# Mendel, Darwin, and Biodiversity

# Diversity exists within species



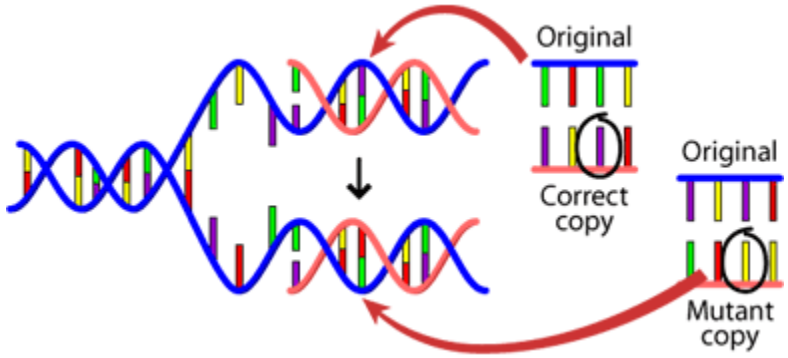



# Willie Shoemaker and Wilt Chamberlain

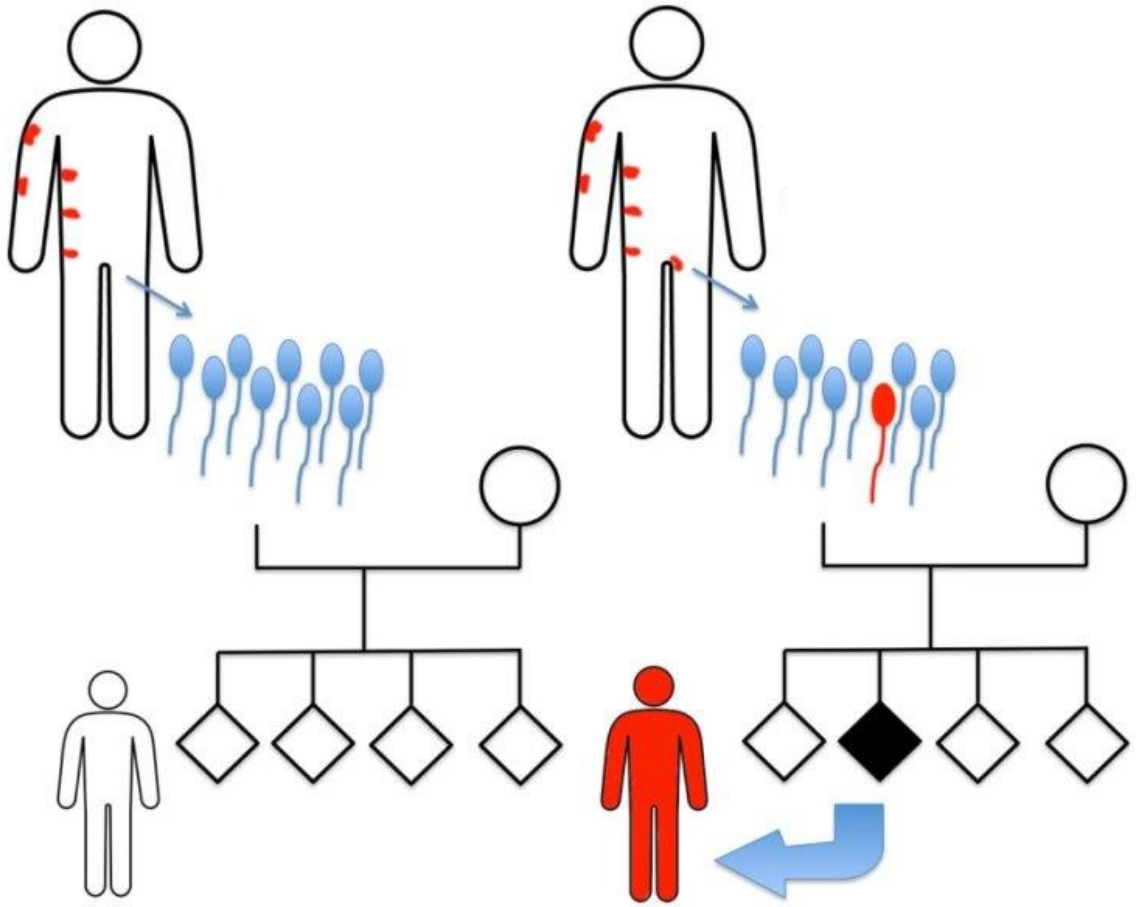
# Why?

- Sexual Reproduction and mutations→variations

# Mutations = changes in DNA

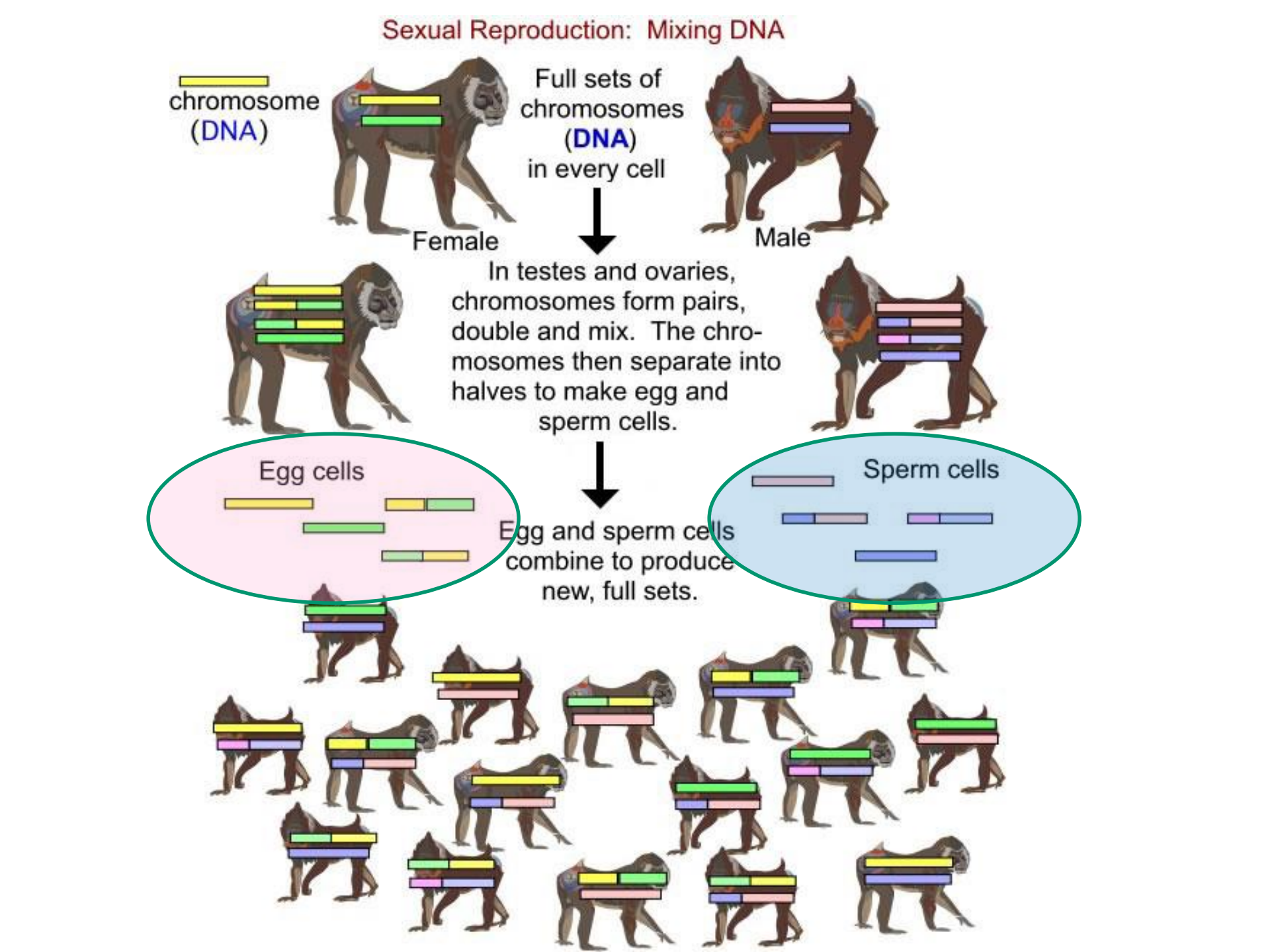


# Mutations in gametes can be inherited



Sexual reproduction → new combinations of genes

# Sexual Reproduction: Mixing DNA



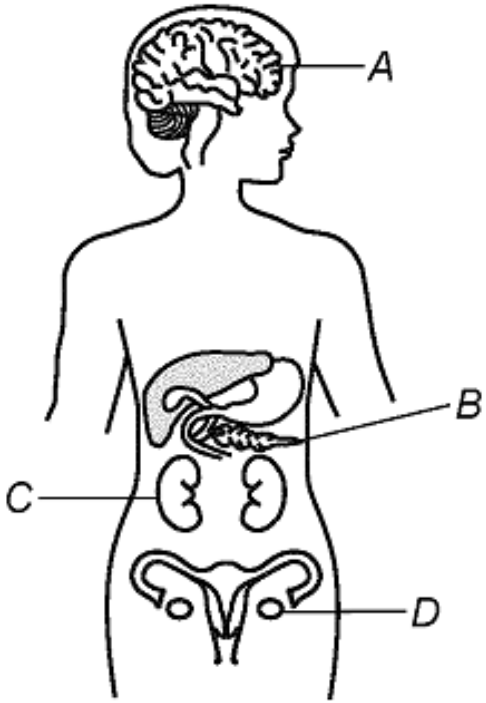
# Review Sexual Reproduction

- 2 parents
- Meiosis recombines genes → unique gametes (egg, sperm, pollen)
- Fertilization = Fusion of gametes → unique combination of genes
- Offspring are similar to but not identical to either parent

# Mutations

- Mutations = Any change in DNA
- Can be random or caused by radiation or toxic chemicals
- **Only passed on if it happens in a gamete or sex cell**

1) Some organs in the human body are represented in the diagram below.




A sudden change in the DNA of cells developing in which organ could be passed to future generations?

A) *A*  B) *B*  C) *C*  D) *D*

2) A normal sequence of DNA bases in a single human skin cell is CATGGC. If this sequence replicates in this cell and becomes GATGGC, this alteration will most likely be passed to

a) All human body cells
b) Offspring of the human
c) Every cell that develops from it
d) All skin cells of this person

3) When receiving x-rays, individuals wear a lead shield over major organs in order to limit the body's exposure to radiation. One reason for this procedure is to

a) Prevent mutations in gametes
b) Protect the patient against broken bones
c) Improve circulation in the patient
d) Increase the chance of change in DNA

The diagram below represents cellular growth that can occur in human skin after prolonged exposure to ultraviolet light.


4) Which one of the following statements provides a possible explanation for this growth pattern?

a) Manipulation of genes caused the movement of embryonic skin cells

b) Exposure to light stimulated the development of cells containing ozone

c) An immune reaction triggered the formation of excess blood cells

d) Uncontrolled mitotic division occurred as a result of gene mutations

5) A man is exposed to large amounts of ultraviolet radiation while sunbathing at the beach. This exposure causes a genetic change in the DNA of a skin cell. In the future, this change can be passed on to

a) His skin cells only

b) His male and female children

c) His male children only

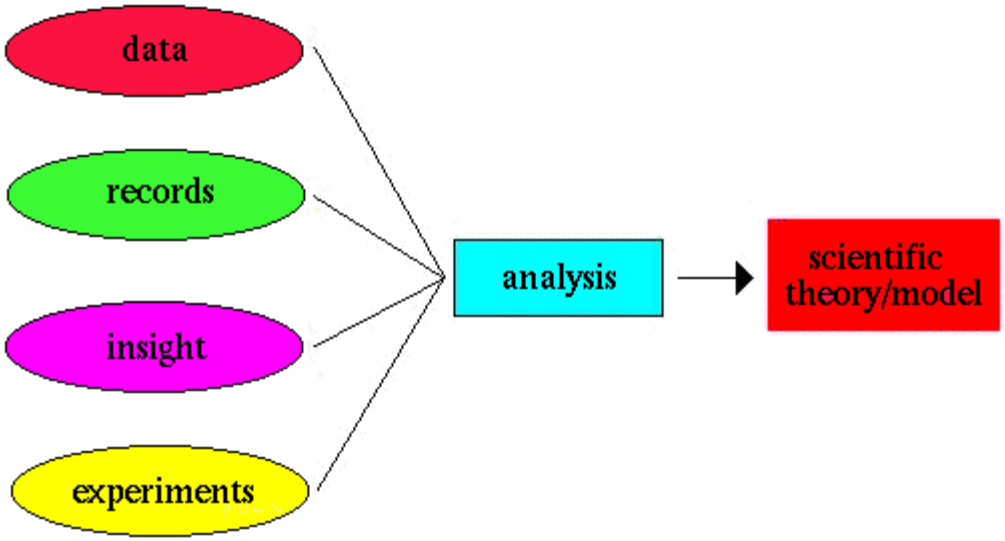
d) All the cells in his body

Some changes are good,
some are bad
some have no effect
depends on the environment

# Variations are essential for Evolution

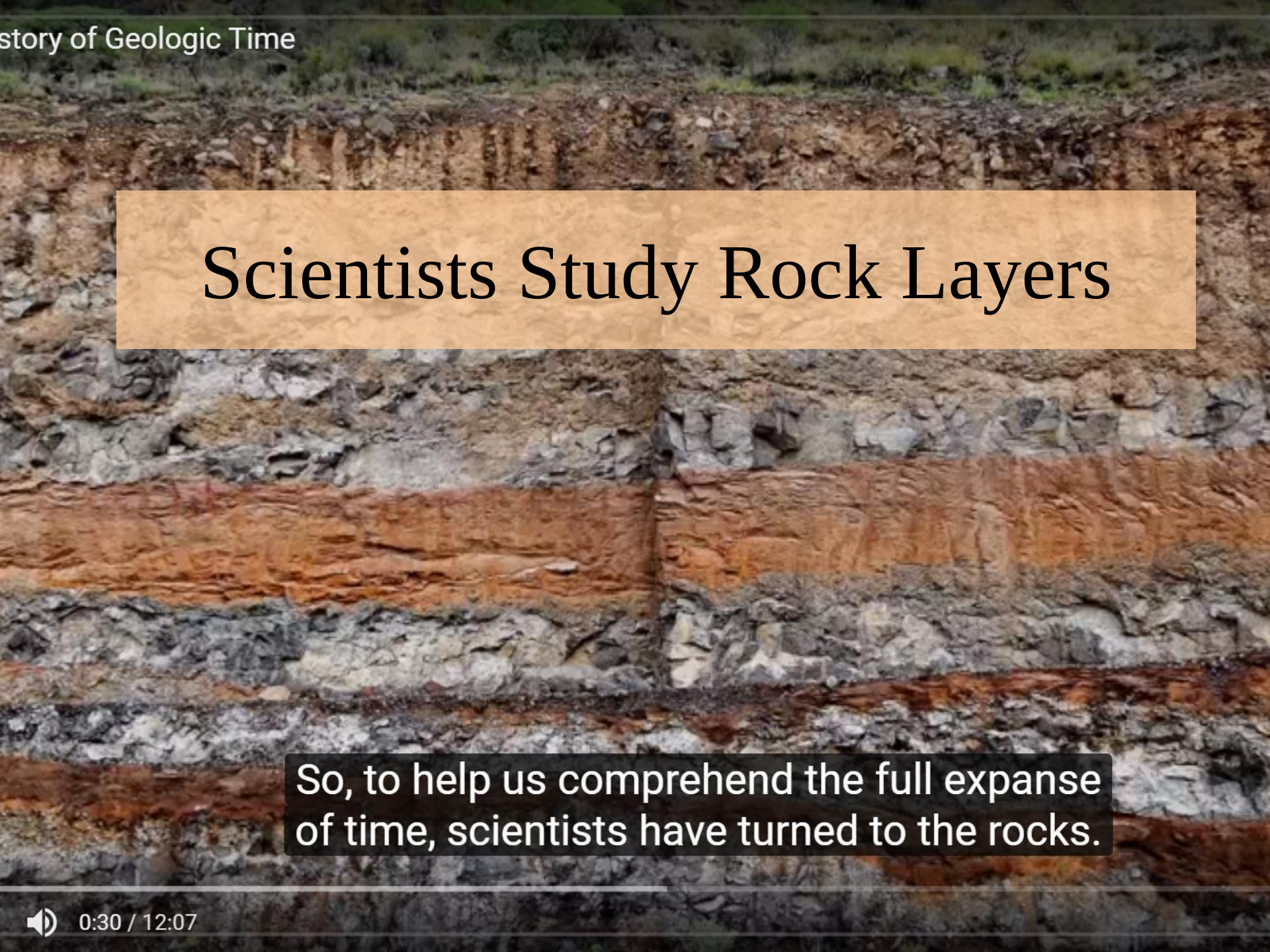
Evolution = Changes in species over time

