

# **Evolution**

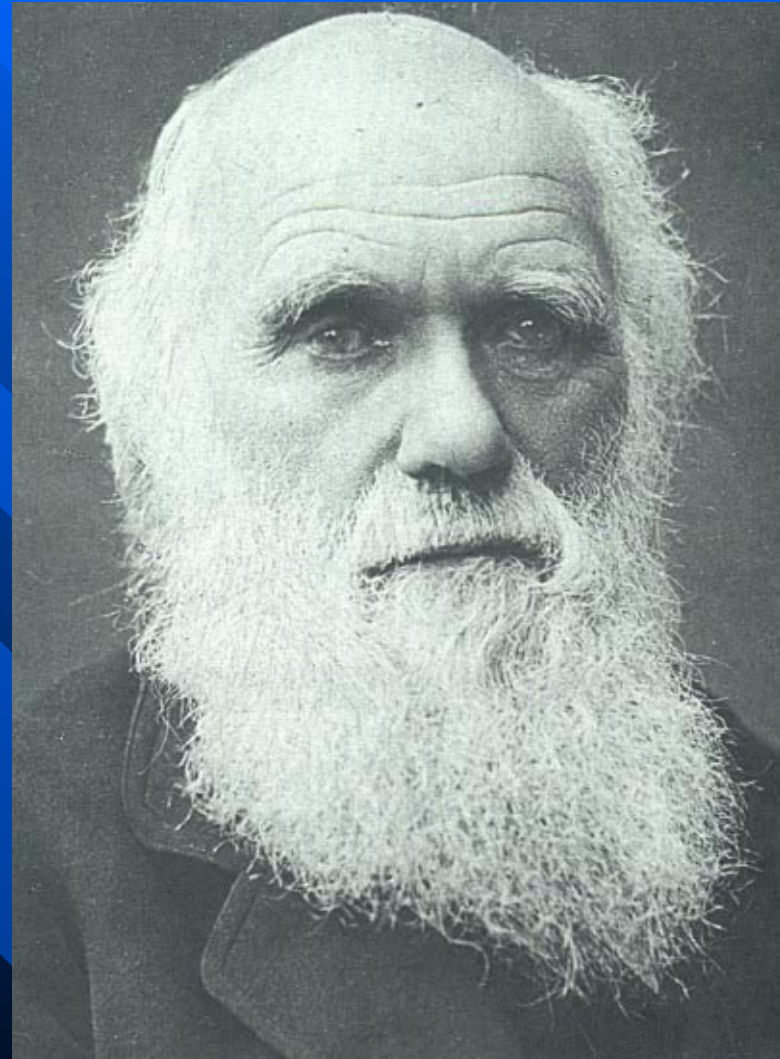
**Diversity of Life**

**High School Biology**

# Evolution

**“Nothing in  
biology  
makes sense  
EXCEPT in the  
light of  
evolution.”**

***Theodosius  
Dobzhansky***



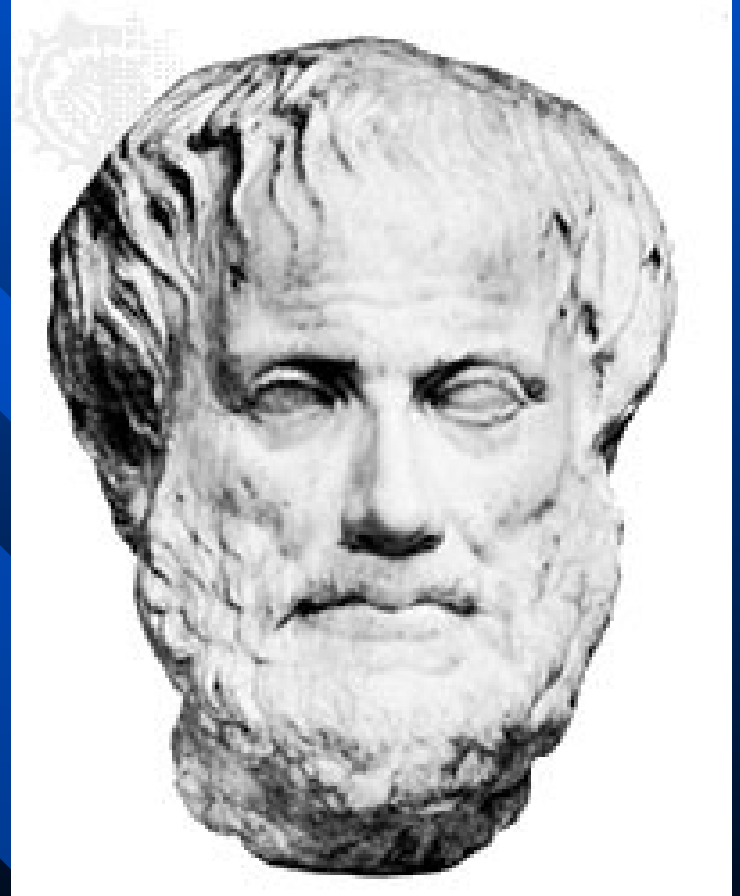
Copyright Rungtong High School. mkm

**Charles Darwin in later years**

# **History of Evolutionary Thought**

# Early Ideas On Earth's Organisms

- **Aristotle** believed species were **fixed creations** arranged by their **complexity**
- Idea **lasted 2000** years



# Early Ideas On Earth's Organisms

- **Linnaeus** - 1<sup>st</sup> to group similar organisms and assign them **Latin** names
- Two word name (**Genus species**)
- Known as **Binomial nomenclature**



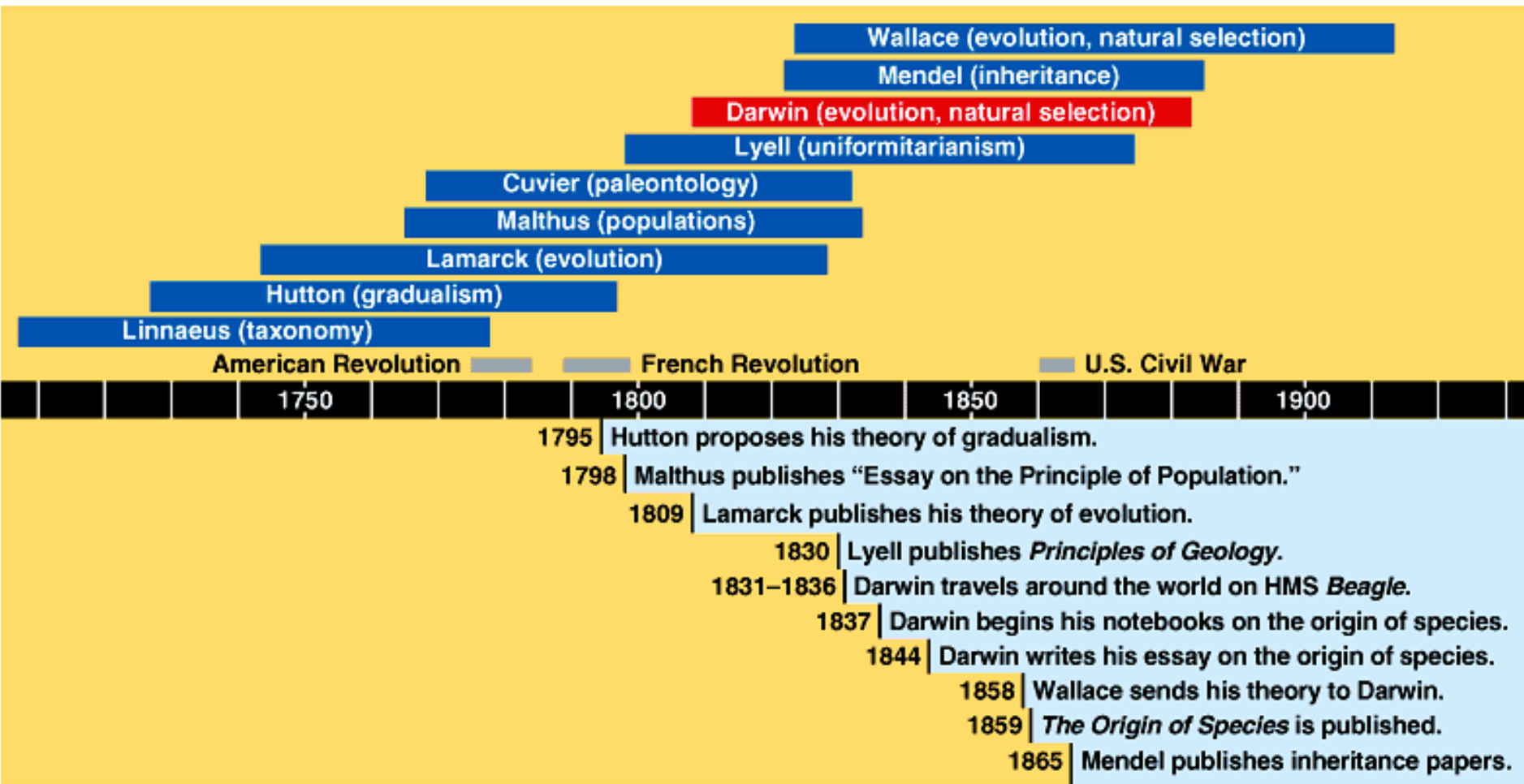
# **Contributor's to Darwin's thinking included:**

- **Charles Lyell - uniformitarianism (geologic processes still changing Earth)**
- **Georges Cuvier - species extinction (Catastrophism)**
- **Thomas Malthus - struggle for existence (resources)**

# Contributor's to Darwin's thinking included:

- James Hutton - Gradualism
- John Baptiste Lamarck - *Inheritance of acquired Characteristics* and *Law of Use and Disuse*
- Alfred Russel Wallace - organisms evolved from common ancestors

# Evolutionary Timeline



# Catastrophism

- Idea proposed by **George Cuvier**
- Studied fossil in **sedimentary rock strata** of Paris
- Found **some species completely disappeared** in more recent layers

# Catastrophism

- Stated that species disappear due to a catastrophic event of the earth's crust (volcano, earthquake...)

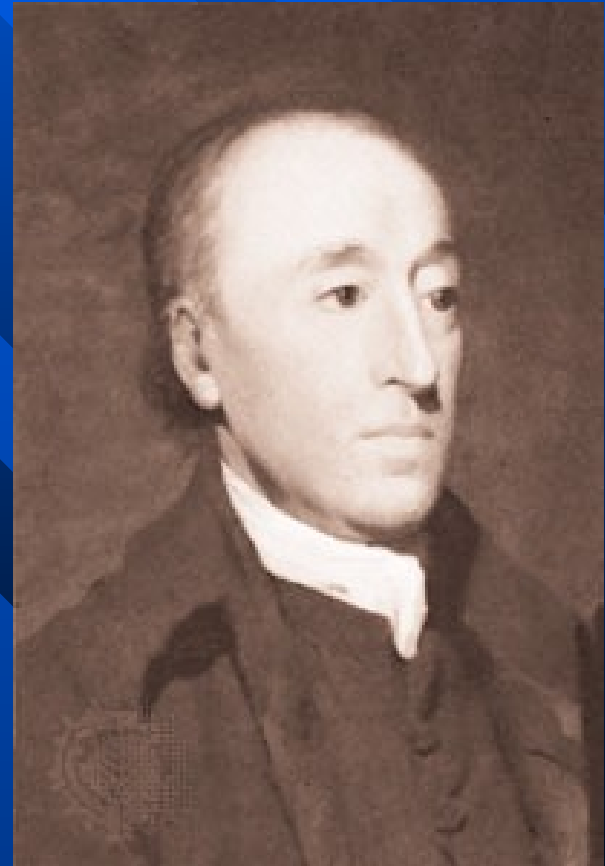


# Hutton's Theory of Geological Change

- **James Hutton**, 1795, Scottish geologist
- Studied **invertebrate fossils** in **Paris Museum**
- Described The **Geological Forces** That Have Changed **Life on Earth** Over Millions of Years (erosion, earthquakes, volcanoes...)

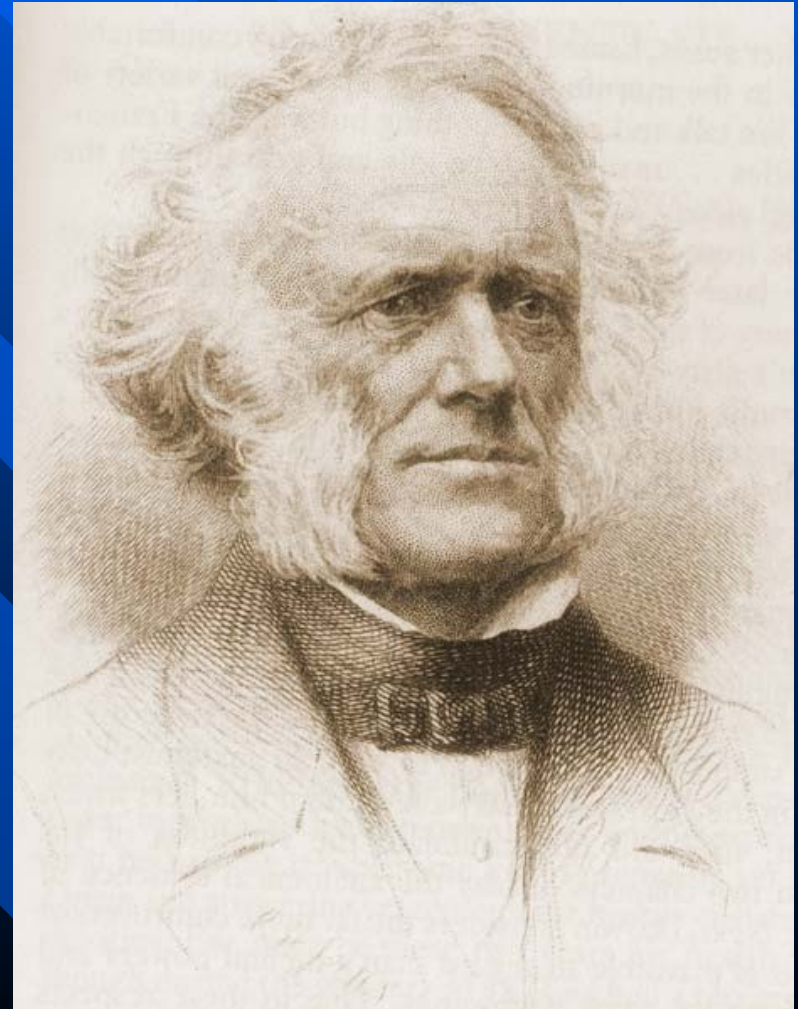
# Hutton's Theory of Geological Change

- Changes in Earth's crust due to **slow continuous processes**
- Idea Known as **Gradualism**



