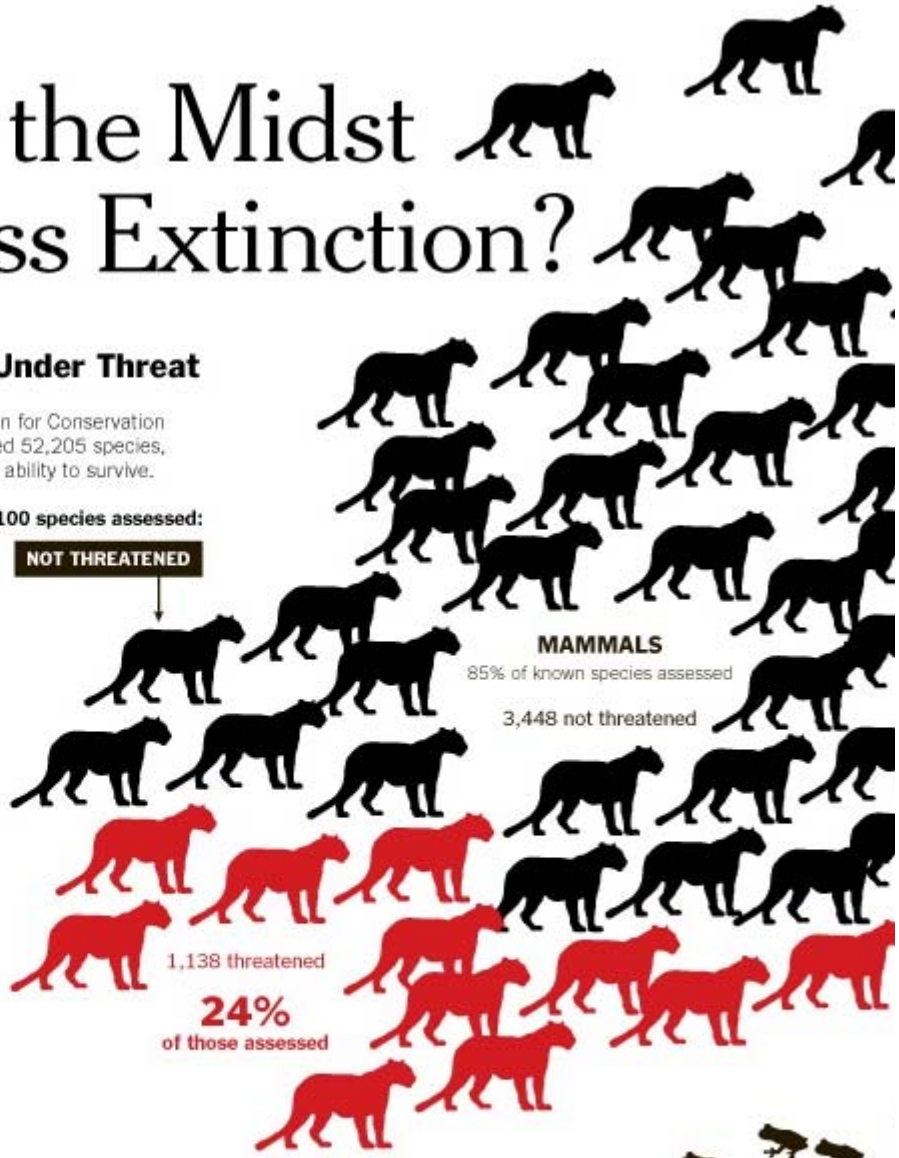
## A Tally of Life Under Threat

The International Union for Conservation of Nature has evaluated 52,205 species, shown here, for their ability to survive.

**Each symbol represents 100 species assessed:**

THREATENED

NOT THREATENED


## Stark Indicators Of Extinction Risks

Most **known species** of birds, mammals and amphibians have been evaluated; the percentage of each group that is threatened is considered a reasonable estimate.

# The Tip of a Vast Unknown

Only fractions of **known species** in these nine groups have been evaluated. Because assessments have focused on species likely to be in danger, the proportion of each group that is threatened may be overstated.

Meanwhile **unknown species** may number in the millions, or tens of millions — many times that of what has been discovered.