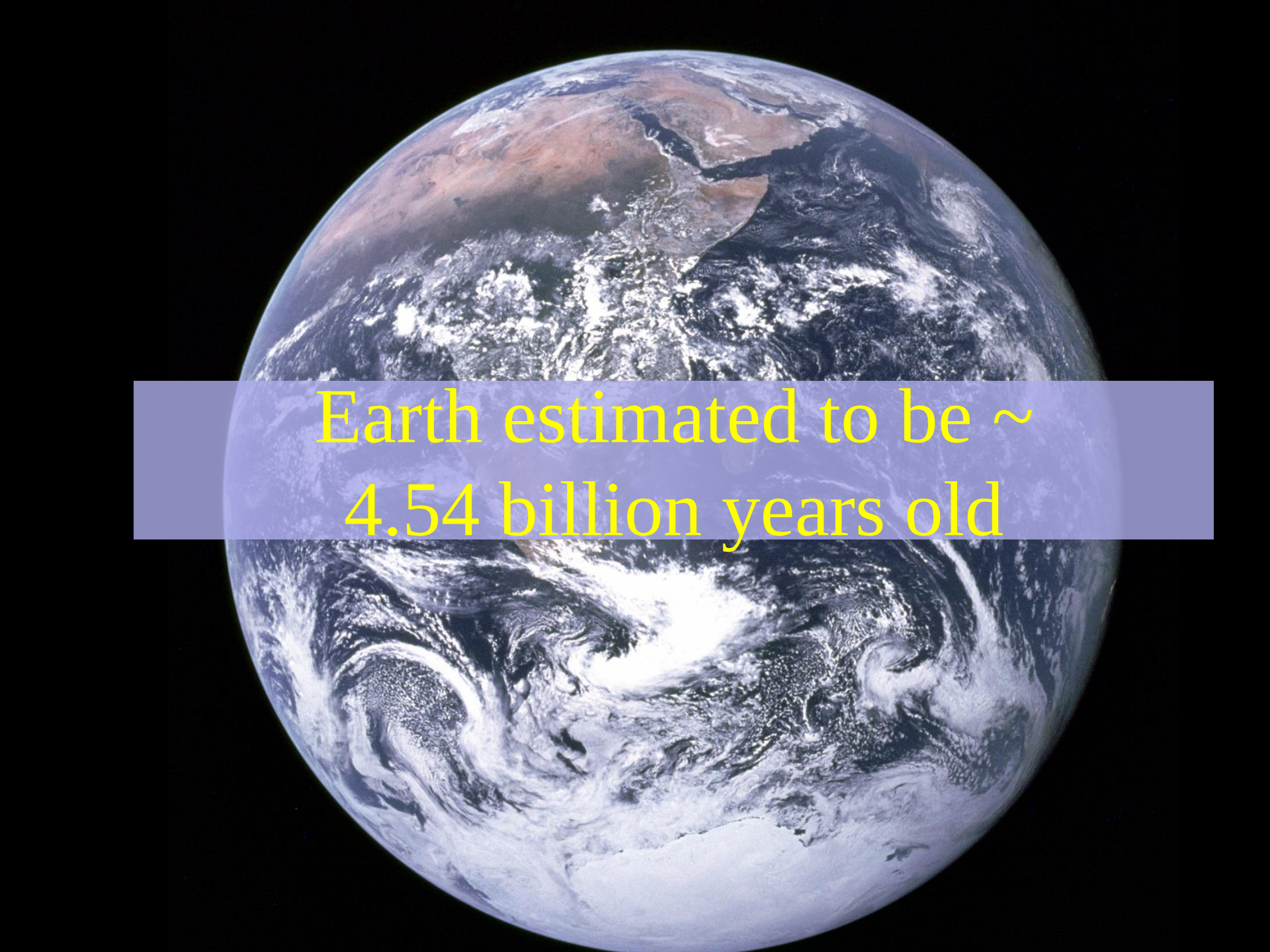
# Note: Scientific theories are based on evidence




- Theories can and do change based on evidence

Based on current scientific evidence

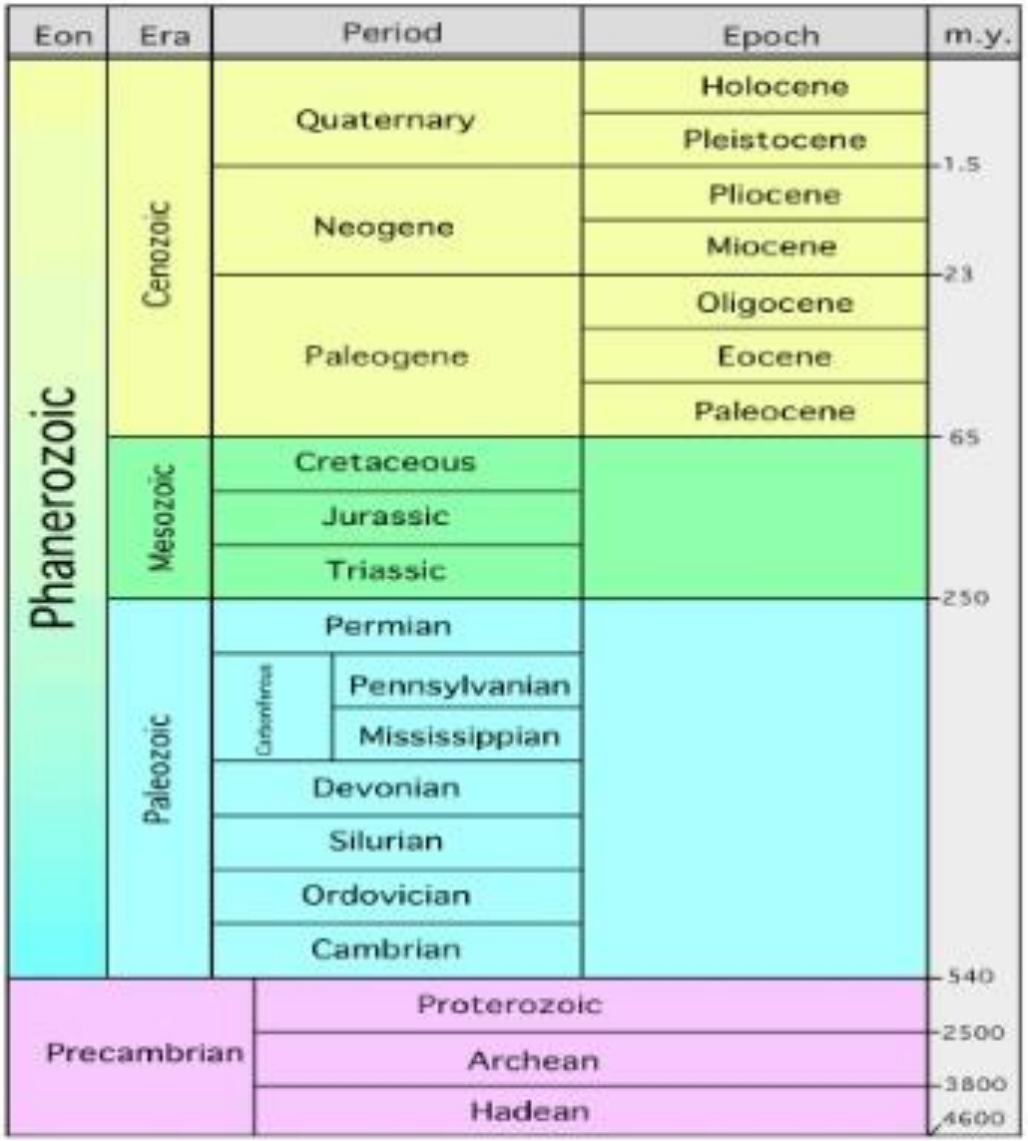

story of Geologic Time
Scientists Study Rock Layers
So, to help us comprehend the full expanse of time, scientists have turned to the rocks.
0:30 / 12:07