# Charles Lyell

- Proposed theory of **Uniformitarianism**
- Geological processes at **uniform rates** building & wearing down Earth's crust
- Proposed that the **Earth was millions of years** instead of a few thousand years old

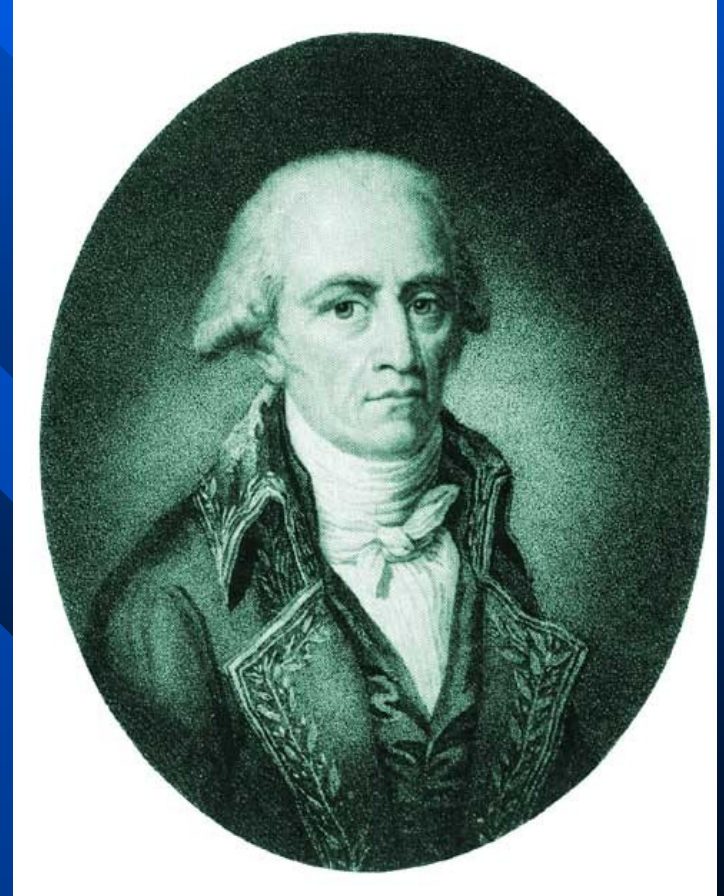


# ***Principles of Geology***

- Published by **Lyell** Just Before The **Beagle Set Sail & read by Darwin**
- Explained **Geological Processes That Shaped The Earth**
- Helped Darwin Understand **Sea Shells In The Andes Mountains At 12,000+ Feet**
  - Expanded Earth's Age

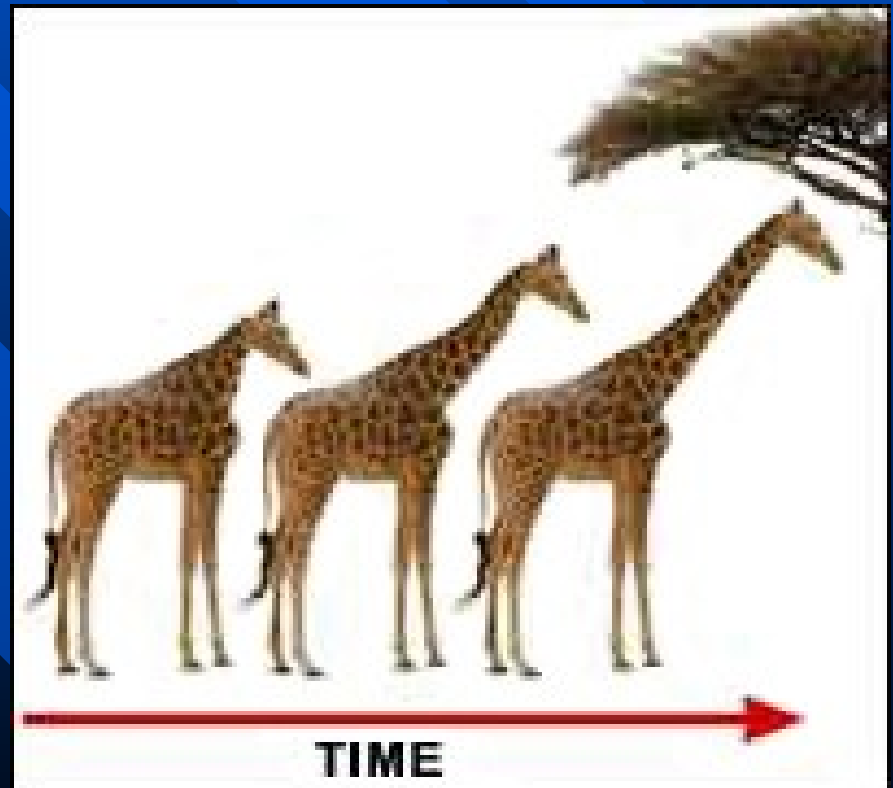
# Lamarck's Theory of Evolution

- **Jean-Baptiste Lamarck, 1809**
- One Of First Scientists To Understand That **Change Occurs Over Time**
- Stated that Changes Are Adaptations To Environment **acquired in an organism's lifetime**
- Said acquired changes were passed to offspring



# Lamarck's Theory of Evolution

- Idea called **Law of Use and Disuse**
- If a body part were used, it got stronger
- If body part NOT used, it deteriorated

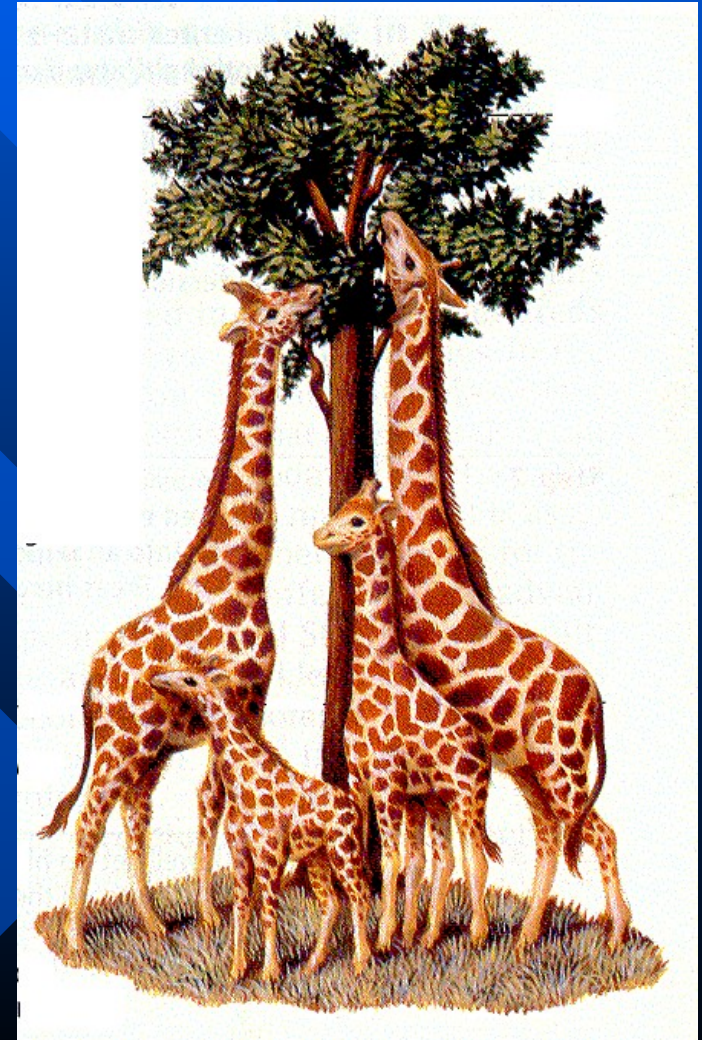


# Lamarck's Theory of Evolution

- **Inheritance of Acquired Characteristics**
- **Proposed That By Selective Use Or Disuse Of Organs, Organisms Acquired Or Lost Certain Traits During Their Lifetime**
- **These Traits Could Then Be Passed On To Their Offspring**
- **Over Time This Led To New Species**

# Lamarck's Theory of Evolution

- **Use & Disuse** - Organisms Could Change The Size Or Shape Of Organs By Using Them Or Not Using Them
- **Blacksmiths & Their Sons** (muscular arms)
- **Giraffe's Necks Longer** from stretching)



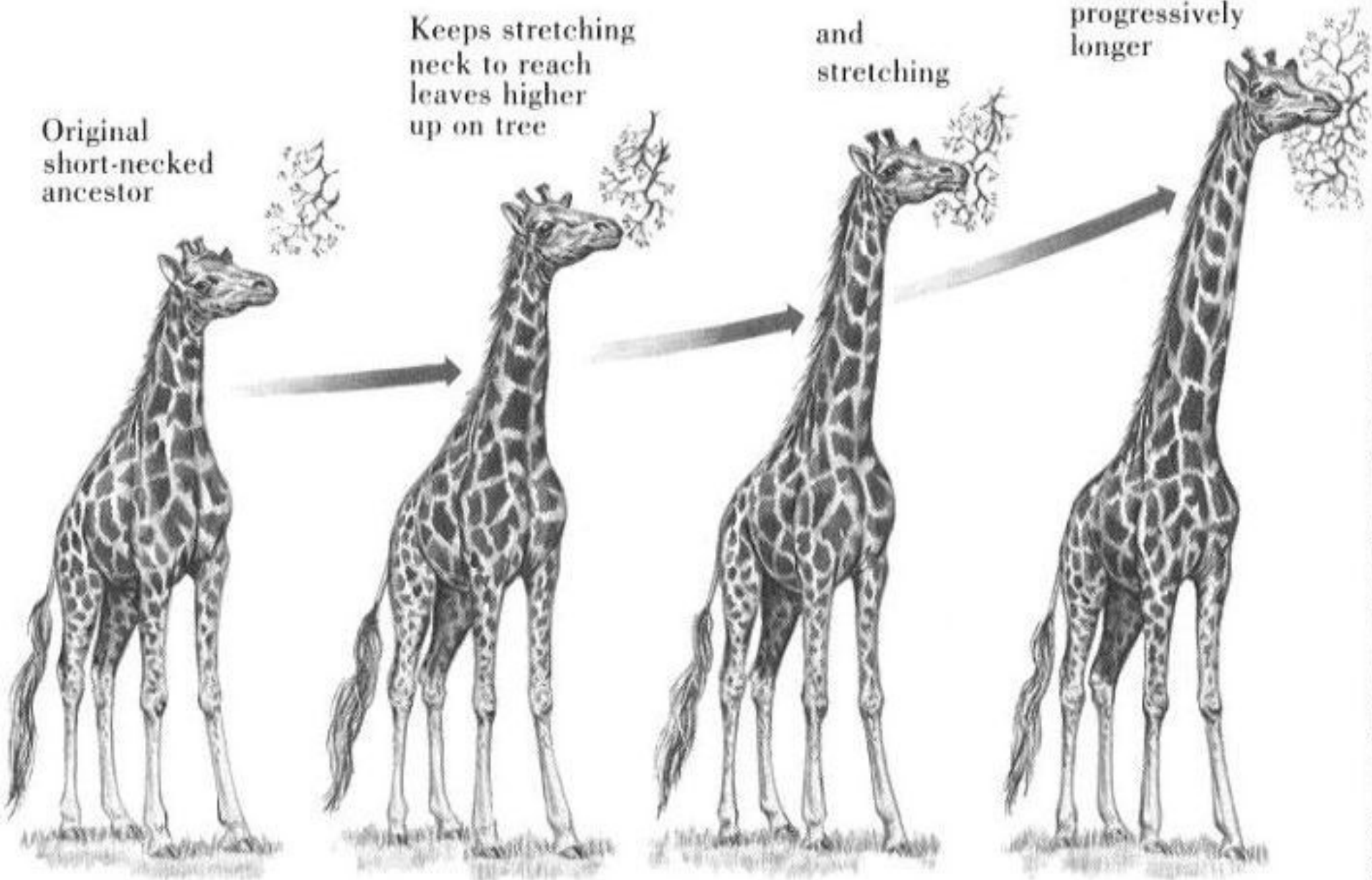
# LAMARCK'S GIRAFFE

Original  
short-necked  
ancestor

Keeps stretching  
neck to reach  
leaves higher  
up on tree

and  
stretching

and stretching  
until neck  
becomes  
progressively  
longer



Driven by inner "need"

# Lamarck's Theory of Evolution

- **Inheritance Of Acquired Traits**
  - Traits Acquired During Ones Lifetime Would Be Passed To Offspring



**Clipped ears of dogs could be passed to**

# Lamarck's Theory of Evolution

- **Tendency Toward Perfection**
- **Organisms Are Continually Changing and Acquiring Features That Help Them Live More Successfully In Their Environment**
- **Example:** Bird Ancestors Desired To Fly So They Tried Until Wings Developed

# Lamarck's Mistakes

- Lamarck Did NOT Know how traits were **inherited (Traits are passed through genes)**
- **Genes Are NOT Changed By Activities In Life**
- **Change Through Mutation Occurs Before An Organism Is Born**

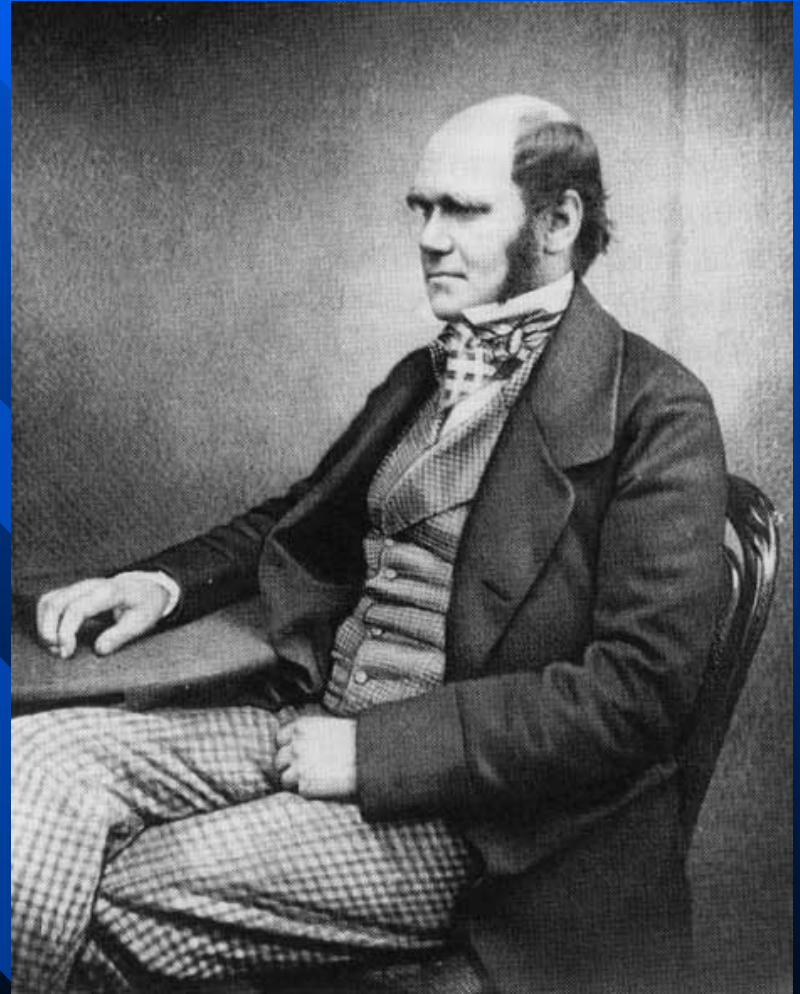
# Charles Darwin the Naturalist



# Voyage of the Beagle

## Charles Darwin

- Born Feb. 12, 1809
- Joined Crew of HMS Beagle, 1831
- Naturalist
- 5 Year Voyage around world
- Avid Collector of Flora & Fauna
- Astounded By Variety of Life