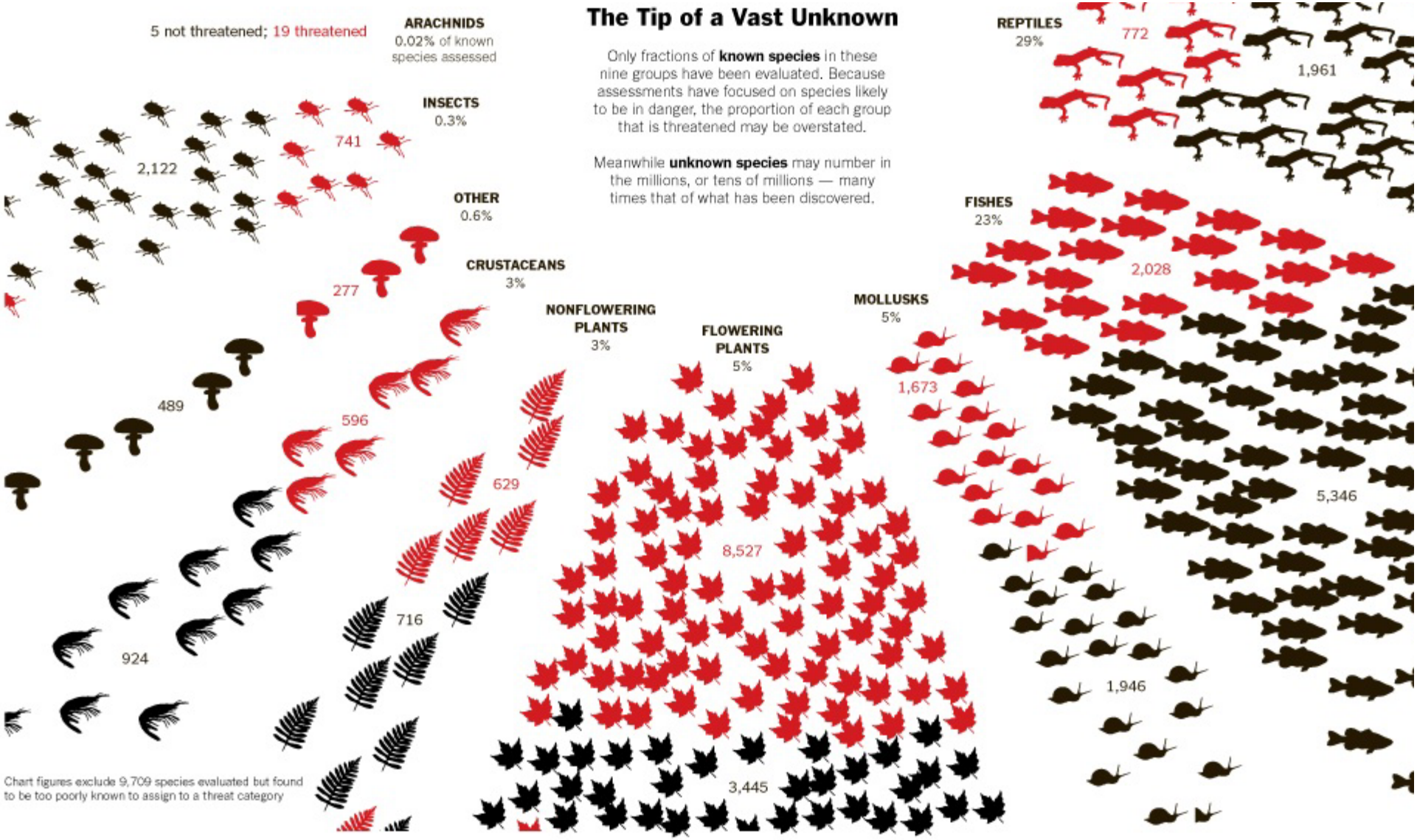
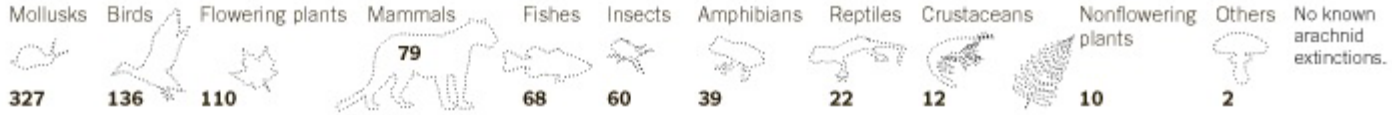



Chart figures exclude 9,709 species evaluated but found to be too poorly known to assign to a threat category

## Already Gone

Species known to be extinct, or extinct in the wild, since 1500:




Source: International Union for Conservation of Nature

BILL MARSH/THE NE