Earth estimated to be ~
4.54 billion years old


Fossils = remains of ancient organisms

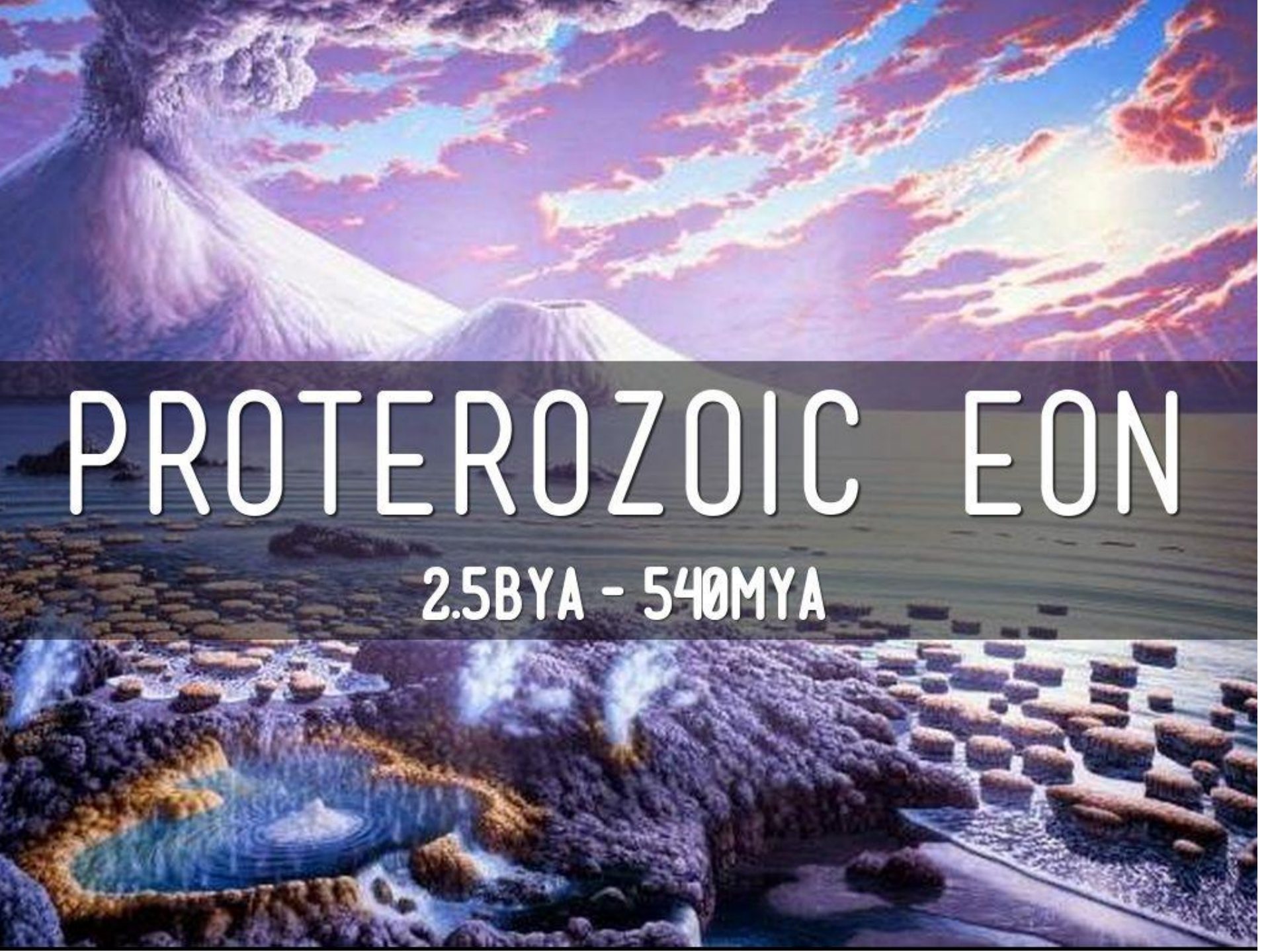
# Geologic time is described in

- Eons
- Eras
- Period
- Epoch
- Ages




ARCHEAN EON
3.9 - 2.5BYA

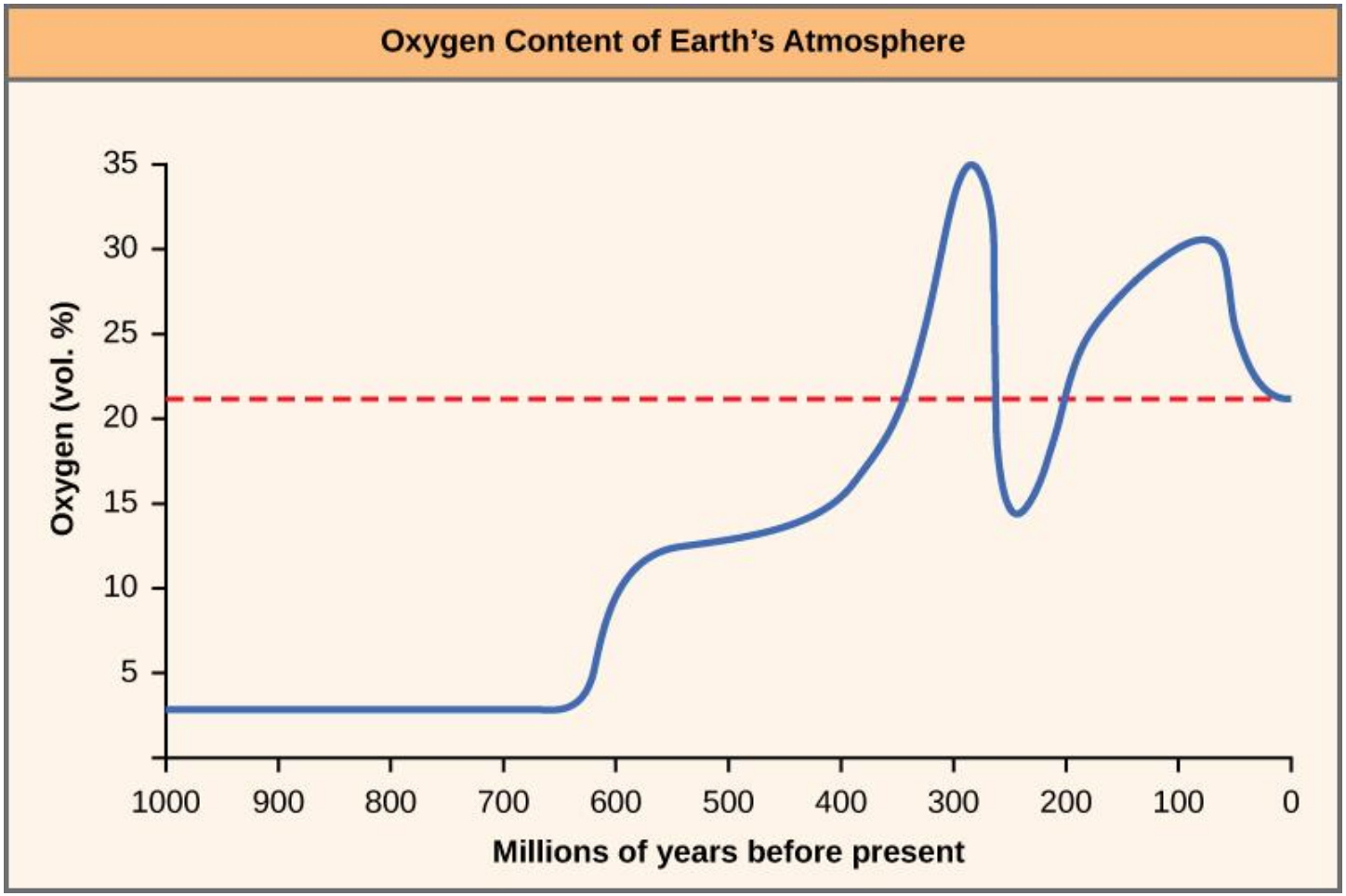

Stromatolites

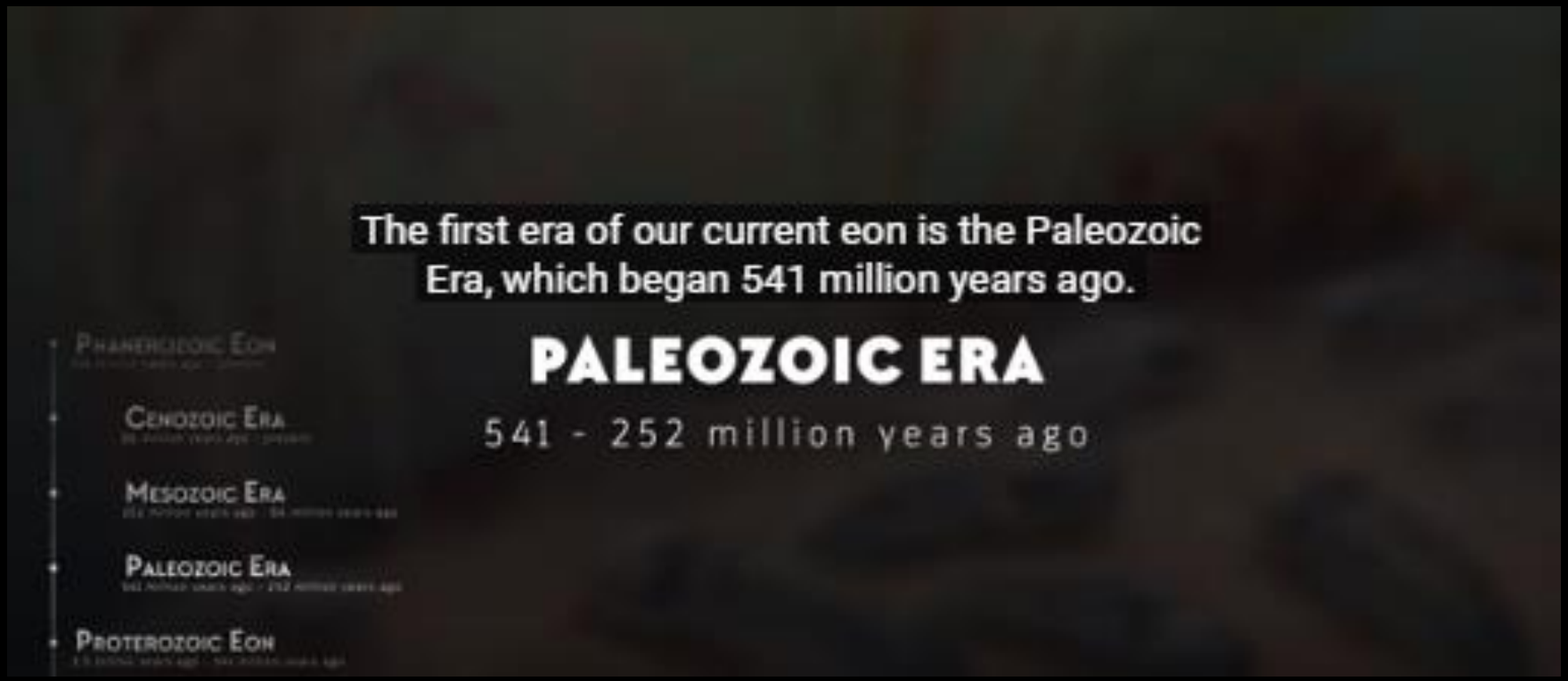


# PROTEROZOIC EON

## 2.5BYA - 540MYA

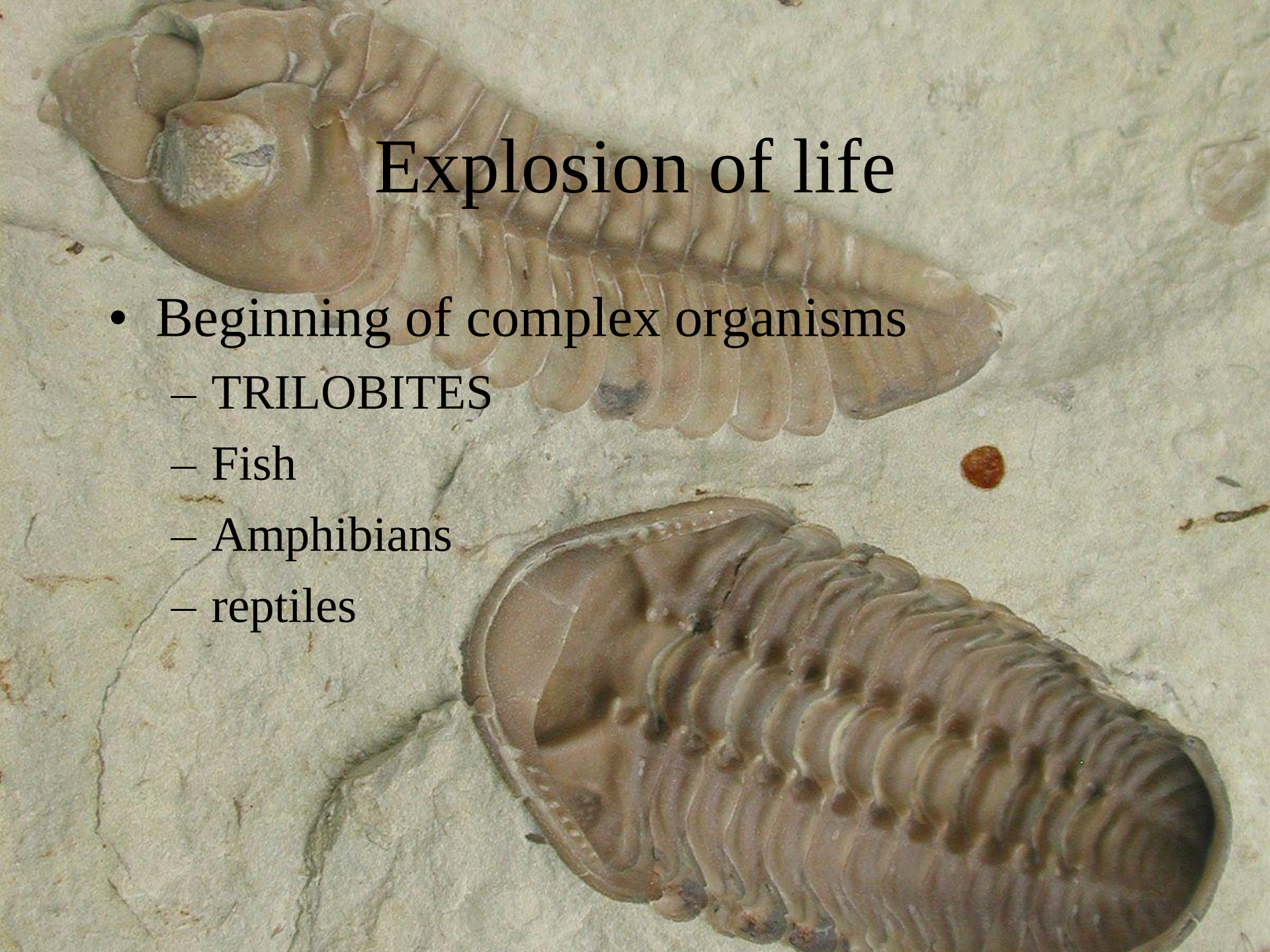
# Cyanobacteria → oxygen rich atmosphere




The first era of our current eon is the Paleozoic Era, which began 541 million years ago.
PALEOZOIC ERA
541 - 252 million years ago
Phanerozoic Eon
Cenozoic Era
Mesozoic Era
Paleozoic Era
Proterozoic Eon

# Explosion of life

- Beginning of complex organisms
  - TRILOBITES
  - Fish
  - Amphibians
  - reptiles




The Great Dying


ARDY/SCIENCE PHOTO LIBRARYScience Photo Library


Mesozoic = Age of Reptiles


A Brief History of Geologic Time
CRETACEOUS-PALEOGENE EXTINCTION EVENT
8:40 / 12:07
CC
HD


THE CENOZOIC ERA
WAS KNOWN AS THE AGE OF ANIMALS

Ice age → dryer conditions → mammals


Last ice age 11,000yrs ago

# Remains from Morocco dated to 315,000 years ago

NHM London/CC BY

Fossils of early members of *Homo sapiens* found in Morocco (left) display a more elongated skull shape than do modern humans (right).

# Based on current scientific evidence

- Earth = 4.54 billion years old
- Life on earth = 3.5 billion years
- Modern humans only ~310,000 years

# What does the fossil record tell us about life on earth?

- Animals go extinct
- There have been 5 mass extinctions
  - (over half of the species on the planet went extinct)
- Dominant organisms on the planet have changed.

# MASS EXTINCTIONS:

## The biggest disasters in history

### ORDOVICIAN

**Death Rate:**

85 %

**Time: 445 million years ago**

**Likely Causes:**

- Rapid global cooling
- Falling sea levels

**Results:**

- Coastal areas destroyed
- Chemical reactions affected by cold

### DEVONIAN

**Death Rate:**

70 %

**Time: 340 million years ago**

**Likely Causes:**

- Asteroid impact(s)
- Rapid global cooling

**Results:**

- Local destruction from debris
- Ocean life affected by temperature

### PERMIAN

**Death Rate:**

95 %

**Time: 250 million years ago**

**Likely Causes:**

- Volcanic activity
- Increase in Methane and $CO_2$
- Rapid global warming

**Results:**

- Oxygen removed from oceans
- Desertification of land

### TRIASSIC

**Death Rate:**

76 %

**Time: 200 million years ago**

**Likely Causes:**

- Increase in Methane and $CO_2$
- Rapid global warming

**Results:**

- Desertification of land
- Frequent heat waves

### K-T

Death Rate:

80 %

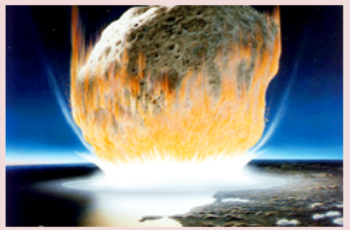
**Time: 65 million years ago**

**Likely Causes:**

- Asteroid impact
- Volcanic activity
- Falling sea levels

**Results:**

- Widespread fires
- Plants disrupted by global ash cloud
- "Nuclear winter"



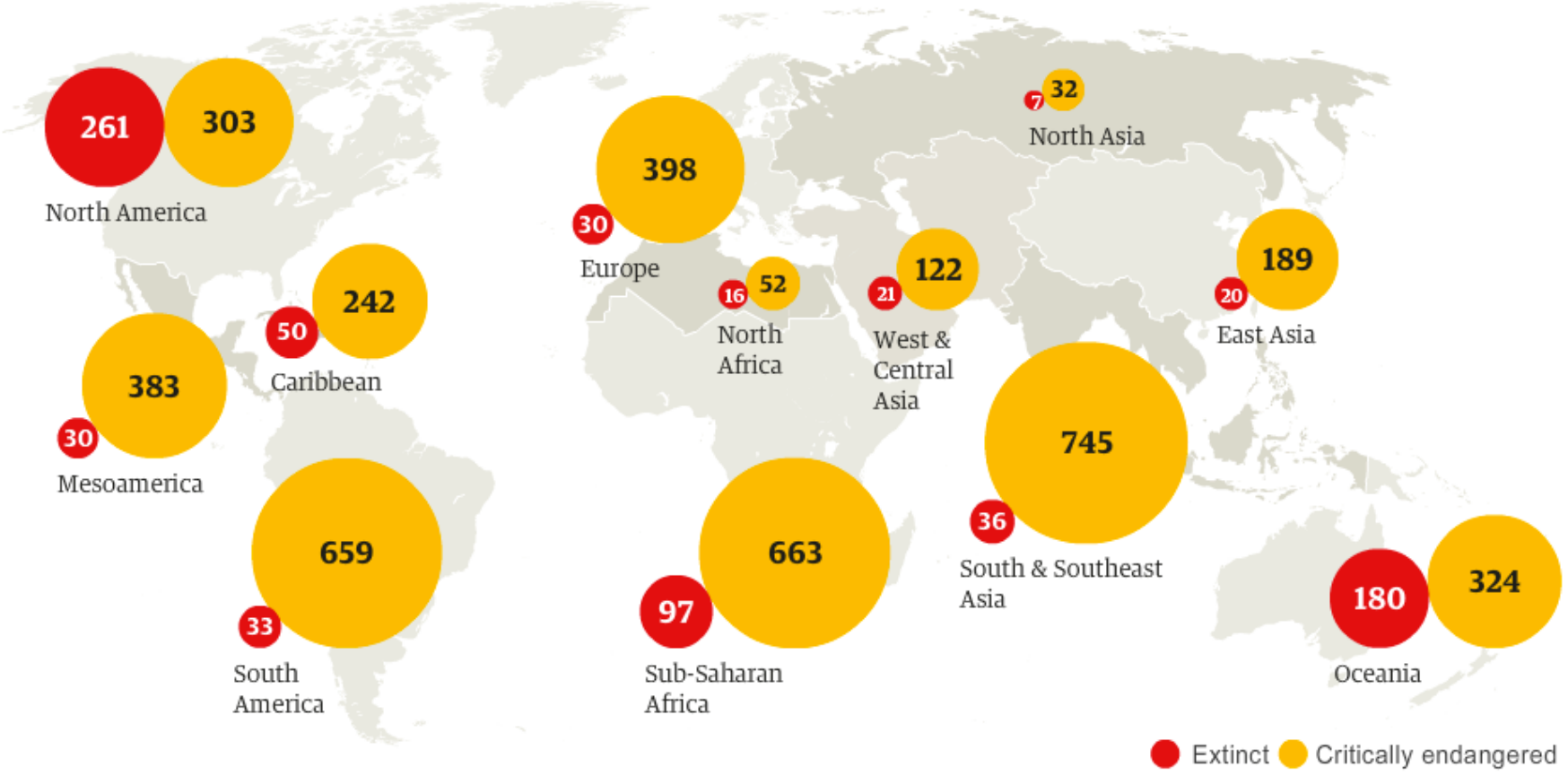
*Poster by Budjarn Lambeth, Information from brittanica.com and bbc.co.uk, Images from Wikimedia Commons – Feel free to redistribute*