# Darwin's Voyage of Discovery



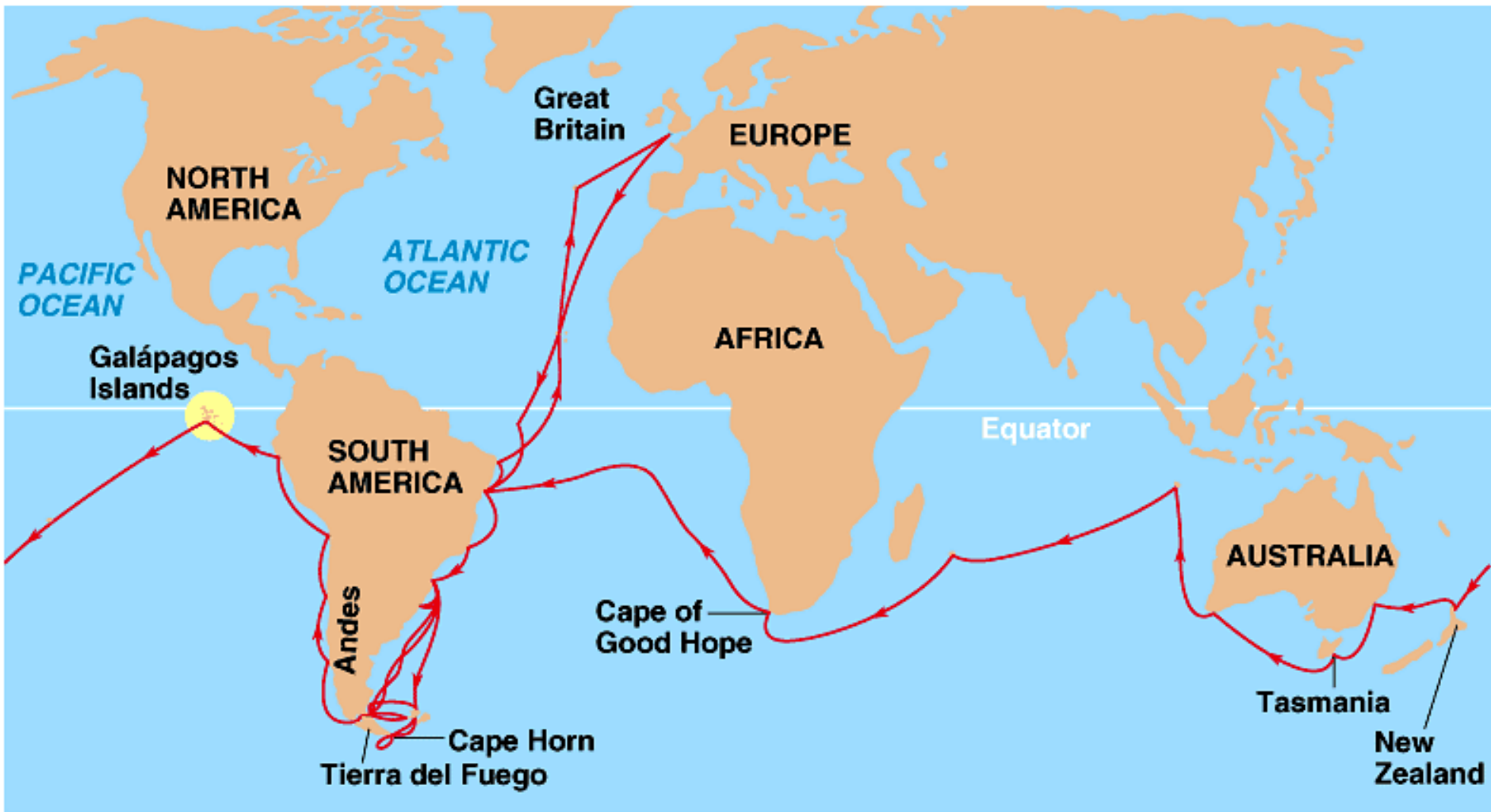
reconstruction of the HMS Beagle sailing off Patagonia

# Darwin Left England in 1831



**Darwin returned 5 years later in 1836**

# HMS Beagle's Voyage



Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

# The Galapagos Islands

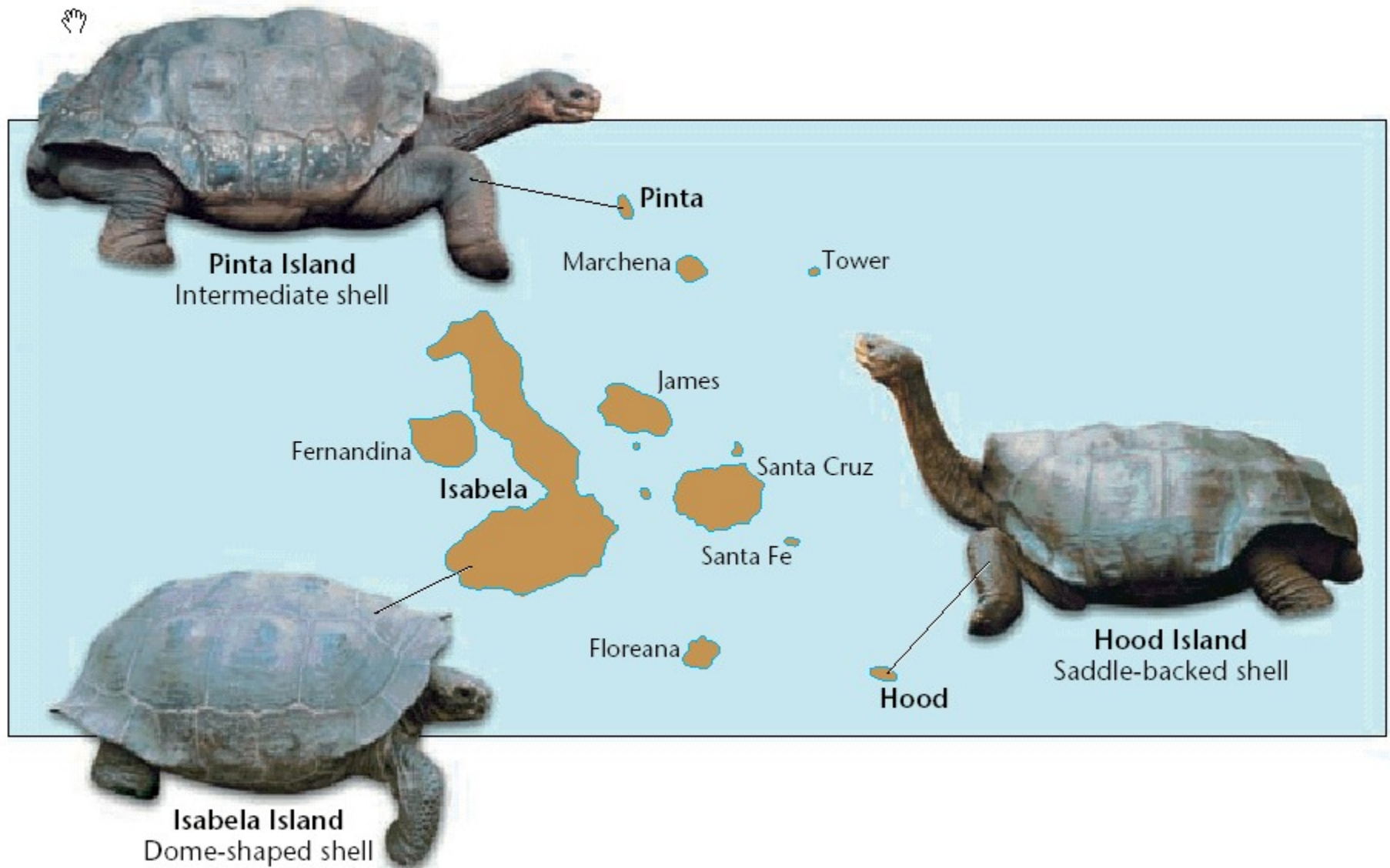
- Small Group of Islands 1000 km West of South America
- Very Different Climates
- Animals On Islands Unique
  - » Tortoises
  - » Iguanas
  - » Finches



# The Galapagos Islands

- **Volcanic islands** off the coast of South America
- **Island species varied from mainland species & from island-to-island species**
- **Each island had long or short neck tortoises**





# The Galapagos Islands

- Finches on the islands resembled a mainland finch
- More types of finches appeared on the islands where the available food was different (seeds, nuts, berries, insects...)
- Finches had different types of beaks adapted to their type of food gathering

## Galápagos Islands Finches

| Shape of Head and Beak |  |  |  |  |  |  |
|------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Name                   | Vegetarian tree finch                                                             | Large insectivorous tree finch                                                    | Woodpecker finch                                                                   | Cactus ground finch                                                                 | Sharp-beaked ground finch                                                           | Large ground finch                                                                  |
| Main Food              | Fruit                                                                             | Insects                                                                           | Insects                                                                            | Cactus                                                                              | Seeds                                                                               | Seeds                                                                               |
| Feeding Adaptation     | Parrotlike beak                                                                   | Grasping beak                                                                     | Uses cactus spines                                                                 | Large crushing beak                                                                 | Pointed crushing beak                                                               | Large crushing beak                                                                 |
| Habitat                | Trees                                                                             | Trees                                                                             | Trees                                                                              | Ground                                                                              | Ground                                                                              | Ground                                                                              |

# **Darwin's Observations & Conclusions**

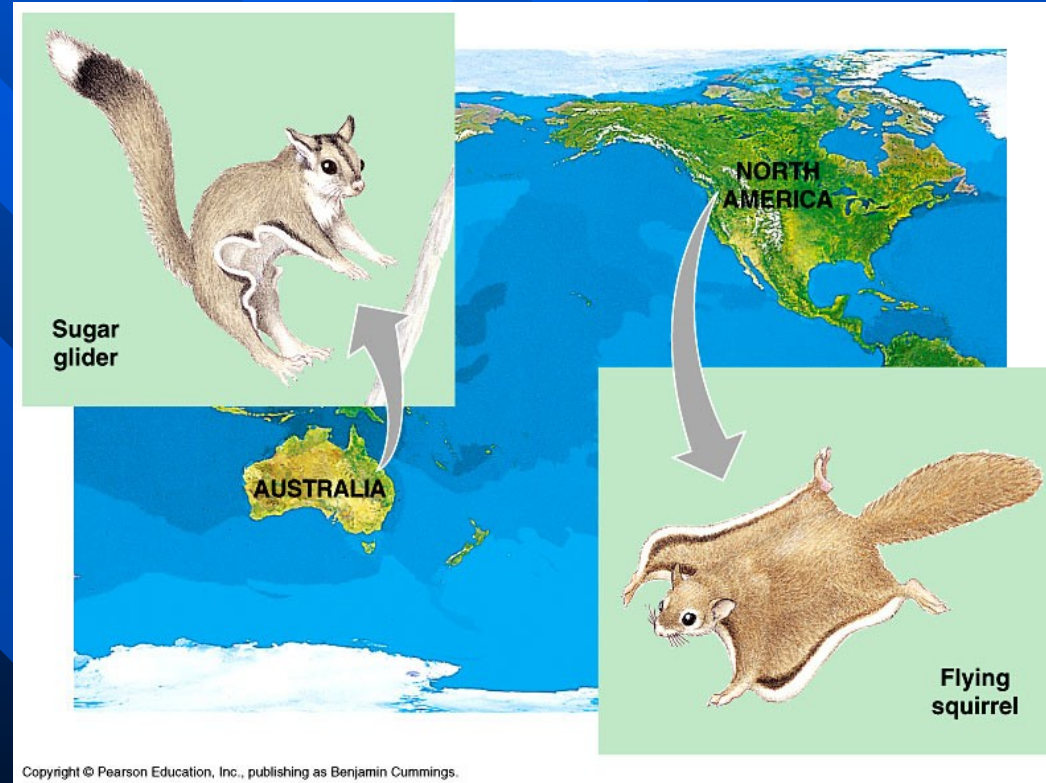
**The Struggle for  
Existence**

# Voyage of the Beagle

During His Travels, Darwin Made Numerous Observations And Collected Evidence That Led Him To Propose A **Revolutionary Hypothesis** About The Way Life Changes Over Time

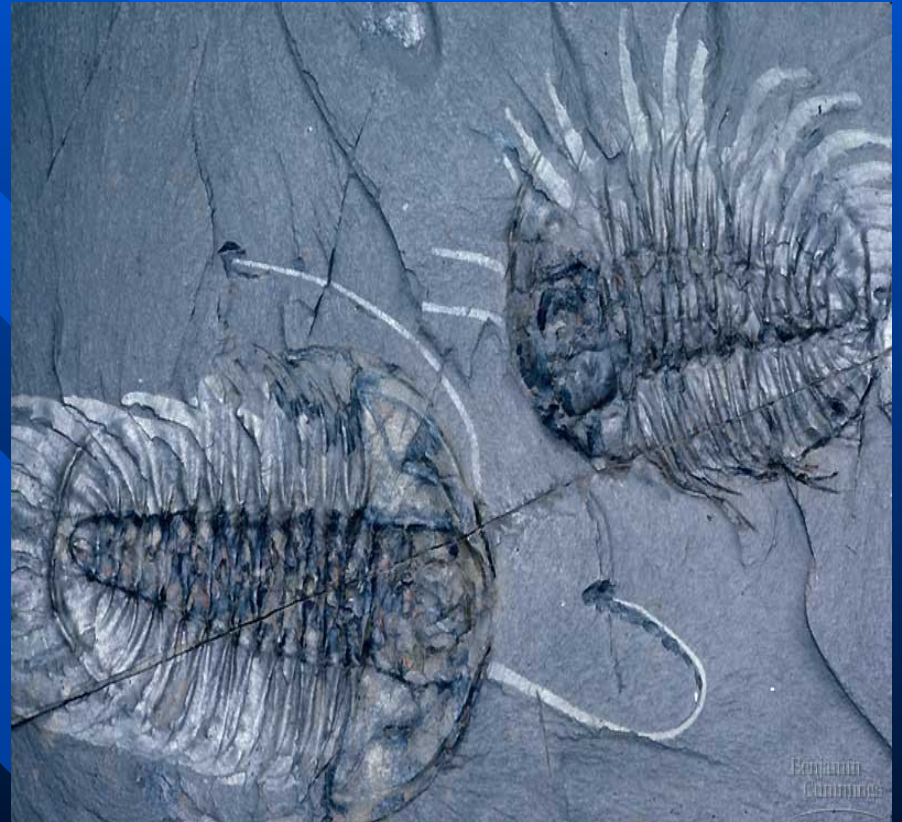
# Darwin's Observations

- Patterns of Diversity were shown
- Unique Adaptations in organisms
- Species Not Evenly Distributed
  - » **Australia, Kangaroos, but No Rabbits**
  - » **S. America, Llamas**



# Darwin's Observations

- Both Living Organisms & Fossils collected
- Fossils included:
  - » **Trilobites**
  - » Giant Ground Sloth of South America



**This species NO longer existed.**  
**What had happened to them?**

# Evidence for Evolution – The Fossil Record

(a) Strata of sedimentary rock with fossils embedded



(b) Fossilized sea urchin, at least 65 million years old



# Definition

- **Evolution** is the slow , gradual change in a population of organisms over time



# Darwin's Observations

- Left unchecked, the number of organisms of each species will increase exponentially, generation to generation
- In nature, populations tend to remain stable in size
- Environmental resources are limited



# Darwin's Conclusion

- Production of more individuals than can be supported by the environment leads to a **struggle for existence among individuals**
- Only a fraction of offspring survive each generation
- **Survival of the Fittest**



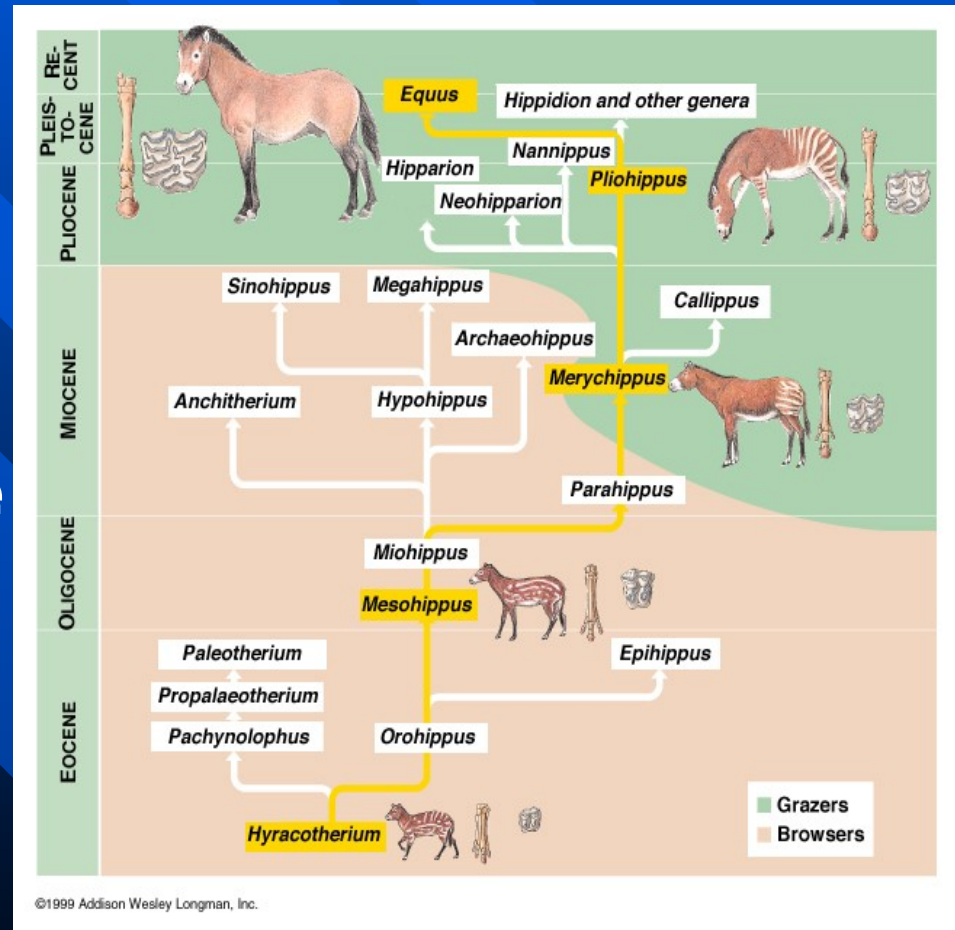
# Darwin's Observations

- Individuals of a population vary extensively in their characteristics with **no two individuals being exactly alike.**
- Much of this variation between individuals is **inheritable.**



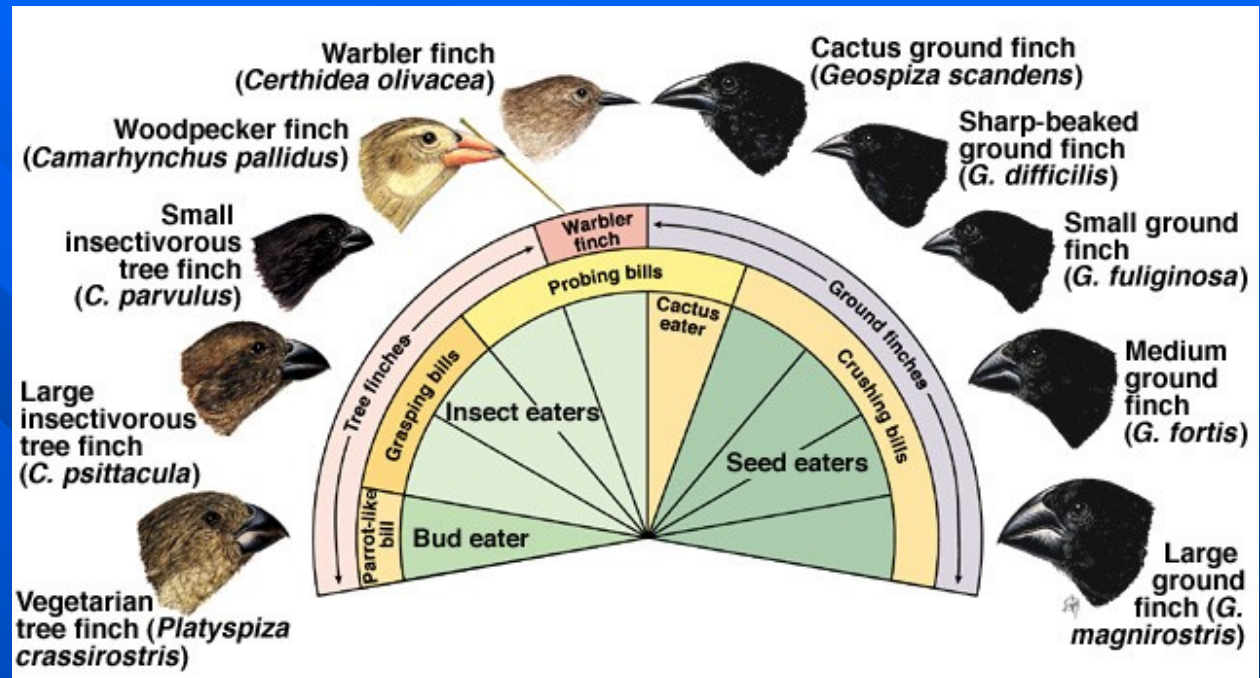
# Darwin's Conclusion

- Individuals who inherit characteristics **most fit for their environment** are likely to leave more offspring than less fit individuals
- Called **Natural Selection**



# Darwin's Theory of Evolution

- The unequal ability of individuals to survive and reproduce leads to a gradual change in a population, with favorable characteristics accumulating over generations (natural selection)



# **Ideas That Shaped Darwin's Thinking**

**Thomas Malthus**

# Population Growth

- **Thomas Malthus, 1798**
- **Economist**
- **Observed Babies Being Born Faster Than People Were Dying**
- **Population size limited by resources such as the Food Supply**

# **The Struggle for Existence**

## ■ **Malthus' Influence:**

- **High Birth Rates & Limited Resources Would Force Life & Death Competition**

## ■ **Each Species Struggles For:**

- **Food**
- **Living Space**
- **Mates**

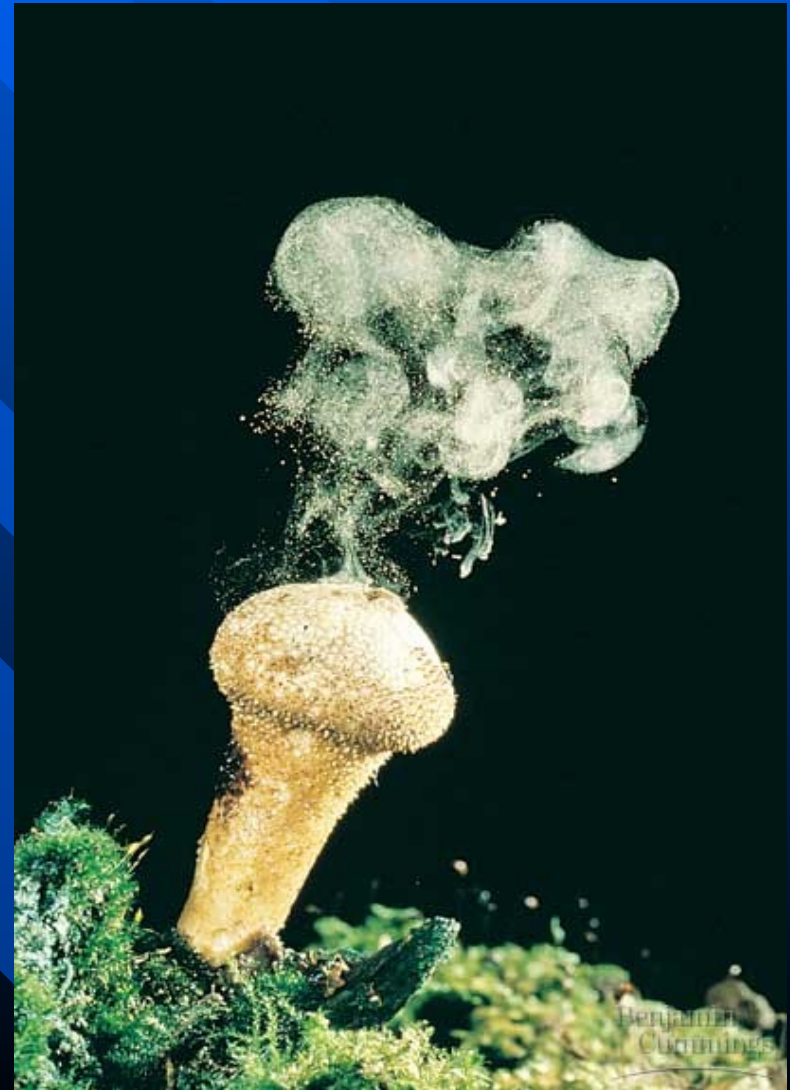
# Population Growth

- **Malthus** Reasoned That If The Human Population **Continued To Grow Unchecked**, Sooner or Later There Would Be **Insufficient Living Space & Food** For Everyone
- **Death Rate Will Increase To Balance Population size & Food Supply**



# Population Growth

- Darwin Realized Malthus's Principles Were Visible In Nature
- Plants & Animals Produce Far More Offspring Than Can Be Supported
  - Most Die
  - If They Didn't - Earth Would Be Overrun