IUCN, International Union for Conservation of Nature

# Extinctions and critically endangered species in numbers

**Click on** the circles to see more information

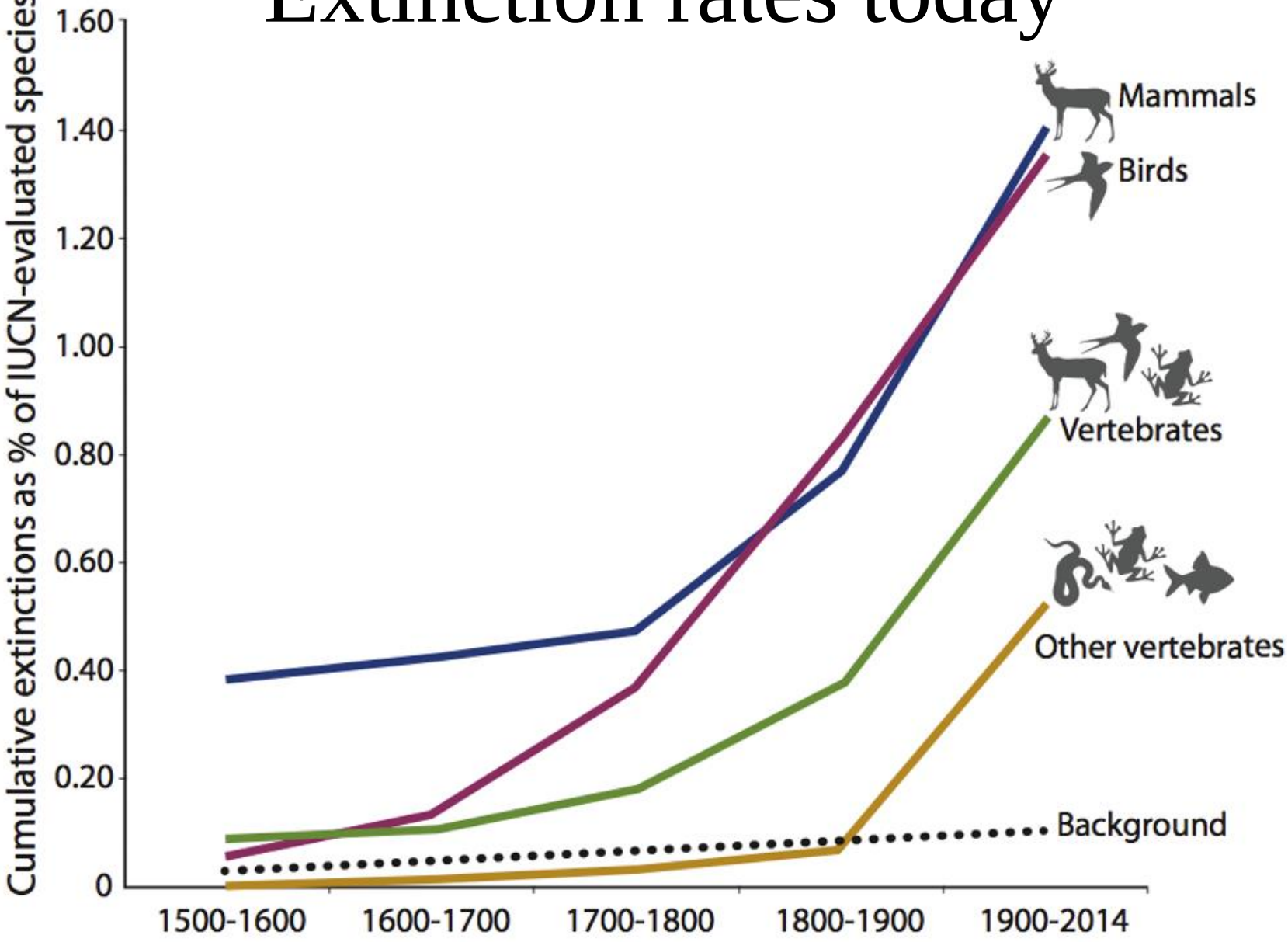
Exinct species » Critically endangered species » In numbers »




SOURCE: IUCN RED LIST

*Red list count began in 1996 but includes extinctions going back to 1500

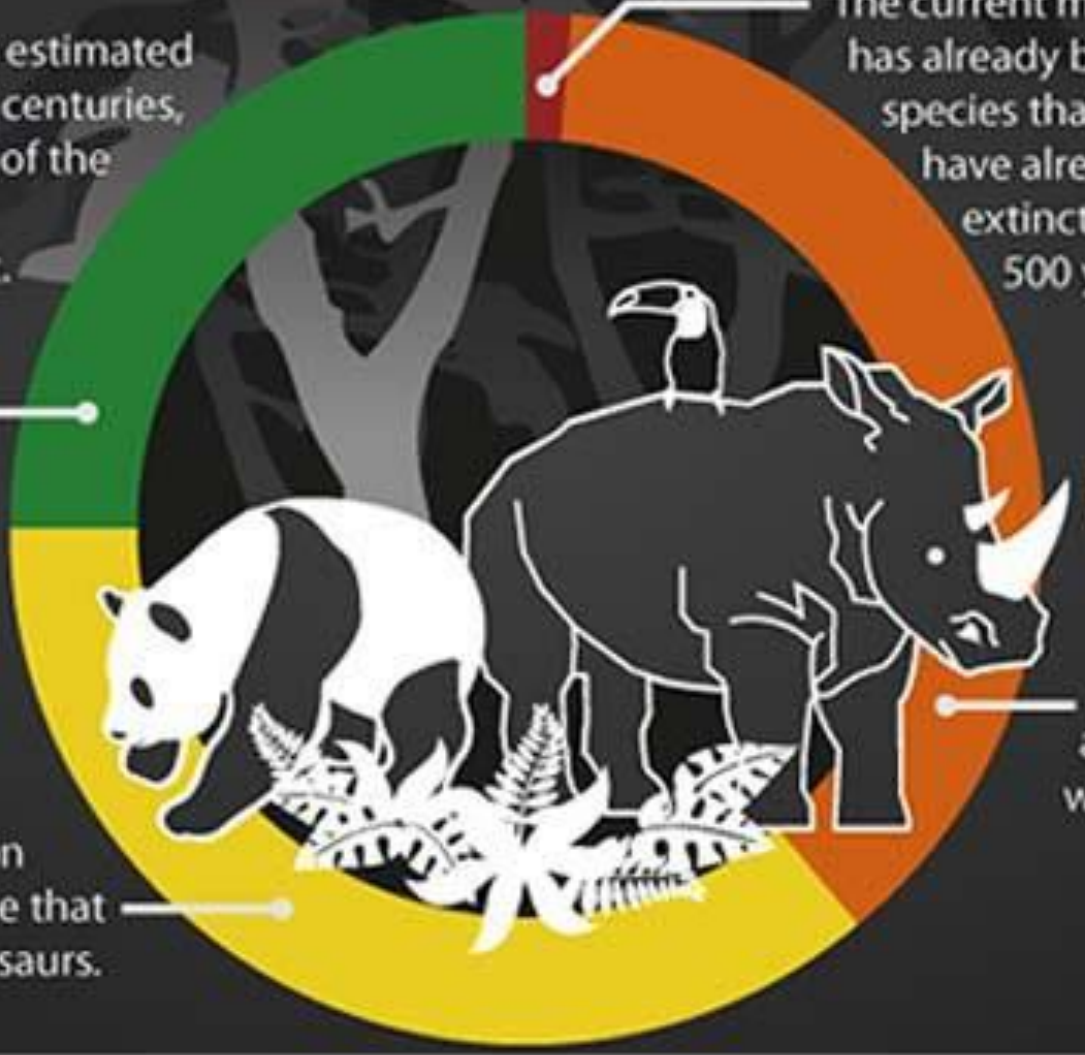
# Extinction rates today



# WE ARE IN THE MIDST OF A 6TH MASS EXTINCTION

**Scientists** have estimated that in the next five centuries, approximately 75% of the species inhabiting Earth will go extinct.

The current mass-extinction has already begun: 865 species that we know of have already gone extinct in the past 500 years.



Almost 20.000 more species are threatened with extinction.

At this rate our own mass extinction will rival the last one that wiped out the dinosaurs.

# IUCN Red List

# Direct causes of extinctions today

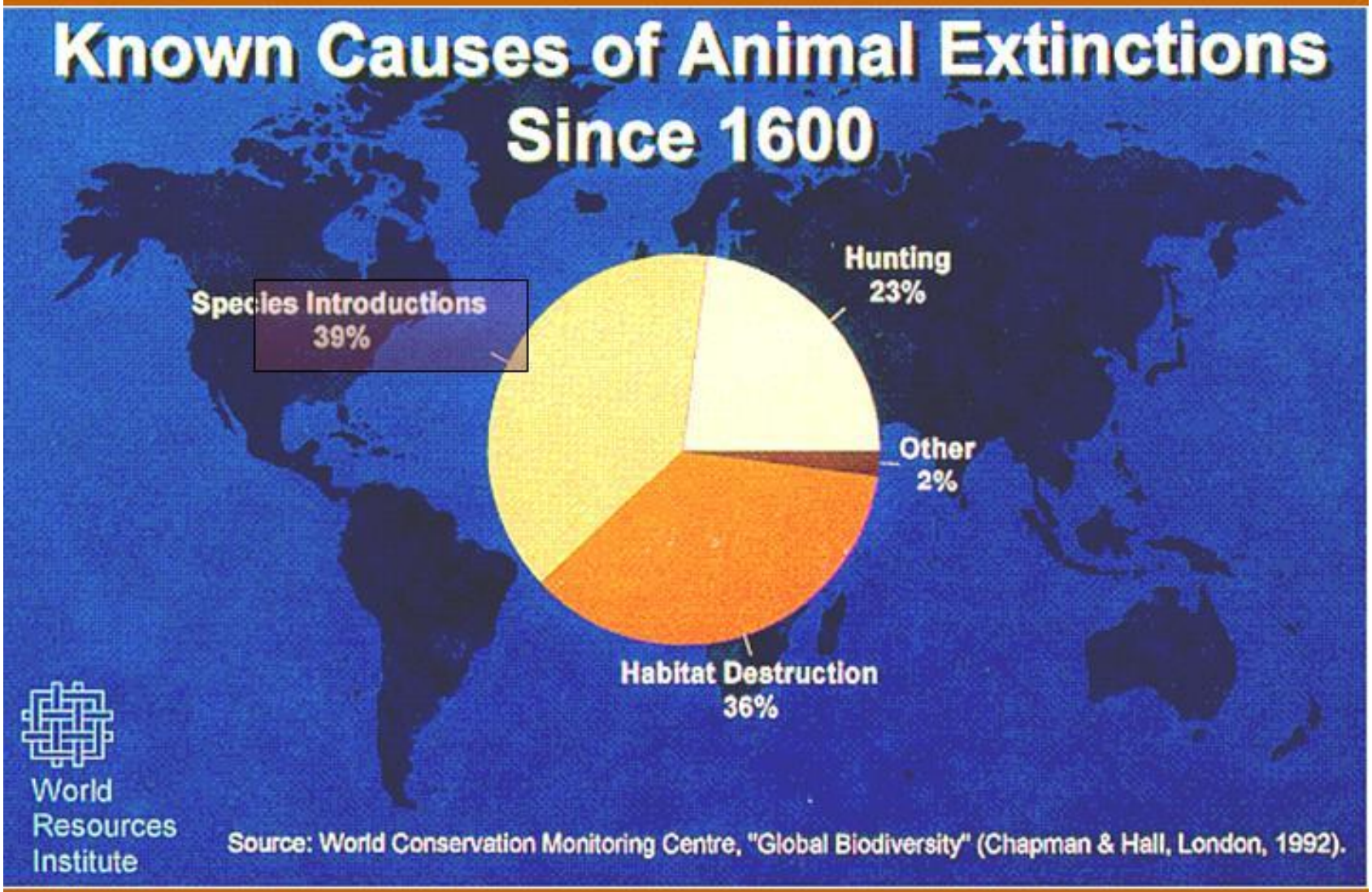
1. Habitat loss
2. Overexploitation (poaching and overfishing)
3. Competition from non-native invasive species
4. Pollution
5. Climate change

# Root cause of extinctions

- Human population growth

- Poverty forcing resource degradation

# Known Causes of Animal Extinctions Since 1600




World Resources Institute

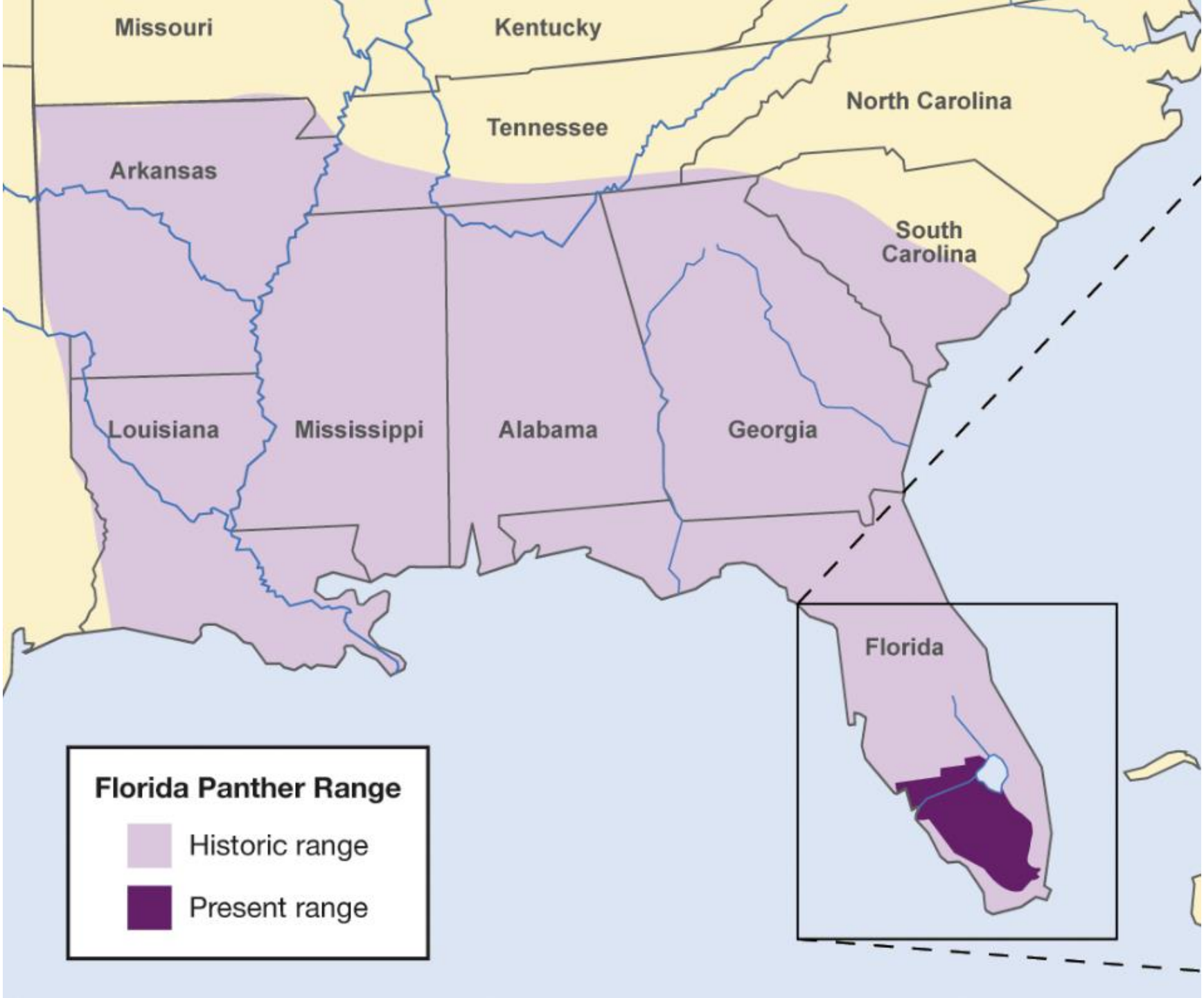
Source: World Conservation Monitoring Centre, "Global Biodiversity" (Chapman & Hall, London, 1992).