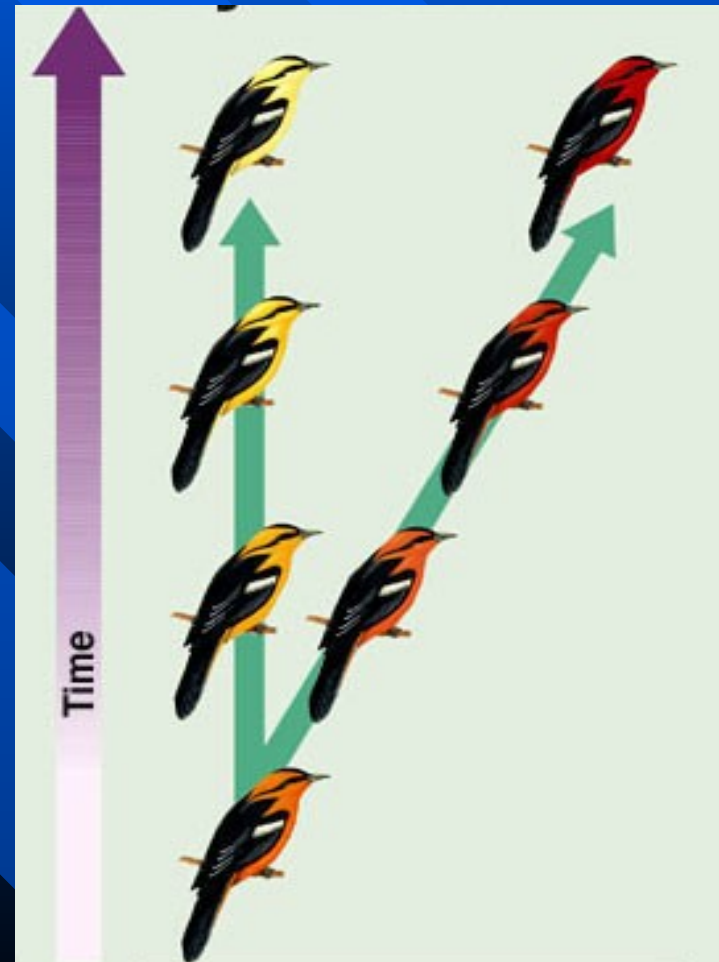


# **Darwin's Theory of Evolution**

**Organisms Change Over Time**

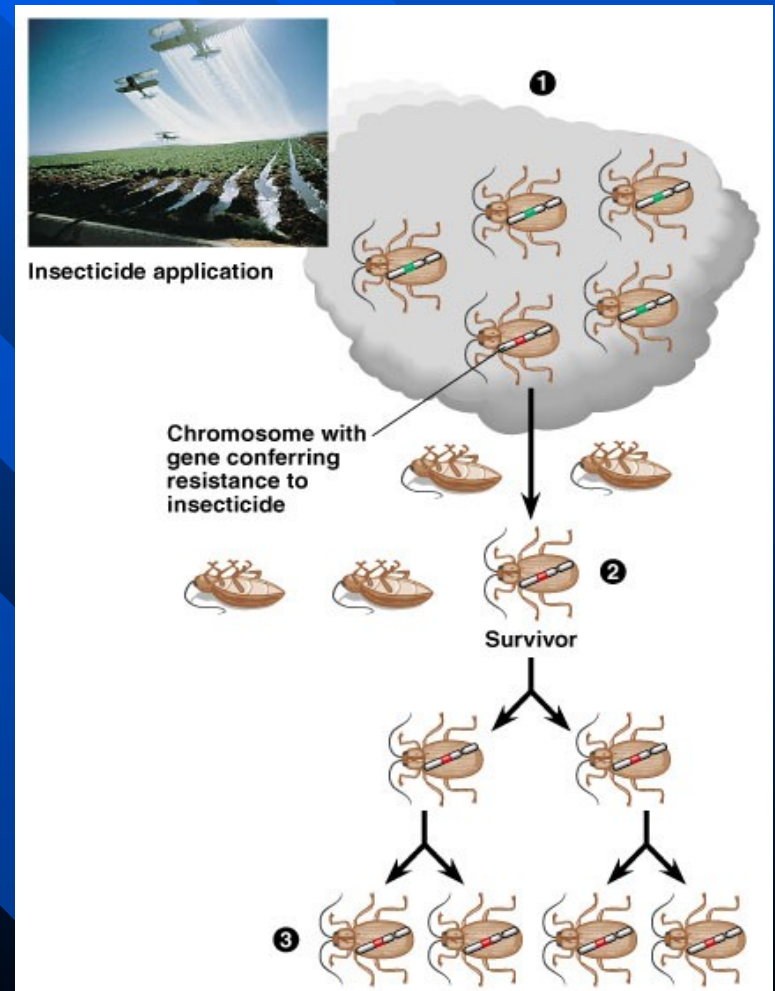
# Common Descent with Modification

- Darwin proposed that organisms descended from **common ancestors**
- Idea that organisms **change with time**, diverging from a common form
- Caused **evolution of new species**



# Natural Selection

- **Driving force** for evolution
- During the struggle for resources, **strongest survive & reproduce**
- Idea that at least **some of the differences** between individuals, which impact their survival and fertility, are **inheritable**



# **Origin of Species**

**Darwin Presents His Case**

# Publication of “On The Origin of Species”

- Upon His Return To England, Darwin Developed His Observations Into The Theory of Evolution
- But He **Did Not Publish For 25 Years** -

**Why?**

# Publication of “On The Origin of Species”

- Darwin Knew That His Theory Would Be **Extremely Controversial** And Would Be Attacked
- His Theory **Challenged Established Religious & Scientific Beliefs**, Particularly About The Creation Of Man

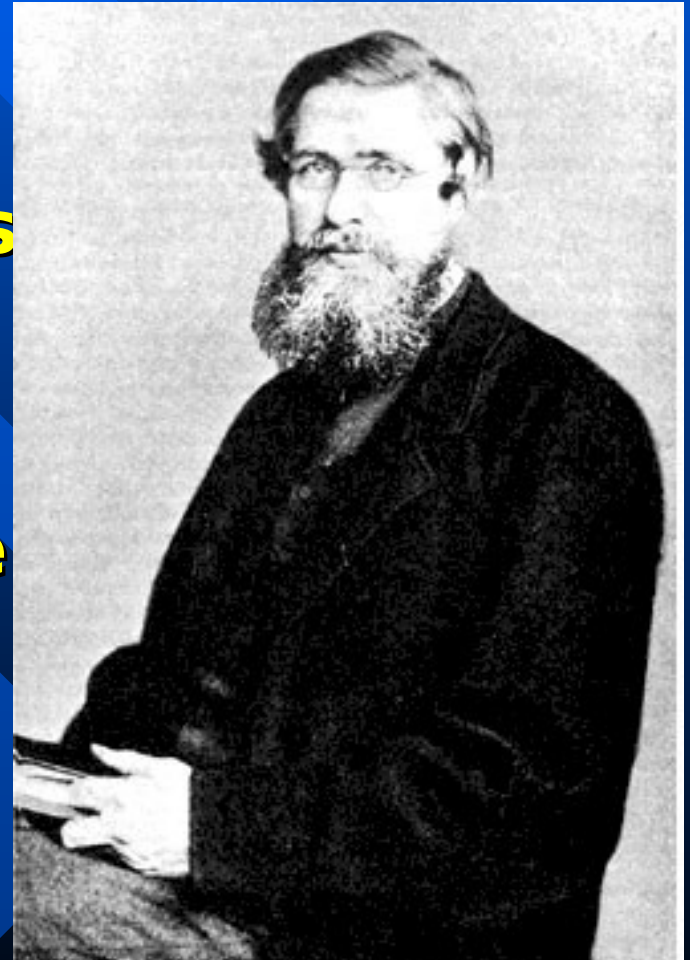
# Publication of “On The Origin of Species”

- He Refused To Publish Until He Received An Essay From **Alfred Wallace**
  - Fellow Naturalist
  - **Independently Developed The Same Theory**
  - After 25 Years, Someone Else Had Come To The Same Conclusions From Their Observations Of Nature



# Wallace's Contribution

- Alfred Russel Wallace Independently came to same Conclusion as Darwin that species changed over time because of their struggle for existence
- When Darwin read Wallace's essay, he knew he had to publish his findings



# Publication of “On The Origin of Species”

- Darwin Presented Wallace’s Essay & Some Of His Work At A Scientific Conference of the **Linnaean Society** in July of **1858**
- Then He Started On his book **“Origin of Species”**
- It Took Darwin 18 Months To Complete The Book

# Natural Variation and Artificial Selection

- **Abandoned The Idea** That Species Were Perfect & Unchanging
- Observed **Significant Variation in All Species** Observed
- Observed **Farmers Use Variation** To Improve Crops & Livestock
- Called **Selective Breeding**

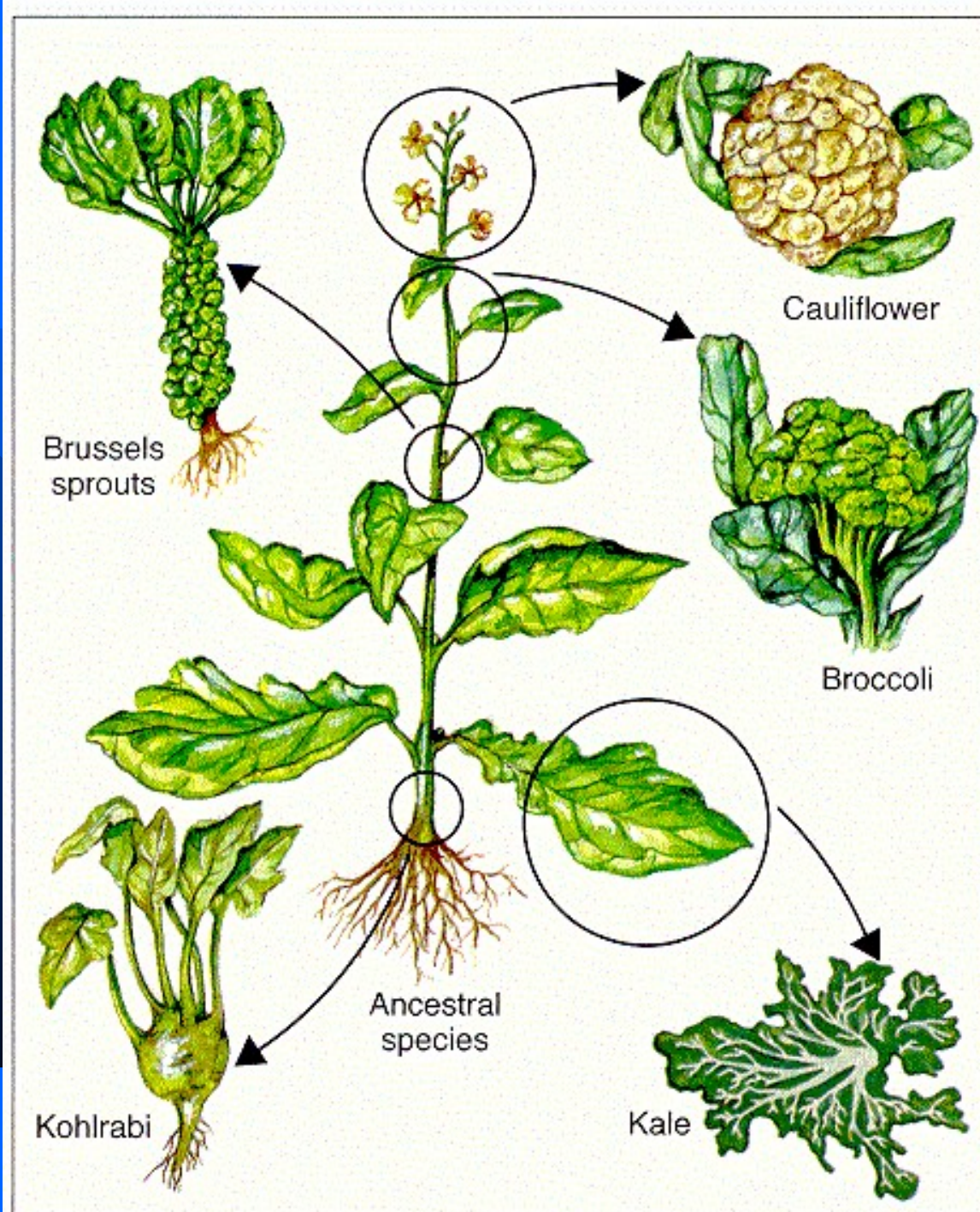
# Natural Variation and Artificial Selection

- **Natural Variation**
  - Differences Among Individuals Of A Species
- **Artificial Selection**
  - Selective Breeding To Enhance Desired Traits Among Stock or Crops

# Natural Variation and Artificial Selection

## Key Concept:

In **Artificial Selection**, Nature Provided The Variation Among Different Organisms, And Humans Selected Those Variations That They Found Useful



# **Origin of Species**

Concepts and Controversy

# Evolution By Natural Selection Concepts

- **The Struggle for Existence** (compete for food, mates, space, water, etc.)
- **Survival of the Fittest** (strongest able to survive and reproduce)
- **Descent with Modification** (new species arise from common ancestor replacing less fit species)

# Survival of the Fittest

## ■ **Fitness**

- **Ability of an Individual To Survive & Reproduce**

## ■ **Adaptation**

- **Inherited Characteristic That Increases an Organisms Chance for Survival**

# Survival of the Fittest

## ■ Adaptations Can Be:

- **Physical**

- » Speed, Camouflage, Claws, Quills, etc.

- **Behavioral**

- » Solitary, Herds, Packs, Activity, etc.

# Survival of the Fittest

- **Fitness** Is Central To The Process Of Evolution
- Individuals With Low Fitness
  - Die
  - Produce Few Offspring

**Survival of the Fittest**

**AKA Natural Selection**

# **Survival of the Fittest**

## **Key Concept**

**Over Time, Natural Selection Results In Changes In The Inherited Characteristics Of A Population. These Changes Increase A Species Fitness In Its Environment**

# Natural Selection



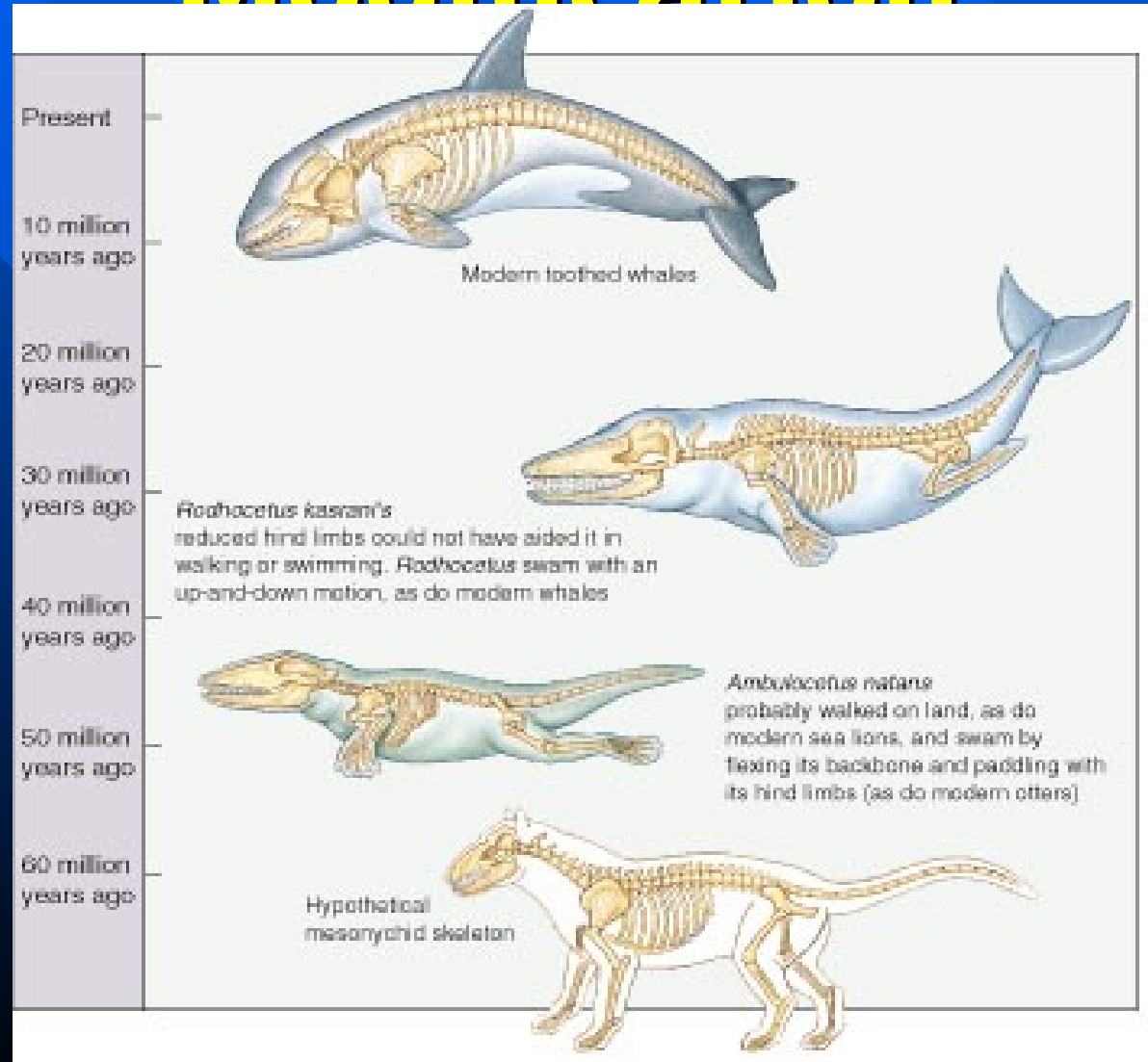
# Descent With Modification

- Takes Place Over **Long Periods** of Time
- Natural Selection Can Be **Observed** As Changes In
  - Body Structures
  - Ecological Niches
  - Habitats