# #1 Cause of extinctions = Habitat Loss

# Florida Panther Case Study:

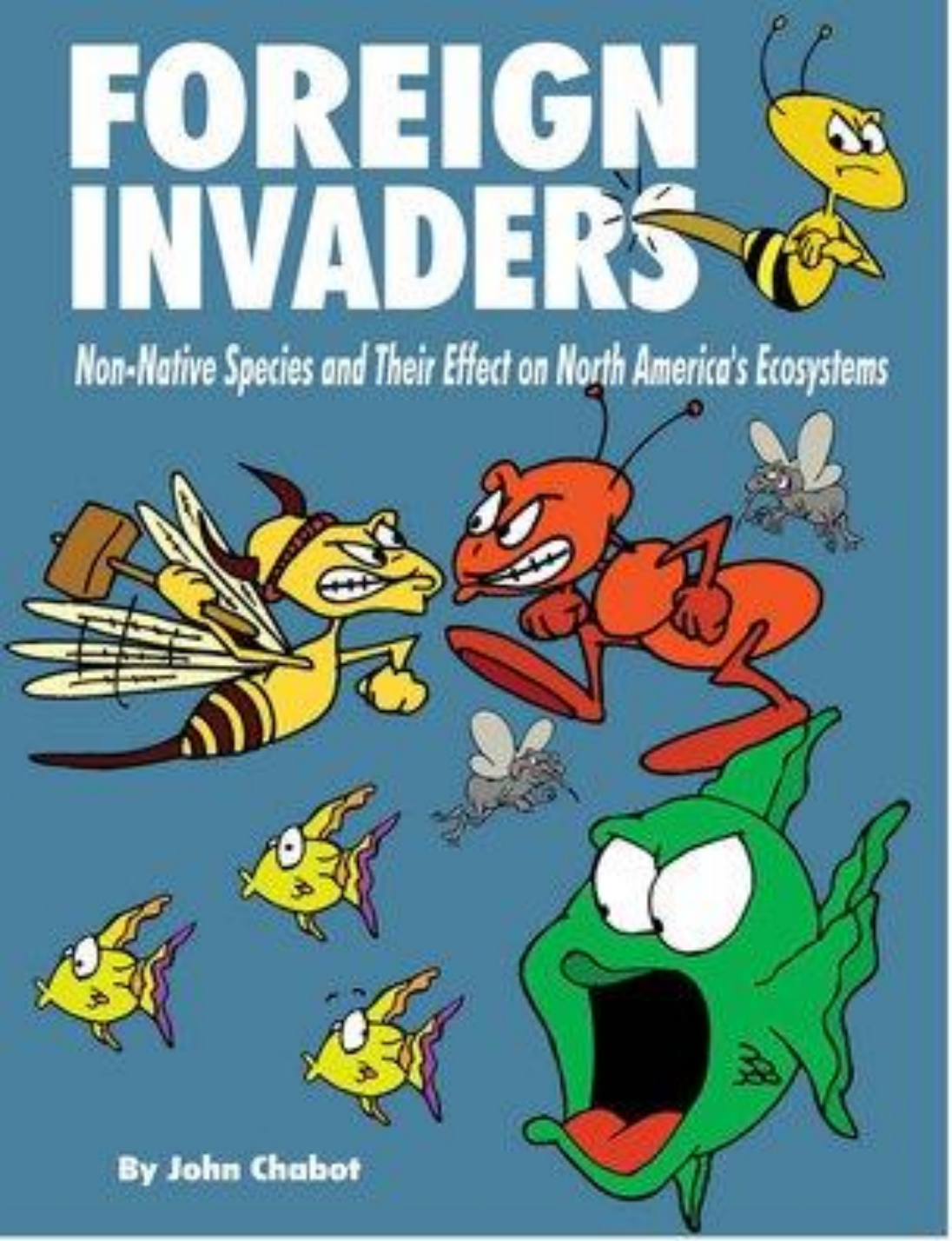
habitat loss → reproductive isolation → decreased genetic diversity → decreased health

Inbreeding → undescended testicles, kinked tails, and heart defects


Missouri
Kentucky
Tennessee
North Carolina
Arkansas
South Carolina
Louisiana
Mississippi
Alabama
Georgia
Florida
Florida Panther Range
Historic range
Present range

# Conservation History

- 1970s and 80s only 20 – 30 left
- Introduced 8 female pumas from Texas
- Rebounded → 120 – 230 Hybrid panthers today




# #2 Extinctions from = Introduced Species

Nonnatives:

- Have no natural predators
- Outcompete natives
- Carry diseases


Cane toads in Australia

- Zebra Mussels

http://fisc.er.usgs.gov/Tracking_Invaders/in_depth/zebra_mussel.jpg

- Asian Longhorned Beetles threaten trees

http://www.dec.state.ny.us/website/dlf/privland/forprot/health/alb.htm

- Gypsy moth larvae destroy trees

http://wihort.uwex.edu/Phenology/images/Gypsy%20Moth%20Larva.jpg

# Emerald Ash Borer

- Native to Asia
- Destroys Ash trees

- Brought in on firewood and untreated lumber


http://www.invasive.org/browse/detail.cfm?imgnum=9000019

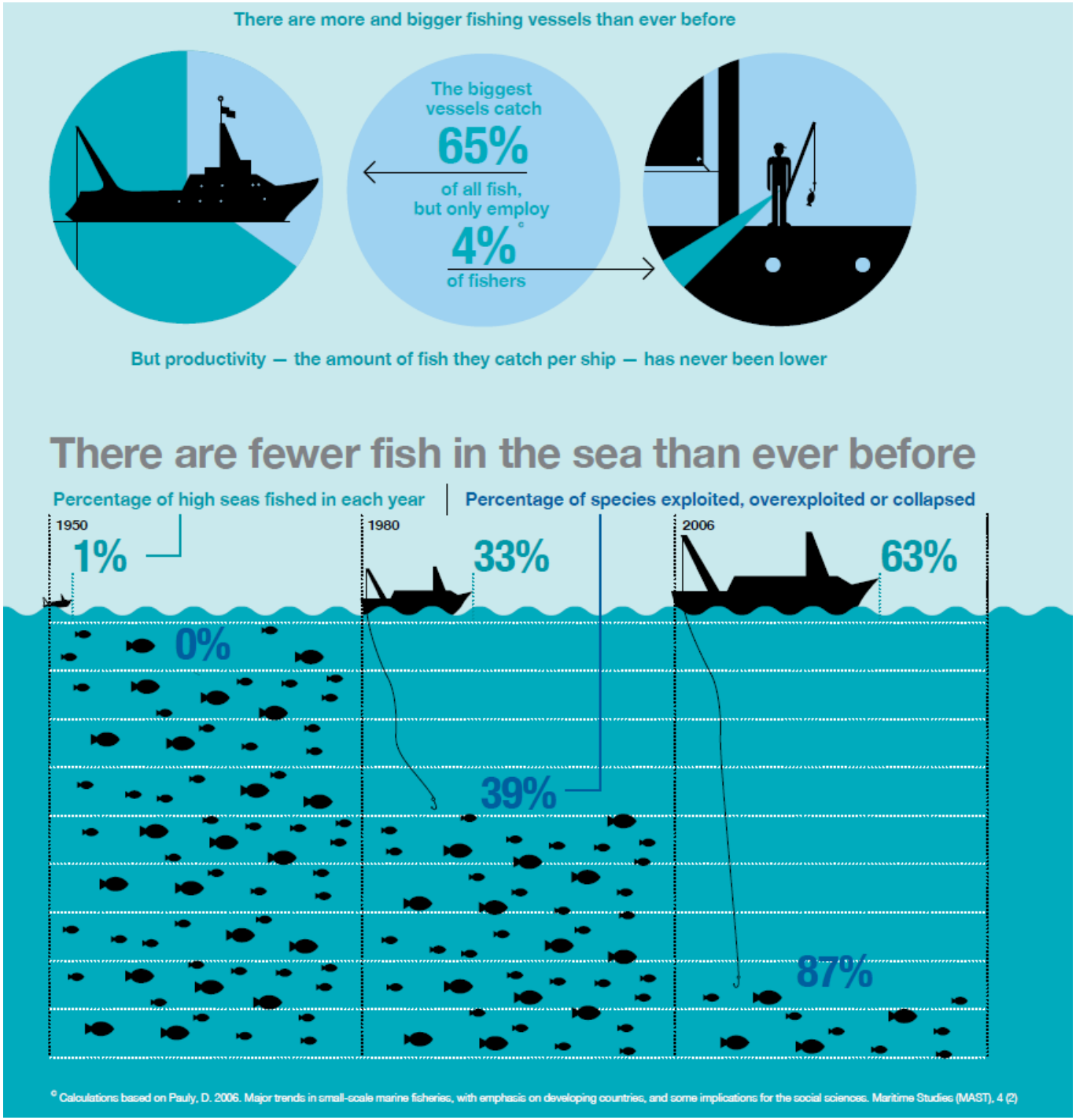
# #3 Cause of extinctions = Exploitation Poaching and Overharvesting

# Why people hunt

- For food
- To kill animals that compete with human food sources
- Sport
- Discuss the pros and cons of hunting

# Case Study: Passenger Pigeon

- 3-5 billion 200 yrs ago
- Hunted to extinction in about 40 yrs
  - hunted for meat, feathers, and bones (used as fertilizer) during the Great Depression



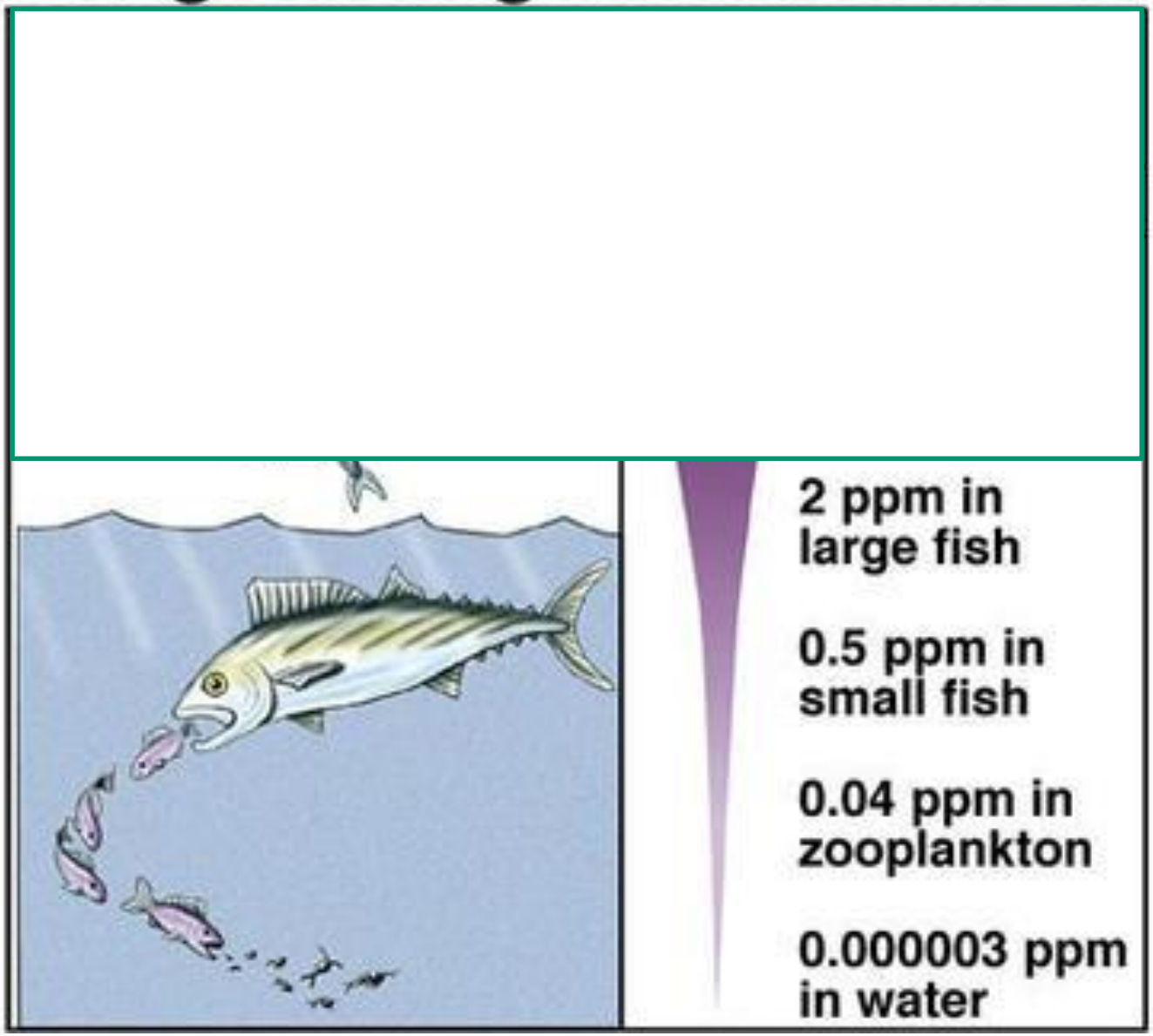

[c] Calculations based on Pauly, D. 2006. Major trends in small-scale marine fisheries, with emphasis on developing countries, and some implications for the social sciences. Maritime Studies (MAST), 4 (2)

# Endangered Bog Turtle almost extinct in NYS illegally traded

#4 Cause of species extinctions = Pollution and Climate Change

# Example of pollution: DDT sprayed to kill insects

# Biological Magnification of DDT



Plastics in the ocean →

extinctions

# Climate change →
# Decline of boreal species in the Adirondacks
# ex: yellow bellied flycatcher

# Why we should care about extinction rates

- Diversity → stability
  - Remove one species affect many

- Diversity → resources
  - Ex: different species → medicines, food, building materials…

What happens to life on earth **after** a mass extinction?