# Descent With Modification

- Species **Today Look Different** From Their Ancestors
- Each Living Species Has
  - Descended
  - With Changes
  - From Other Species
  - Over Time

# Descent With Modification



# **Descent With Modification**

## ■ **Implies**

- All Living Organisms Are Related
- Single Tree of Life
  - » DNA, Body Structures, Energy Sources

## ■ **Common Descent**

- All Species, Living & Extinct, Were Derived From Common Ancestors

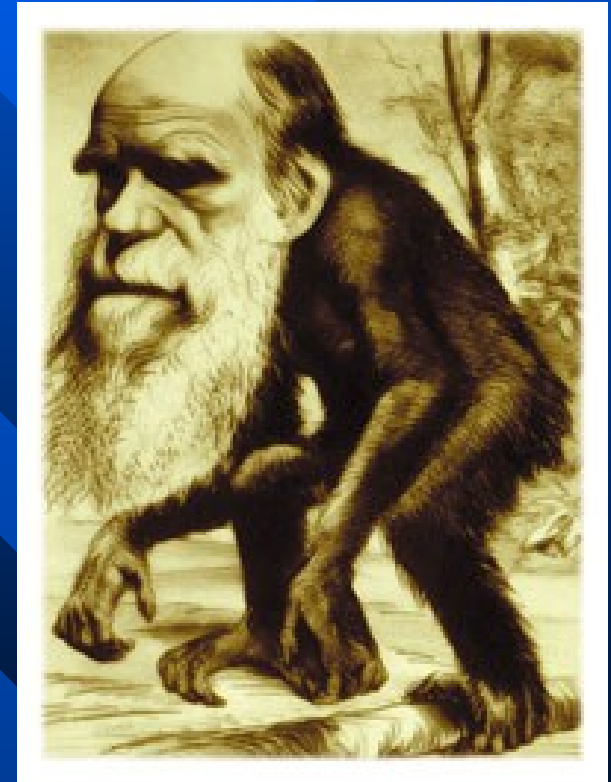
# Major Problem in Darwin's Theory

- **No mechanism to explain natural selection**
- How could favorable variations be transmitted to later generations?
- With the rediscovery of **Mendel's work** in the first half of the 20th century, the missing link in evolutionary theory was found



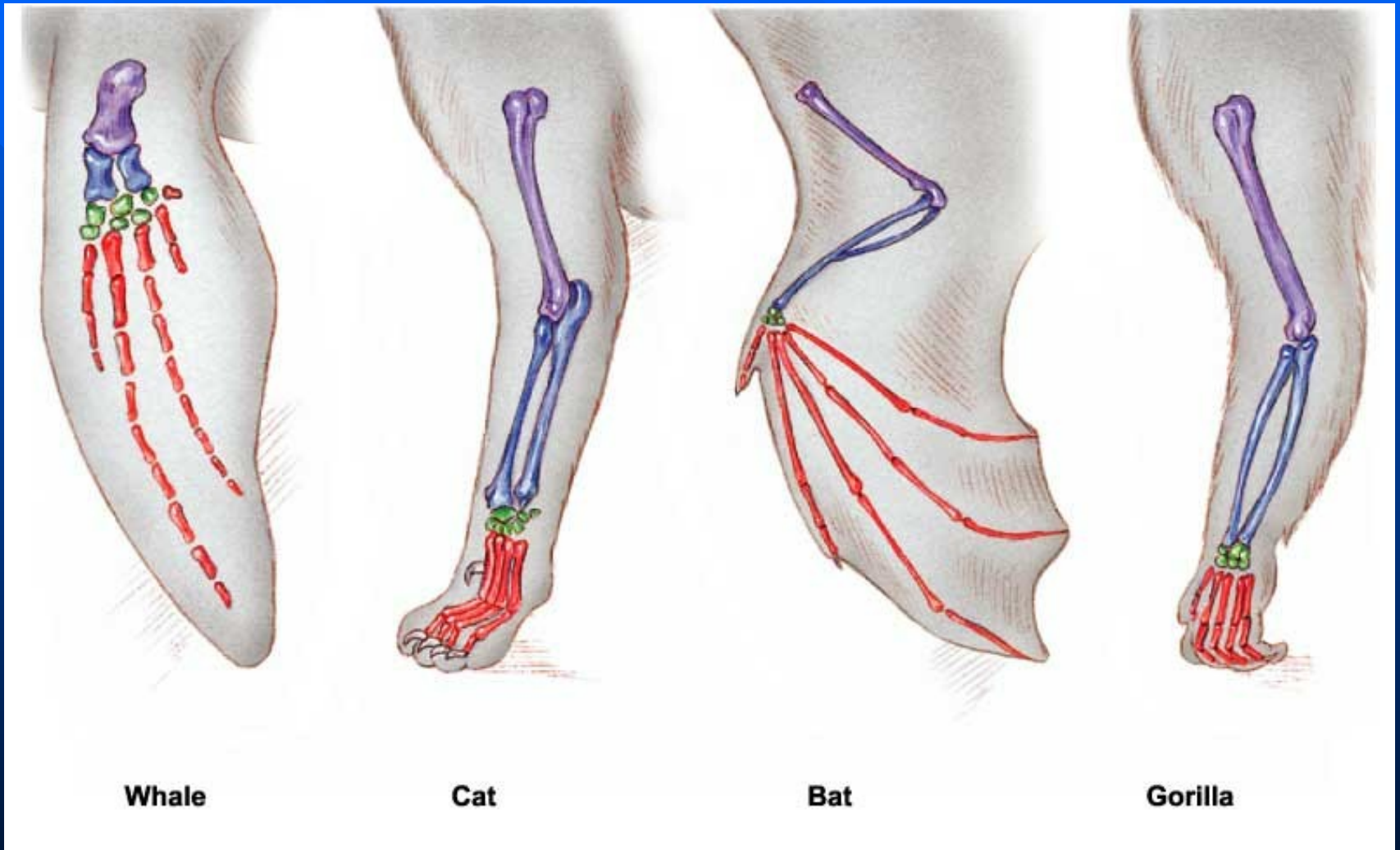
# Opposition to Evolution

- The upheaval surrounding evolution began with Darwin's publication of *On the Origin of Species By Means of Natural Selection*
- The debate continues nearly 150 years later



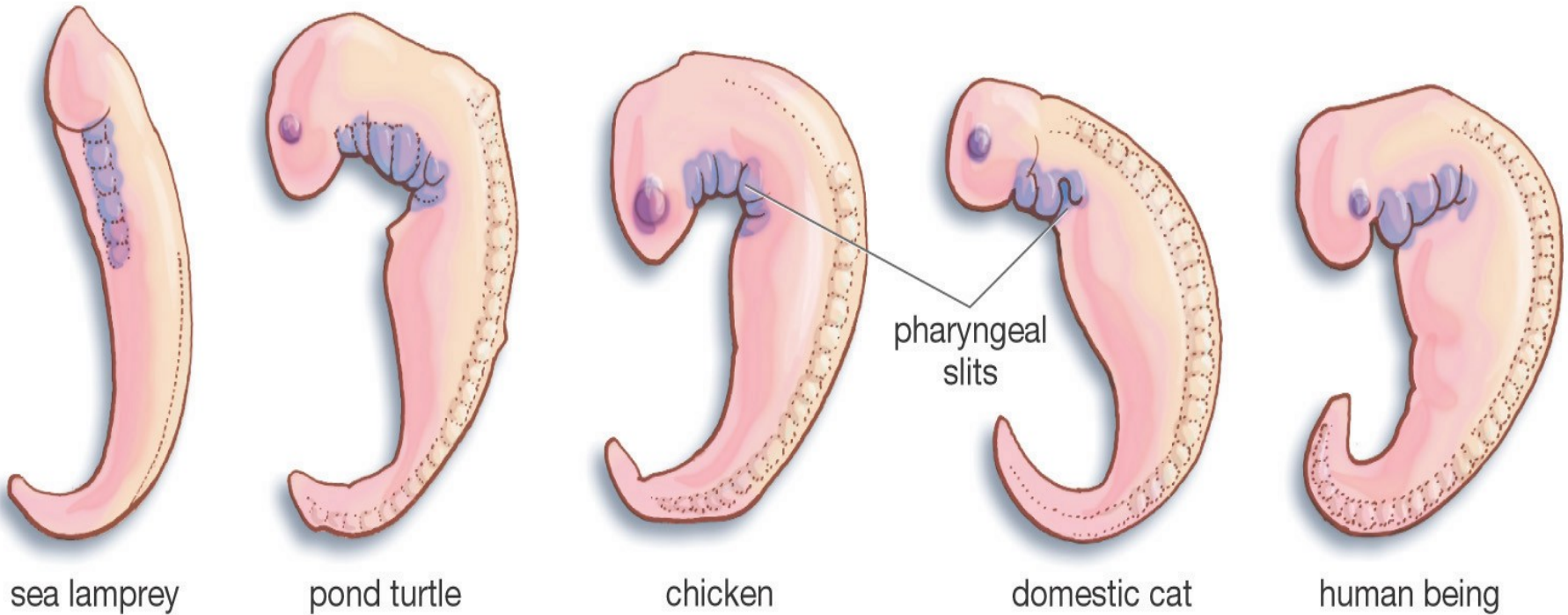
# **Theory of Evolution Today**

Supporting Evidence



# Homologous Structures

Pharyngeal slits exist in these five vertebrate animals ...

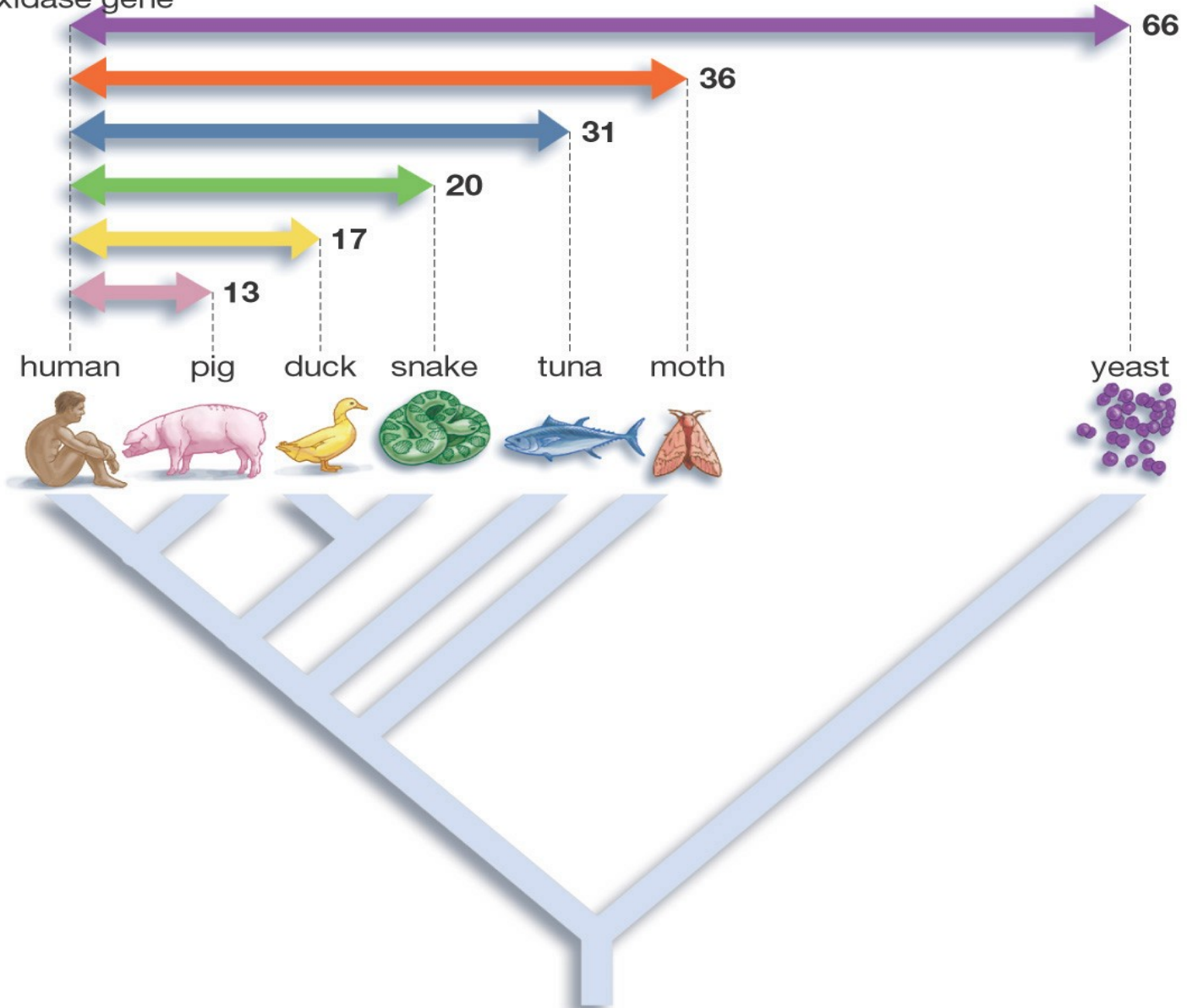


... evidence that all five evolved from a common ancestor.

# Similarities In Embryonic Development

Number of DNA nucleotide base differences in the cytochrome oxidase gene

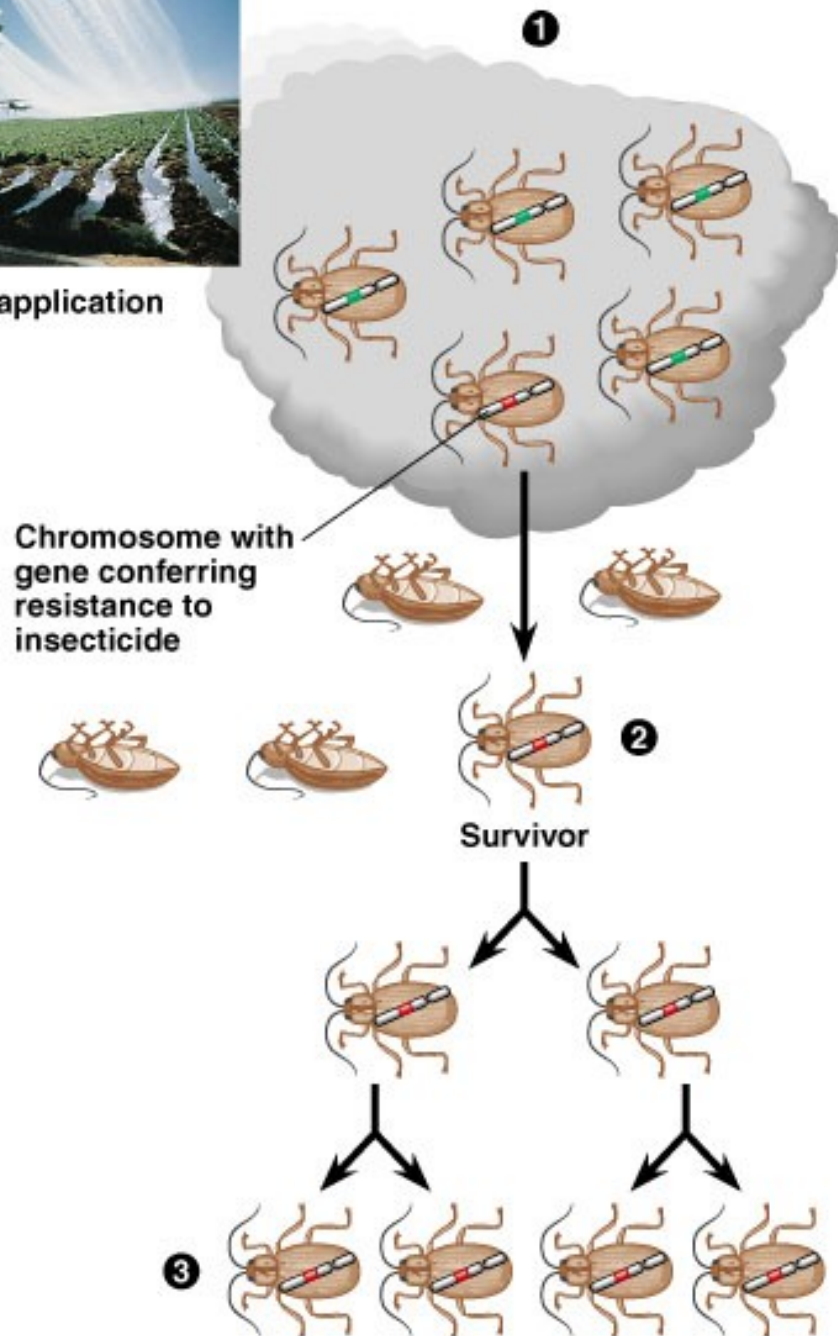
c



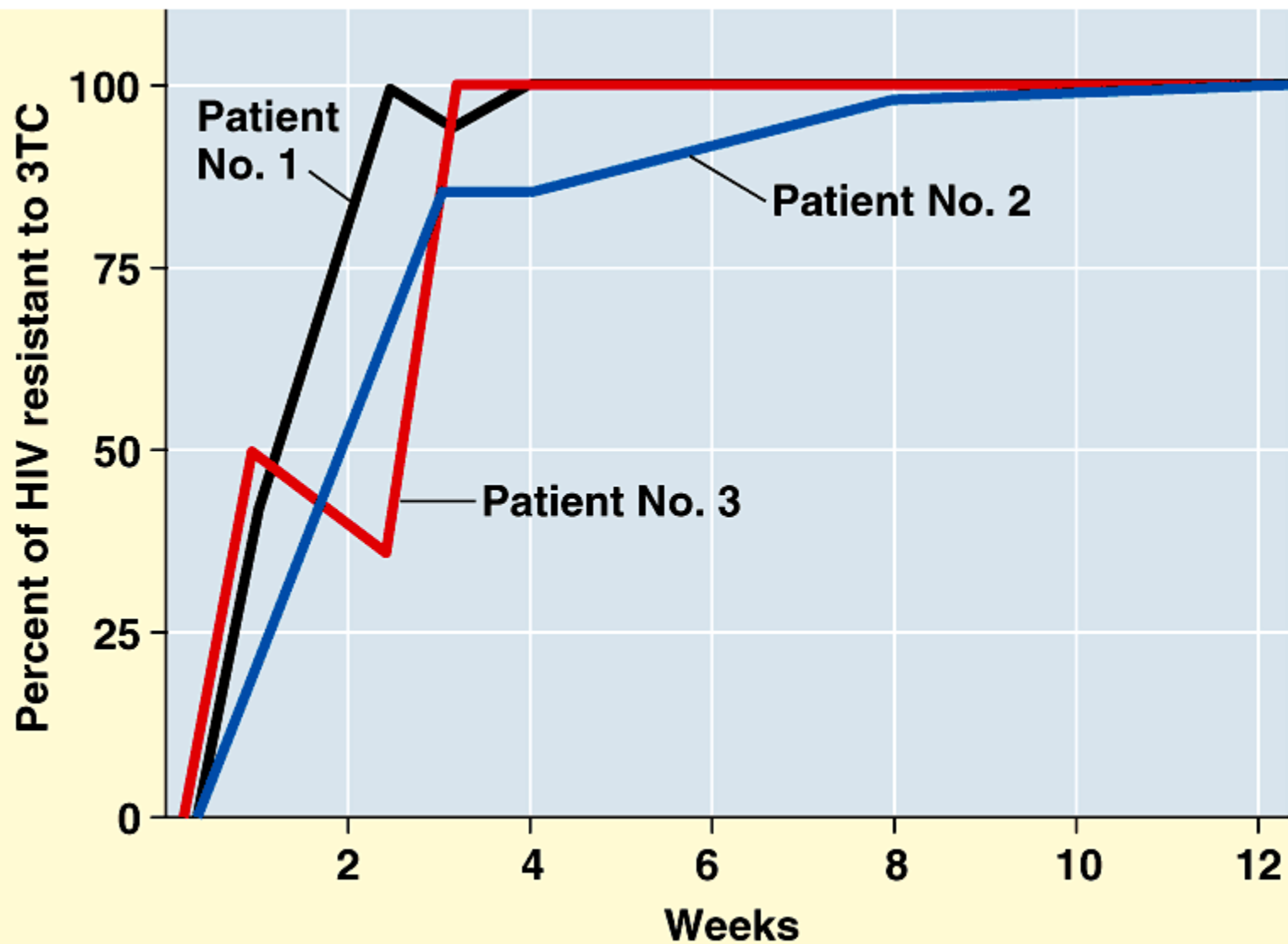
**Similarities in DNA**



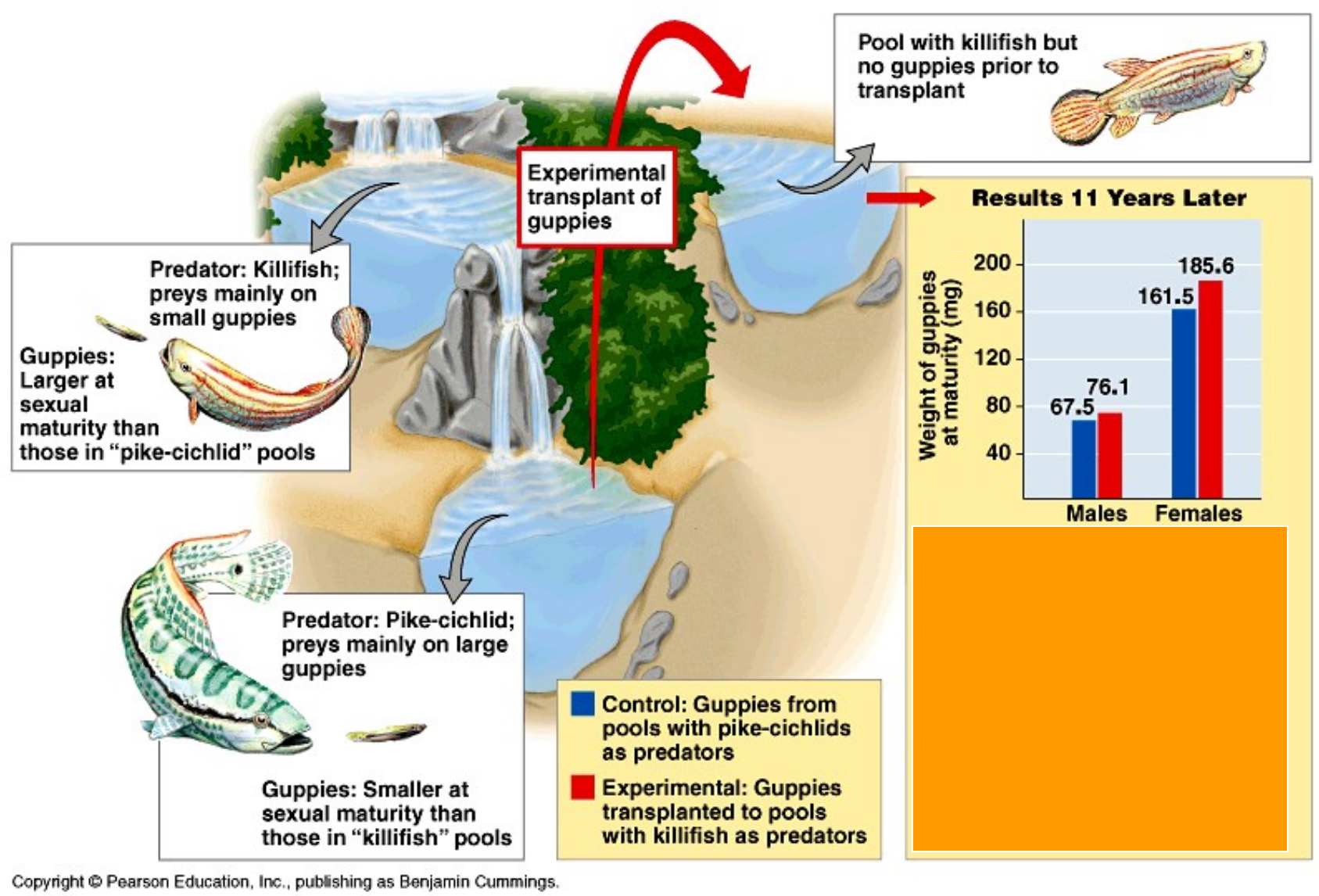
Insecticide application



# Evolution of pesticide resistance in response to selection



## Evolution of drug-resistance in HIV



**Selection against small guppies results in an increase in average size**

# Evolutionary Time Scales

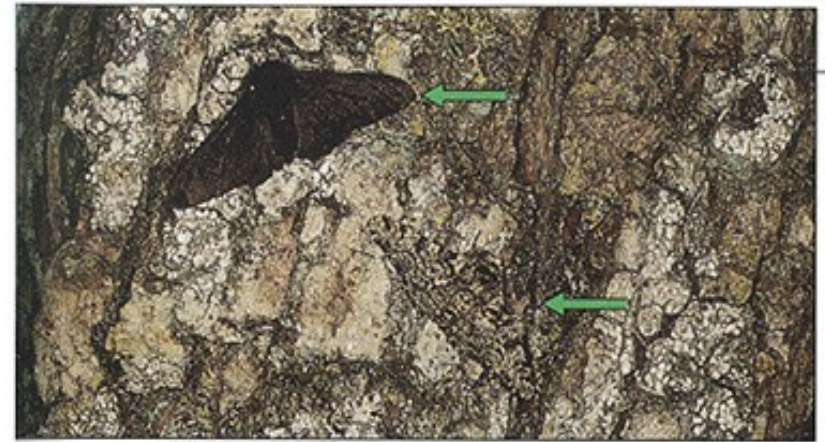
**Macroevolutio**  
**n:** Long time  
scale events  
that create and  
destroy  
species.



# Evolutionary Time Scales

## Microevolution:

Short time scale events (generation-to-generation) that change the genotypes and phenotypes of



a



b

**Figure 14.11** Individuals of a moth population that has undergone directional selection in response to changes in the environment. Light-winged and dark-winged peppered moths (*Biston betularia*) are resting on a lichen-covered tree trunk in (a) and on a soot-darkened tree trunk in (b).

# Evidence of Evolution

## Key Concept

Darwin Argued That Living Things Have Been Evolving On Earth For **Millions of Years**. Evidence For This Process Could Be Found In:

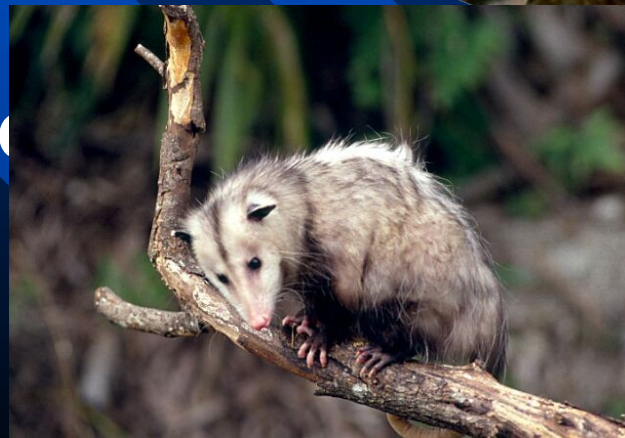
- The **Fossil Record**
- The **Geographical Distribution** of Living Species
- **Homologous Structures** of Living Organisms
- Similarities In **Early Development**

# Fossil Record

- Earth is **Billions of Years Old**
- Fossils In Different Layers of Rock (sedimentary Rock Strata) Showed Evidence Of Gradual Change Over Time

# Geographic Distribution of Living Species

- Different Animals On Different Continents But Similar Adaptations To Shared Environments