# Charles Darwin and the Theory of Evolution

# Evolution =

## Changes in species over time

- Proof of evolution comes from
- The fossil record
- Examples of evolution
- Antibiotic resistance in bacteria
- Pesticide resistance in insects

# "Nothing in biology makes sense EXCEPT in the light of evolution."

**(early geneticist *Theodosius Dobzhansky*)**

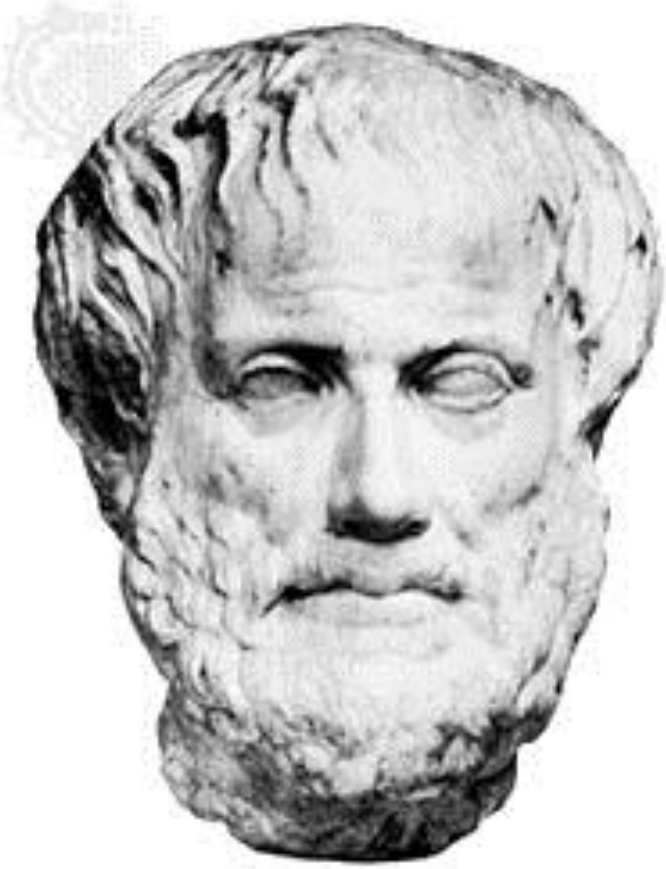
- Explains why overuse of antibiotics has led to new antibiotic resistant strains of bacteria

- Explains why spraying with pesticides results in pesticide resistant pest populations

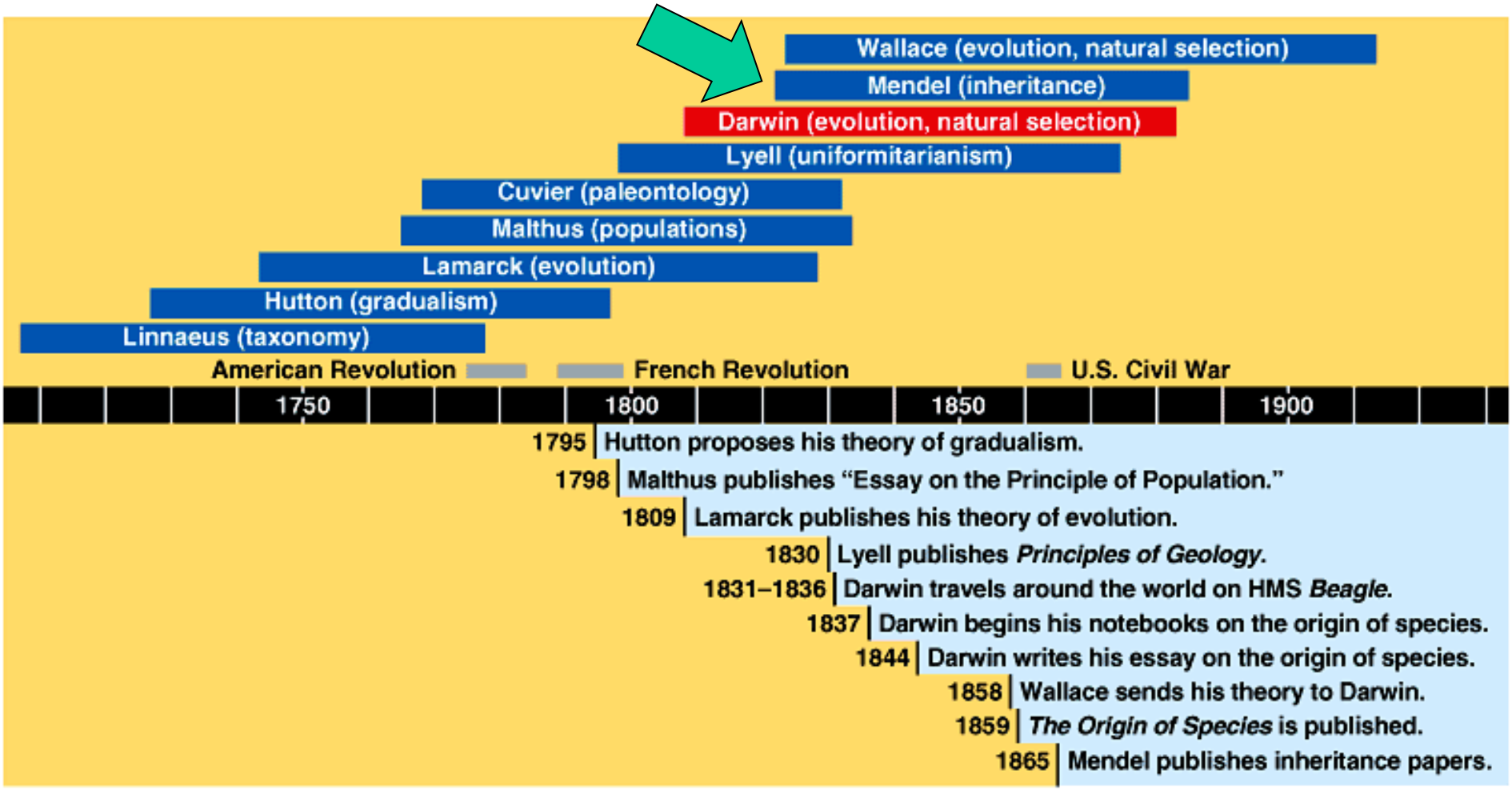
# History of Evolutionary Thought

# Early Ideas On Earth's Organisms

- Aristotle 384BC (famous Greek philosopher)
  - species were fixed creations (don't change)
  - organized by the way they looked (or their level of perfection)
  - Idea lasted 2000 years



# Evolutionary Timeline



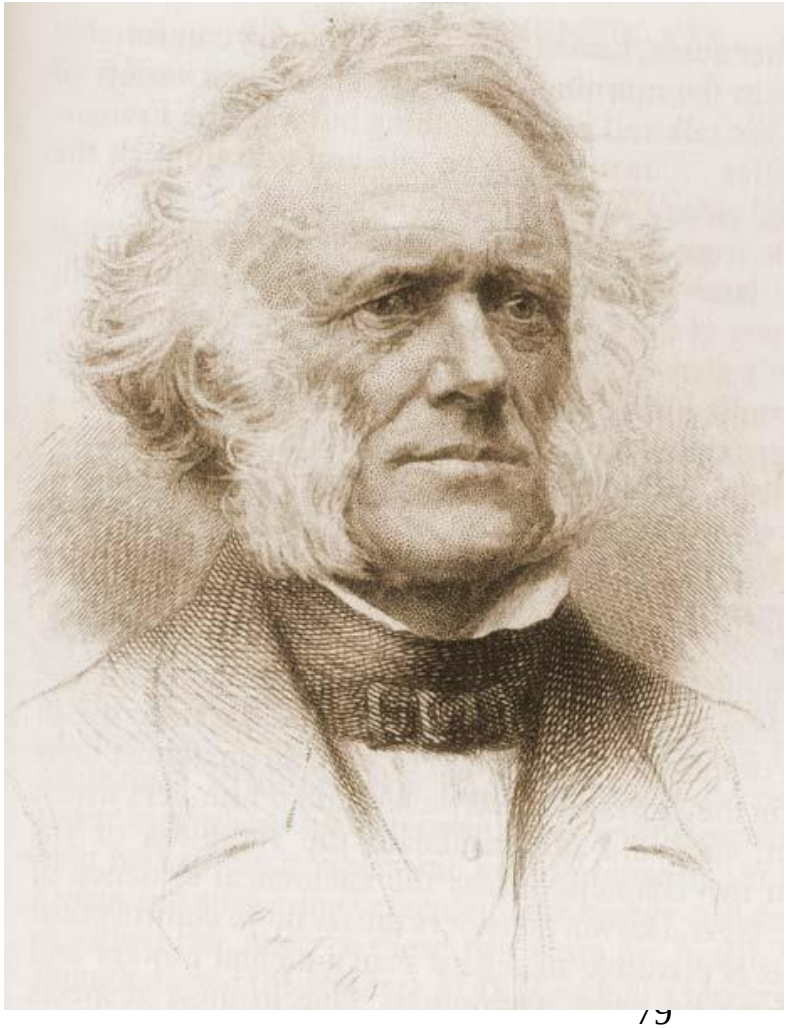
# Contributor's to Darwin's thinking included:

- Charles Lyell –geologist → earth is older than we thought

# Charles Lyell

- Geologist → earth is older than people thought

- Geologic time = millions of years not hundreds



# Lyells book “Principles of Geology”

- Explained geological processes that shaped the Earth

- Helped Darwin understand why there were sea shells In The Andes Mountains (12,000+ Feet above sea level)

# George Cuvier

- Collected organisms (live and extinct)
- Helped create the fossil record

# Fossil Record

- Fossil record →proof of mass extinctions

- Cuvier stated that species disappear due to a catastrophic event of the earth's crust (volcanoes, climate changes…)

# Thomas Malthus theory

## Struggle for existence → population crashes

AN

ESSAY

ON THE

*PRINCIPLE OF POPULATION,*

AS IT AFFECTS

THE FUTURE IMPROVEMENT OF SOCIETY

WITH REMARKS

ON THE SPECULATIONS OF MR. GODWIN,

M. CONDORCET,

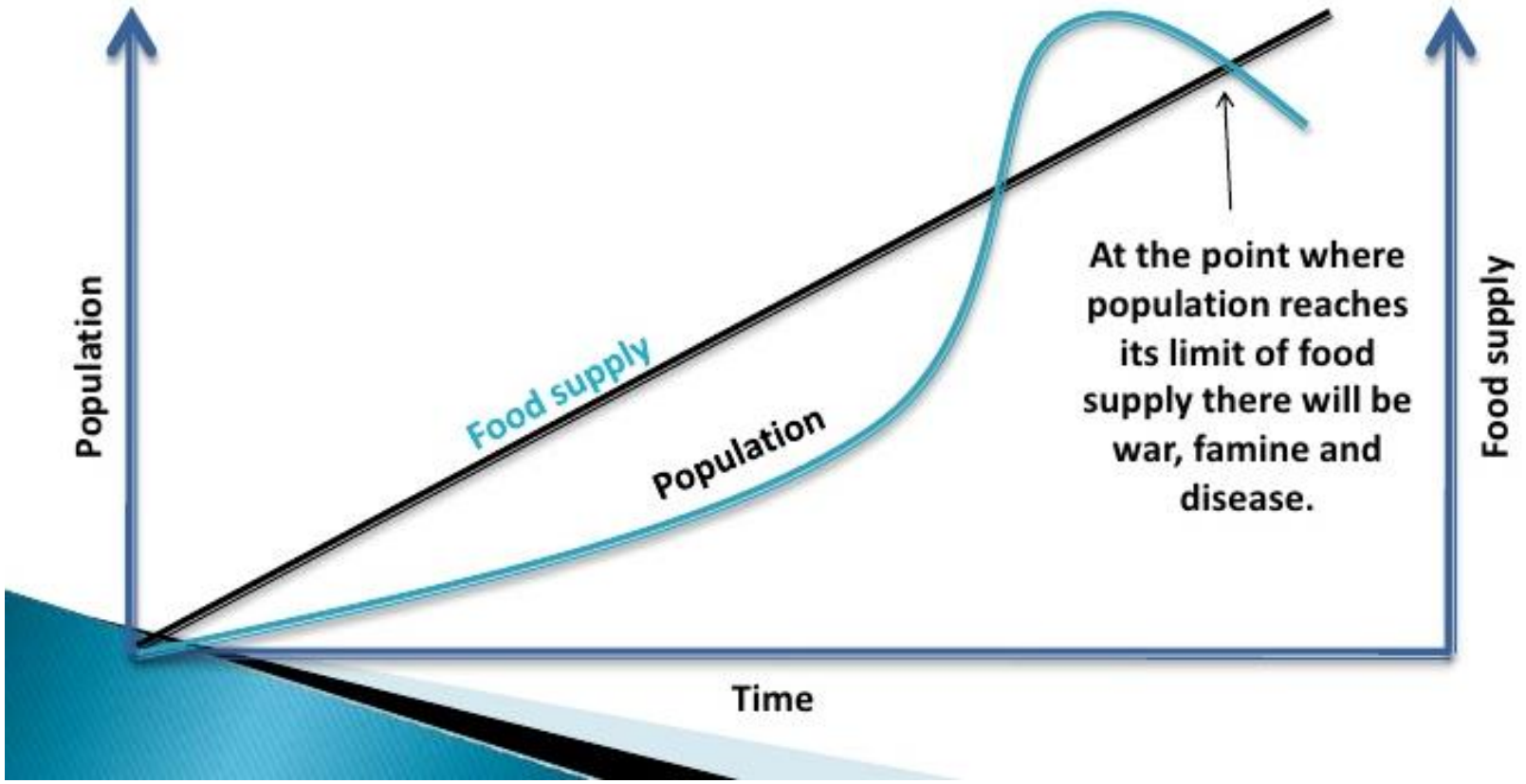
AND OTHER WRITERS.

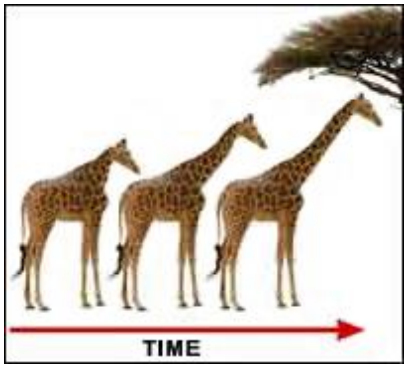
LONDON:

PRINTED FOR J. JOHNSON, IN ST. PAUL'S CHURCH-YARD.

1798.

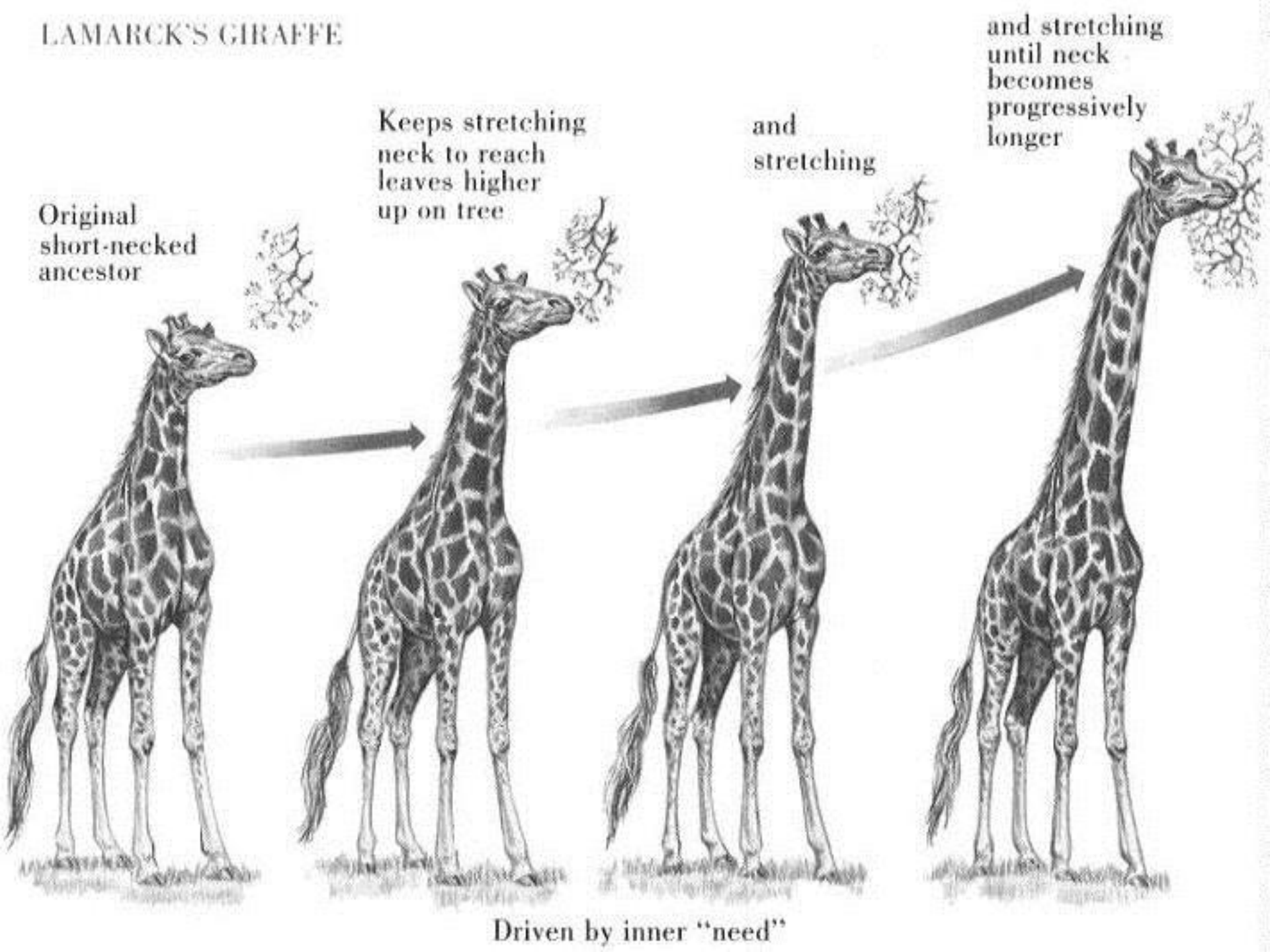
# Populations grow exponentially until they hit the carrying capacity






# Lamarck's Theory of Evolution

- Theory that acquired traits were inherited
- If a body part were used, it got stronger
- If body part NOT used, it deteriorated


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"

BUT Acquired traits are not inherited

# 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

# Regents practice

1) A basketball player develops speed and power as a result of practice . This athletic ability will not be passed on to her offspring because
   a) Base sequences in DNA are not affected by this activity
   b) Muscle cells do not carry genetic information
   c) Mutations that occur in body cells are not inherited
   d) Gametes do not carry complete sets of genetic information

1) The fossil record of ancient life forms provides scientific evidence of

a) Direct harvesting

b) Gene manipulation

c) Selective breeding

d) Evolutionary changes

- Fossils provide evidence that
  a) Life on Earth millions of years ago was more complex than life is today
  b) Many species of organism that lived long ago are now extinct
  c) The changes that will occur in species in the future are easy to predict
  d) Most species of organisms that lived long ago are exactly the same today

- A scientist at a large natural history museum has collection of fossils that were found throughout the world. Only a few of the fossils represent species that are still alive on Earth today. One reason for this is that
  a) Species alive today will not form any fossils for future discovery by scientists
  b) Fossils of only extinct species have been found
  c) Most of the species that have ever lived on Earth are alive today
  d) Most of the species that have ever lived on Earth are extinct

- A woman changes her hair color to red; however, her children will not inherit this red hair color because the woman does not have
  a) Genes for red hair in her skin
  b) Proteins for red hair in the placenta
  c) Genes for red hair in her sex cells
  d) Proteins for red hair in her egg cells
-