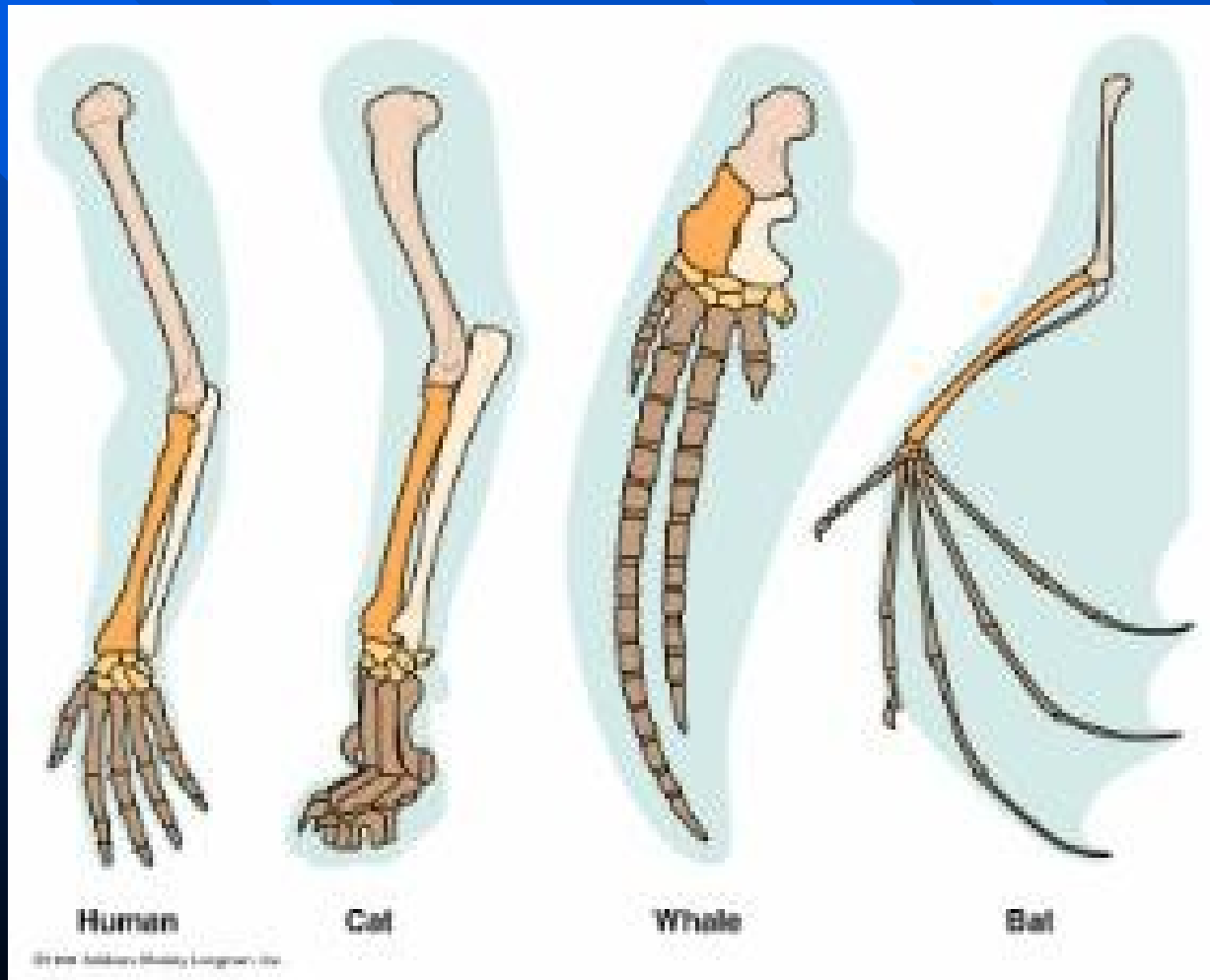
# Homologous Body Structures

- Scientists Noticed Animals With Backbones (Vertebrates) Had Similar Bone Structure
- May **Differ In Form or Function**
- Limb Bones Develop In Similar Patterns
  - » Arms, Wings, Legs, Flippers

# Homologous Body Structures

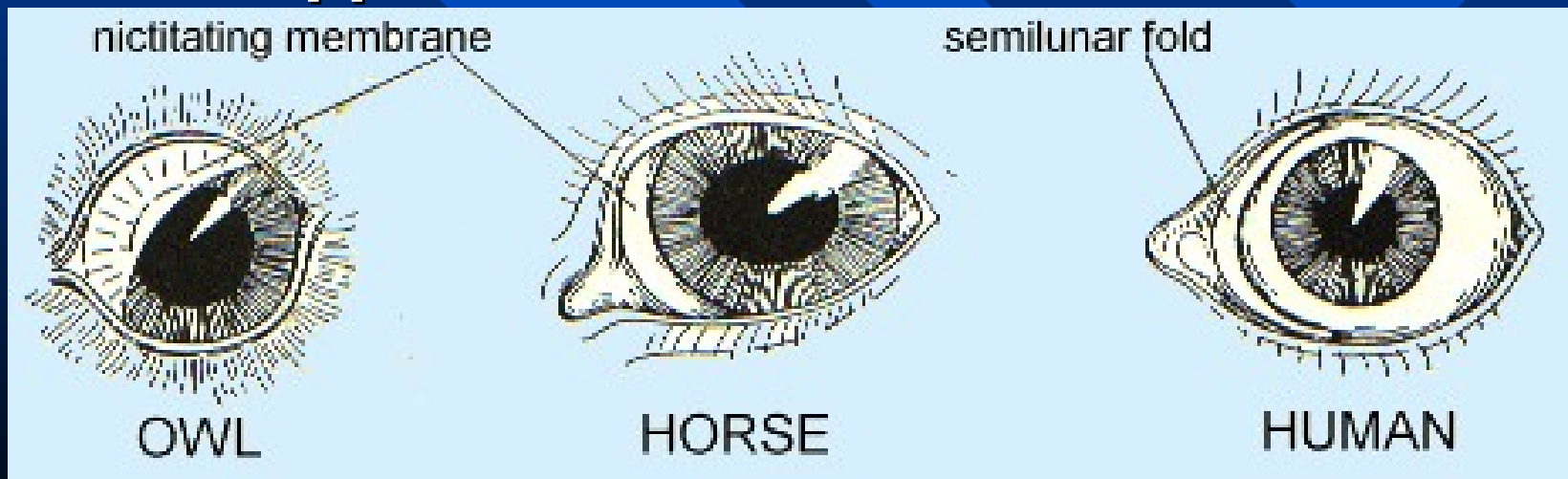
- Structures That Have Different Mature Forms But Develop From The Same Embryonic Tissues
- Strong Evidence That **All Four-Limbed Animals With Backbones Descended, With Modification, From A Common Ancestor**
- Help Scientist Group Animals

# Homologous Body Structures



# Homologous Body Structures

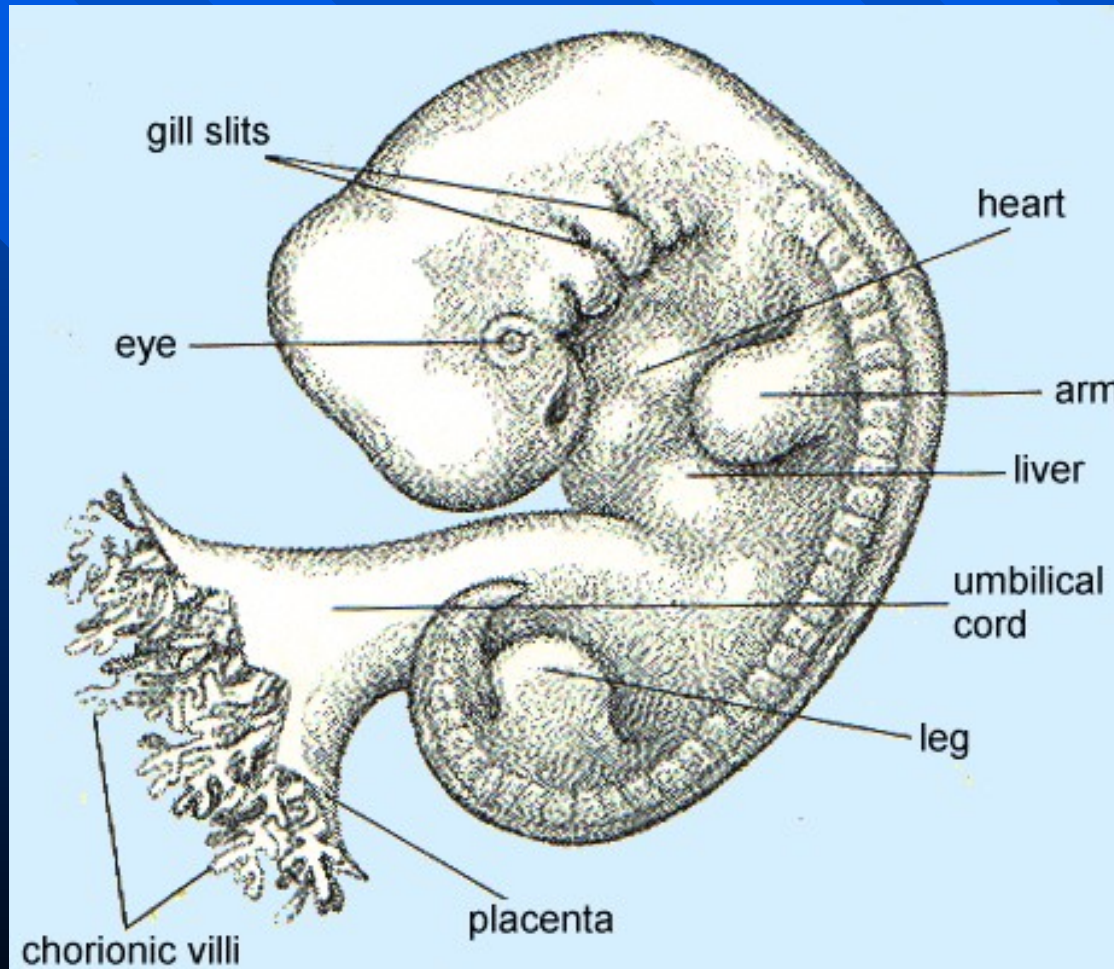
- Not All Serve Important Functions
  - **Vestigial Organs**
    - » Appendix In Man



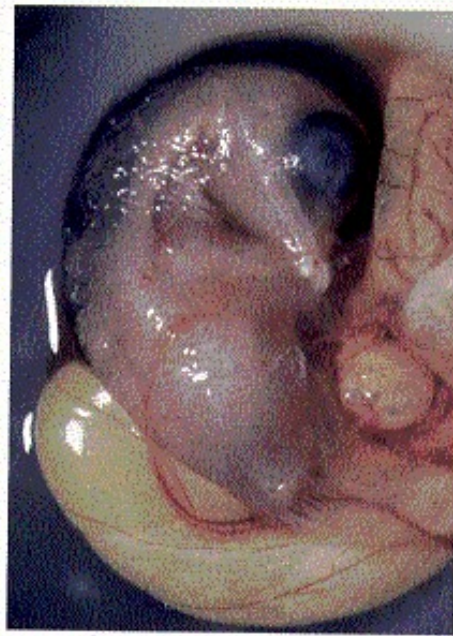
# Similarities In Early Development

- Embryonic Structures Of Different Species Show Significant Similarities
- **Embryo** - early stages of vertebrate development

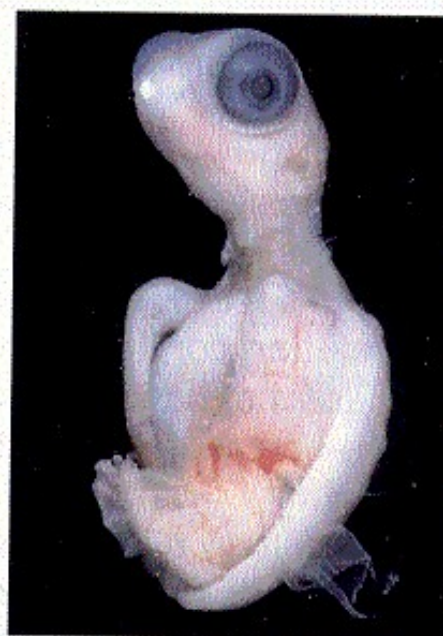
# Human Fetus - 5 weeks



Chicken

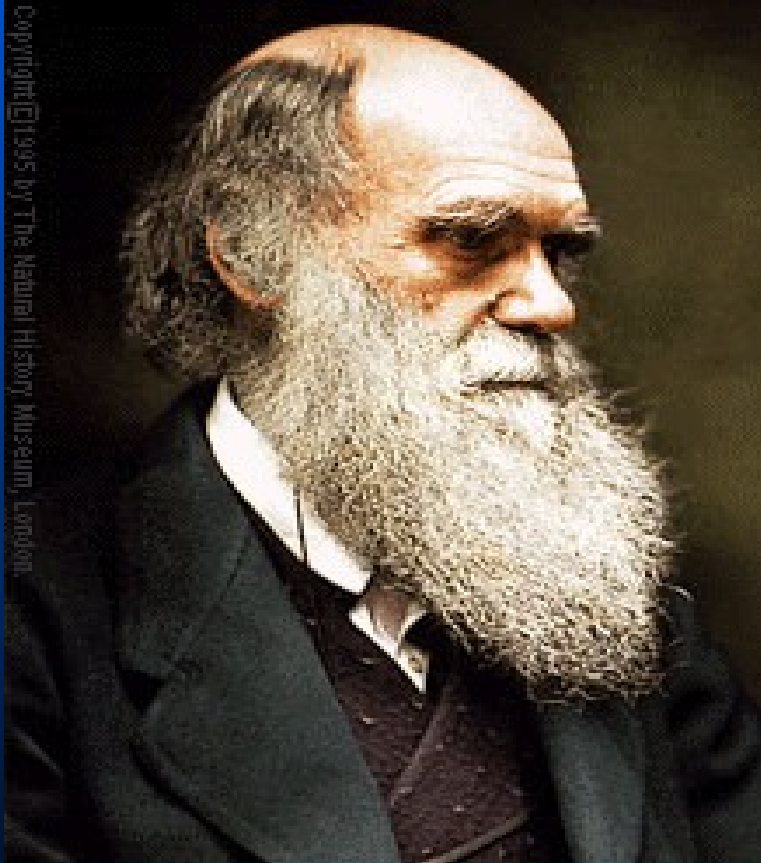


Turtle



Rat





# Review

# **Darwin's Theory**

- 1. Individual Organisms In Nature Differ From One Another. Some Of This Variation Is Inherited**
- 2. Organisms In Nature Produce More Offspring Than Can Survive, And Many Of These Offspring Do No Reproduce**

# **Darwin's Theory**

- 3. Because More Organisms Are Produced Than Can Survive, Members Of Each Species Must Compete For Limited Resources**
- 4. Because Each Organism Is Unique, Each Has Different Advantages & Disadvantages In The Struggle For Existence**

# **Darwin's Theory**

- 5. Individuals Best Suited To Their Environment Survive & Reproduce Successfully - Passing Their Traits To Their Offspring.**
- 6. Species Change Over Time. Over Long Periods, Natural Selection Causes Changes That May Eventually Lead To New Species**

# **Darwin's Theory**

- 7. Species Alive Today Have Descended With Modifications From Species That Lived In The Past**
- 8. All Organisms On Earth Are United Into A Single Tree Of Life By Common Descent**