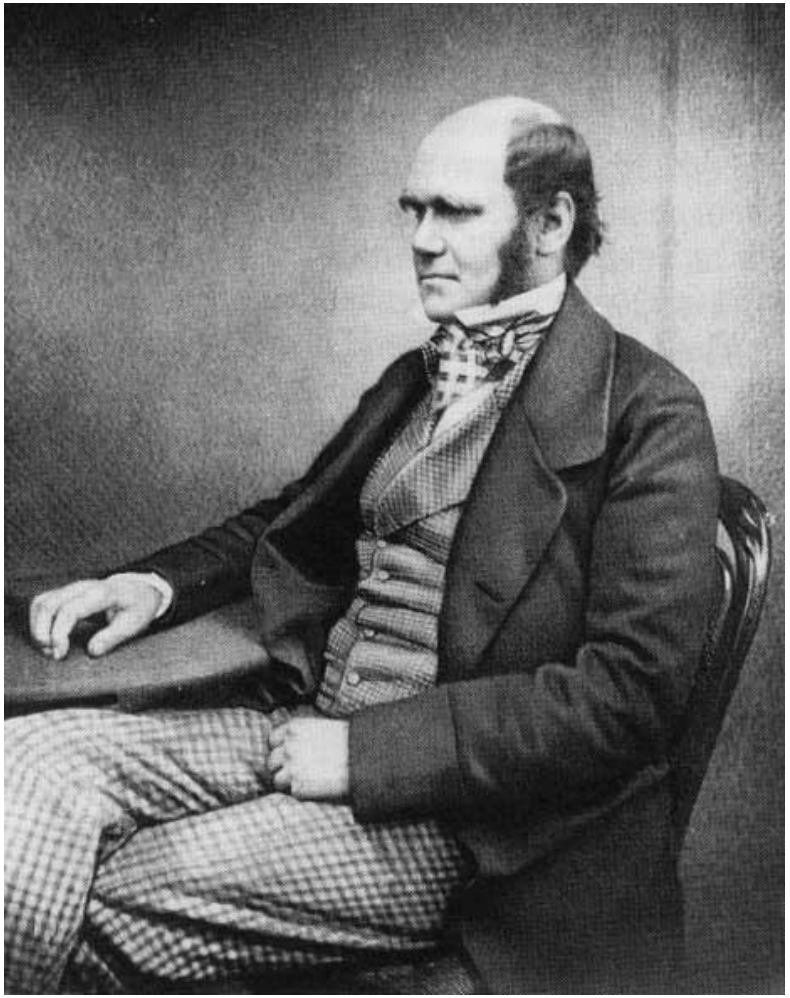
# Darwin's Voyage of Discovery

**A reconstruction of the HMS Beagle sailing off Patagonia.**

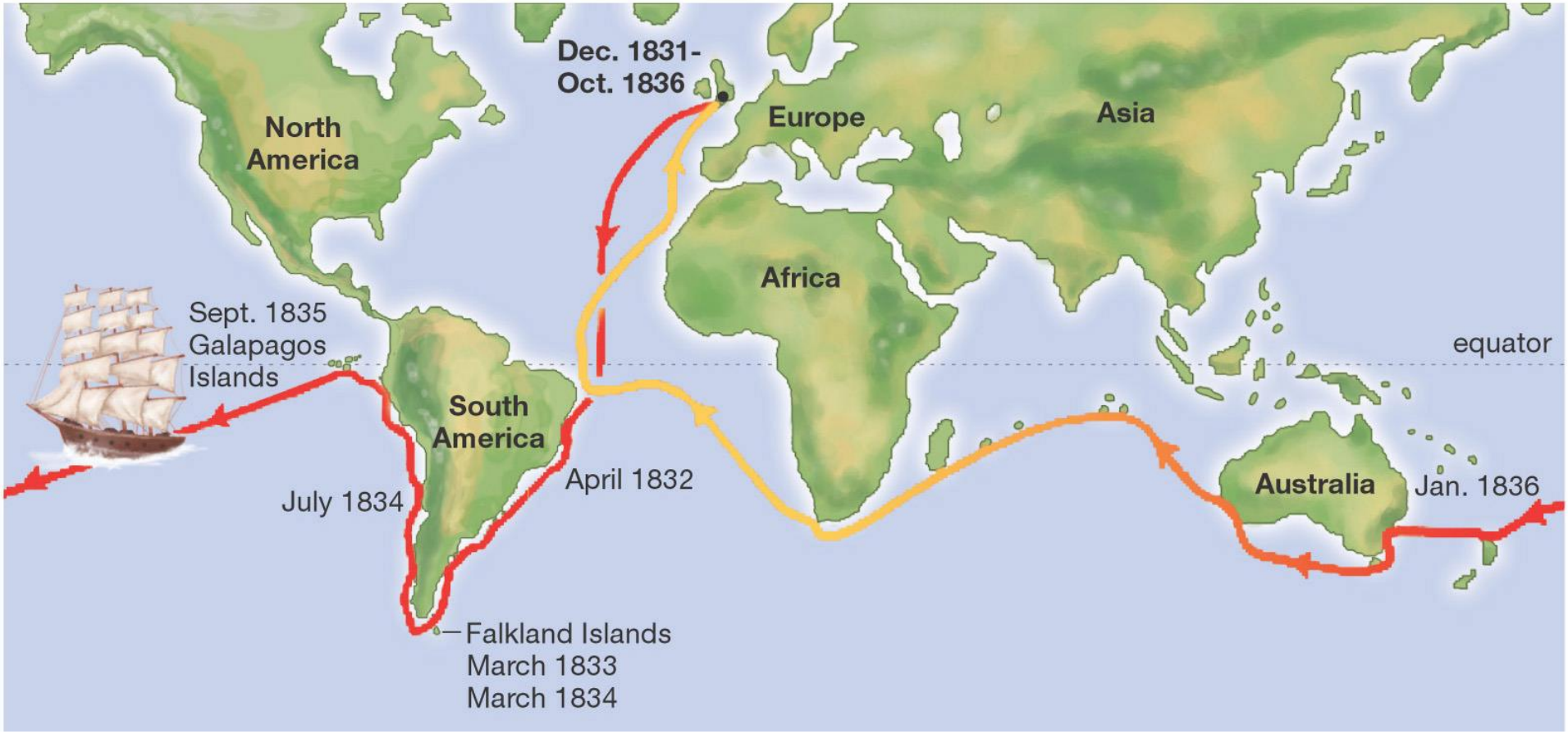
# Voyage of the Beagle

## Charles Darwin

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



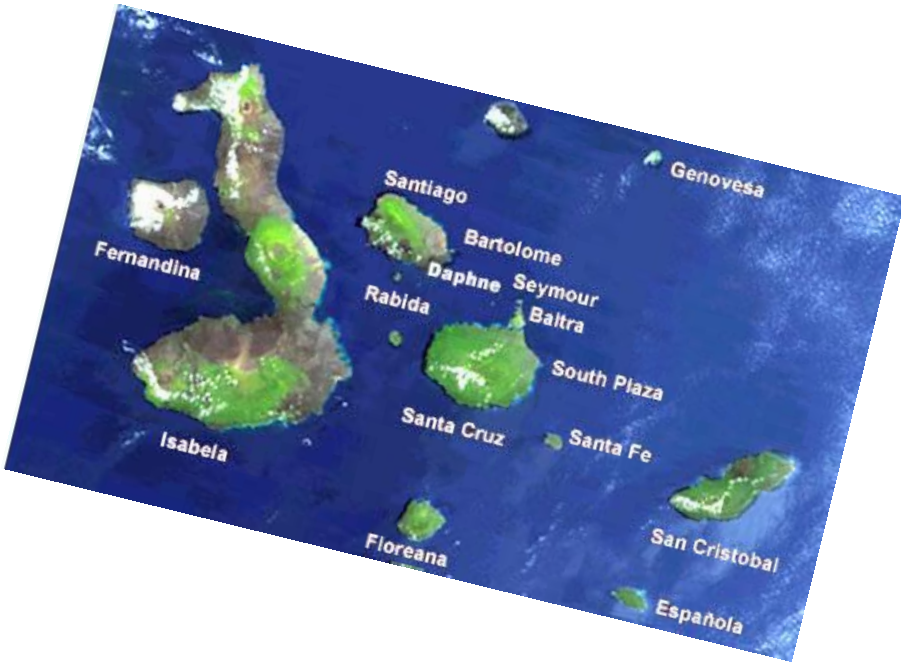
# Darwin Left England in 1831

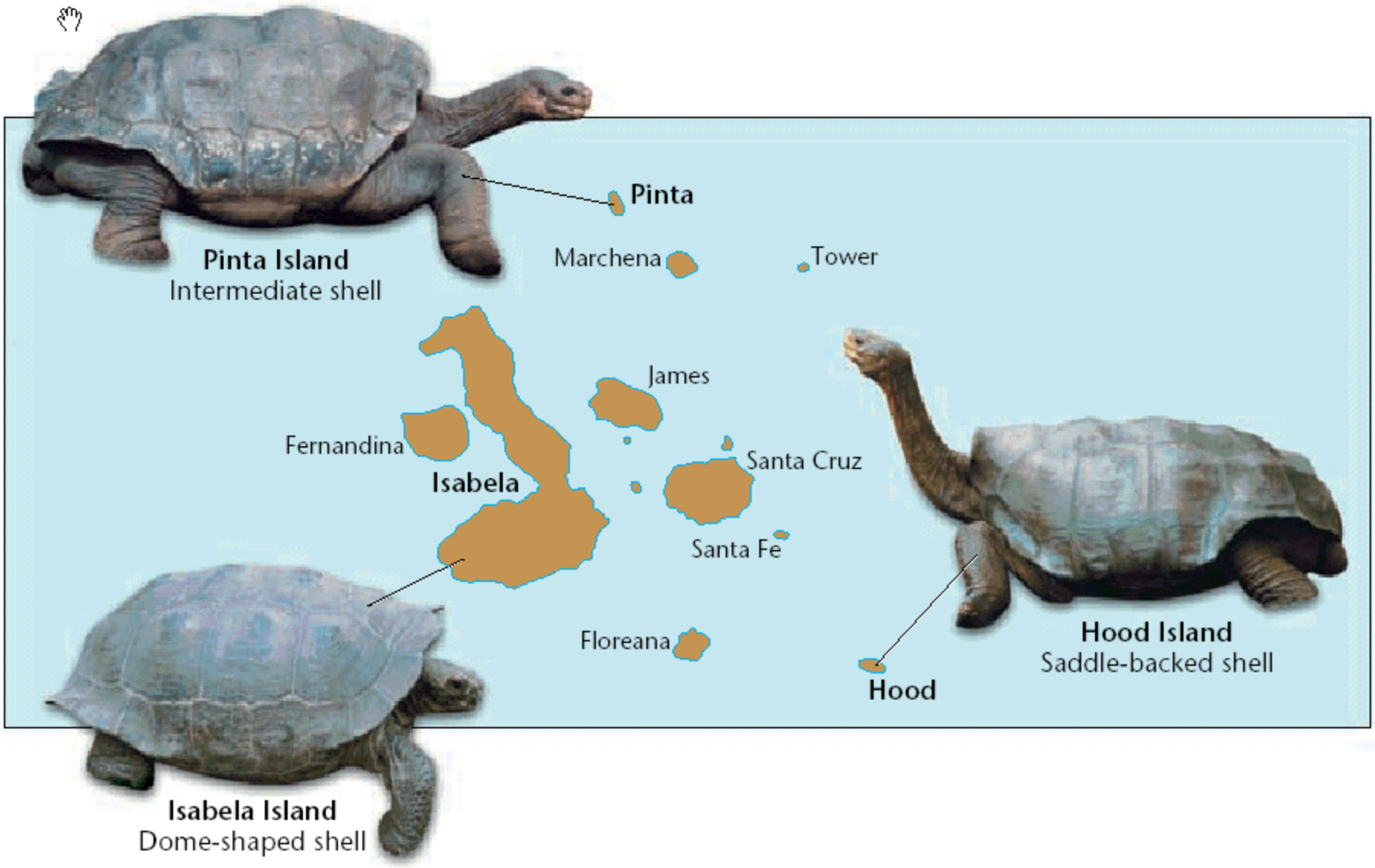



**Darwin returned 5 years later in 1836**

# Darwin traveled to the Galapagos Islands

- **Volcanic islands 1000km off the coast of South America**
- **Darwin found unique organisms on each island**
- **Island species varied from mainland & from island-to-island**
- **Ex: he found different species of turtles, iguanas, and finch populations on each island**




Pinta
Pinta Island
Intermediate shell
Marchena
Tower
James
Fernandina
Isabela
Santa Cruz
Santa Fe
Floreana
Hood
Hood Island
Saddle-backed shell
Isabela Island
Dome-shaped shell
© D.Cavagnaro/DRK Photo • © M.Cavagnaro/DRK Photo

## 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 |

# The Galapagos Island Finches

- More types of finches appeared on the islands where the available food was different (seeds, nuts, berries, insects…)

- Ex.: different types of finch beaks adapted to different types of food found on each island

# Darwin's 4 observations of nature

Based on living organisms and fossils found

# 1) Members of a population have variations

**Variation = differences between organisms**

# 2) Traits are inherited from parents to offspring

- Adaptation = traits that help you survive

**3) <u>All species are capable of producing more offspring than the environment can support</u>**

Left unchecked, organisms can <u>overproduce</u> because they reproduce exponentially

1-<u>2-4-8-16-32</u>…

**4) Because of lack of resources many offspring do not survive**

# Darwin's Conclusions

1. Individuals with traits that increase survival → more offspring

2. Over time favorable traits increase in a population

# How Evolution Works

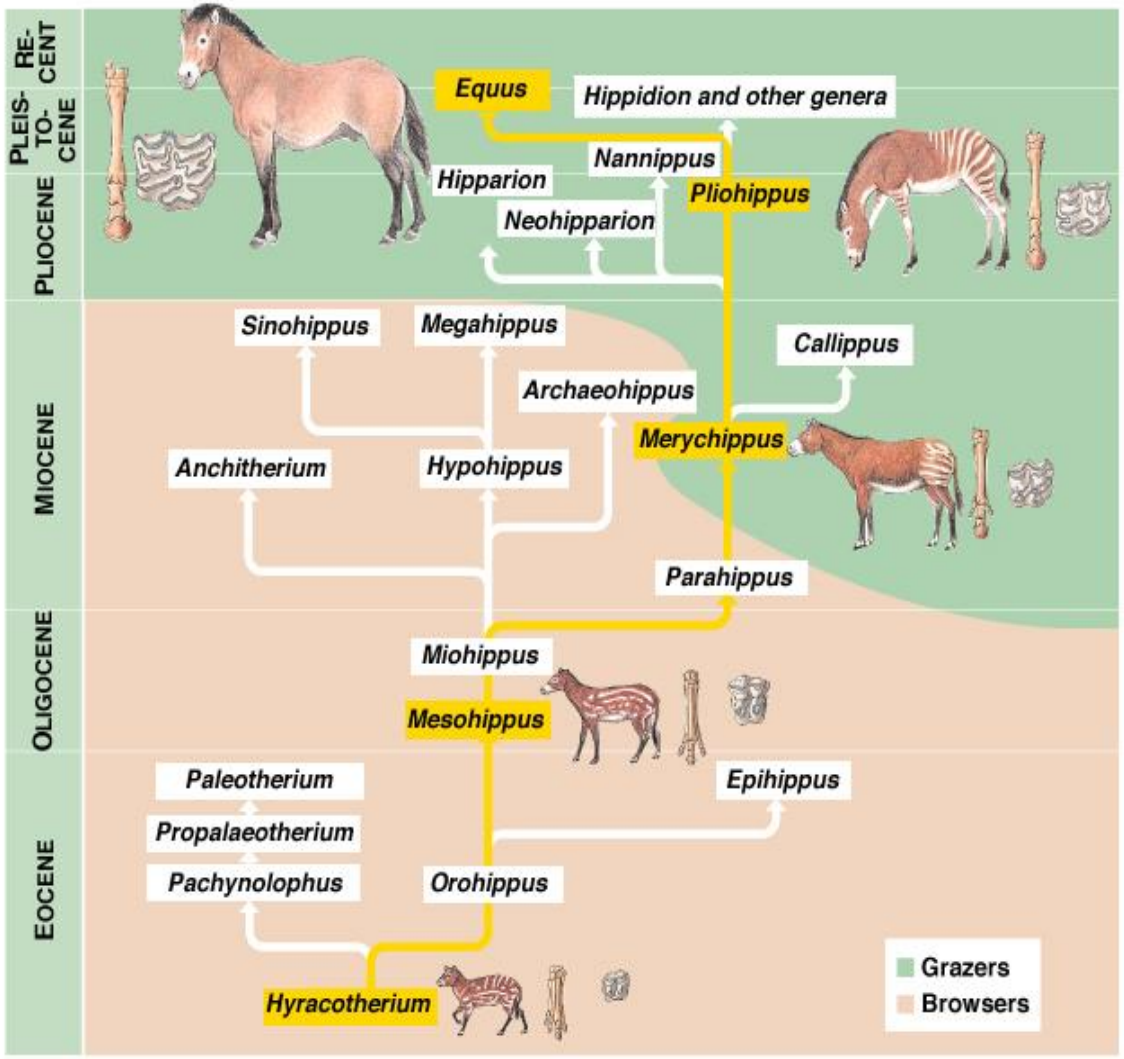
- Resources are limited →
- competition and
- struggle for existence

- Survival of the Fittest=
- Only the best adapted
- survive and reproduce each generation

# Darwin's Theory

Natural Selection = Environment acts as selecting agent → next generation

- **Best adapted survive and reproduce**



# Natural Selection → build-up of favorable traits

- Depends on variation
- No variation = no evolution
- Mutation and sexual reproduction → variation
  - Note: Mutation = change in DNA

# Natural Selection

- Nature works as selecting agent → changes in species
- Abandoned The Idea That Species Were Perfect & Unchanging
- Helped explain Significant Variation in All Species

# Artificial Selection → build up of desirable traits

- Farmers act as selecting agents → change varieties
- Farmers Use Variation To Improve Crops & Livestock
- Called Selective Breeding been used for centuries

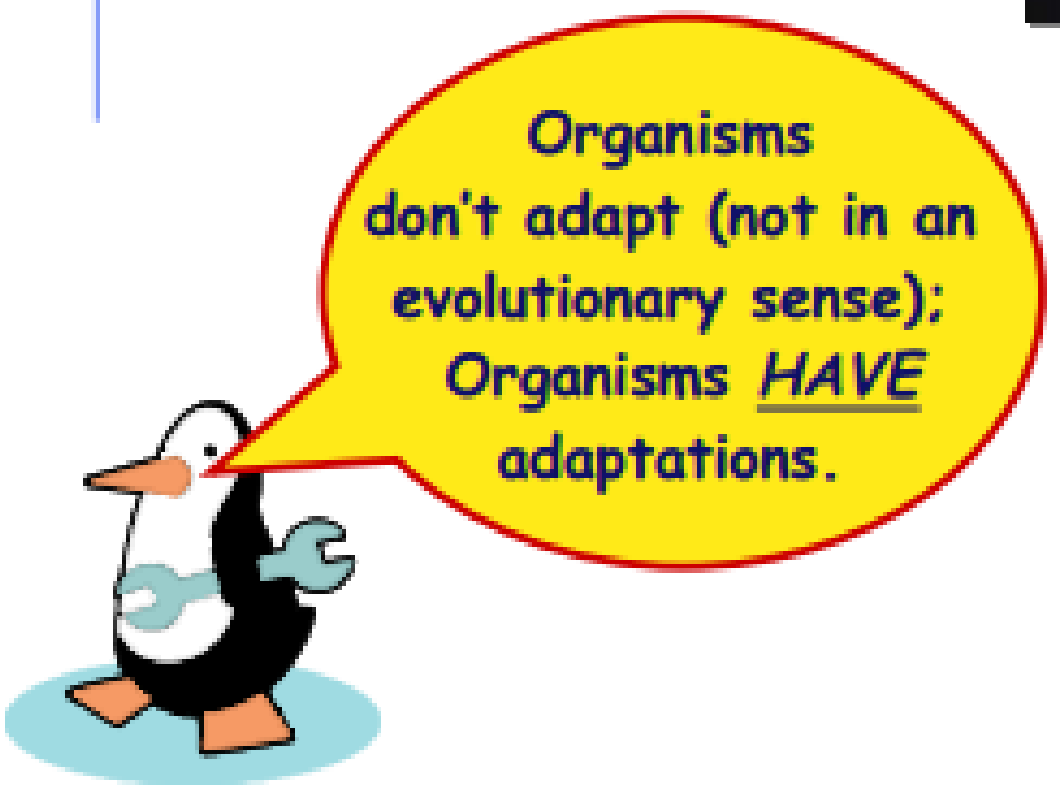
# Natural Variation and Artificial Selection

- Natural selection
  - Environment acts as selecting agent

- Artificial Selection
  - Humans act as selectors (ex: breeding dogs)

# Common Misconception #1

Individual organisms do NOT evolve!!!



# Common Misconception #2

One trait is not better than another unless the environment determines which traits → survival.

Change the environment → need different adaptations

Ex: antibiotic resistance doesn't help bacteria survive unless there are antibiotics in the environment.

# Common Misconception #3

- The environment doesn't give you adaptations

- Natural selection can only increase or decrease heritable traits that are already in the population.
  - Remember no variation = no natural selection = no evolution

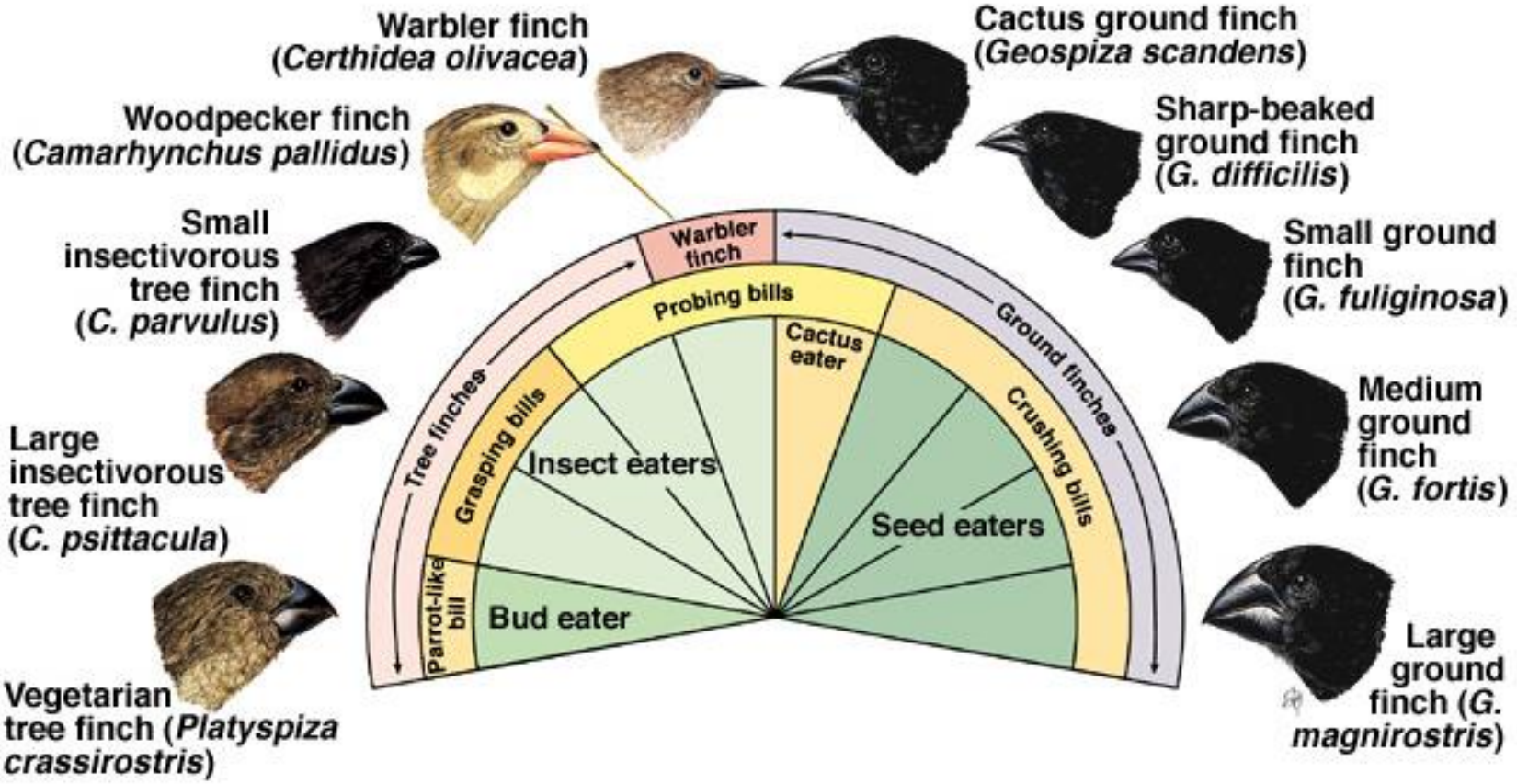
# Practice Evolution Questions

# Darwin's book "Origin of Species"

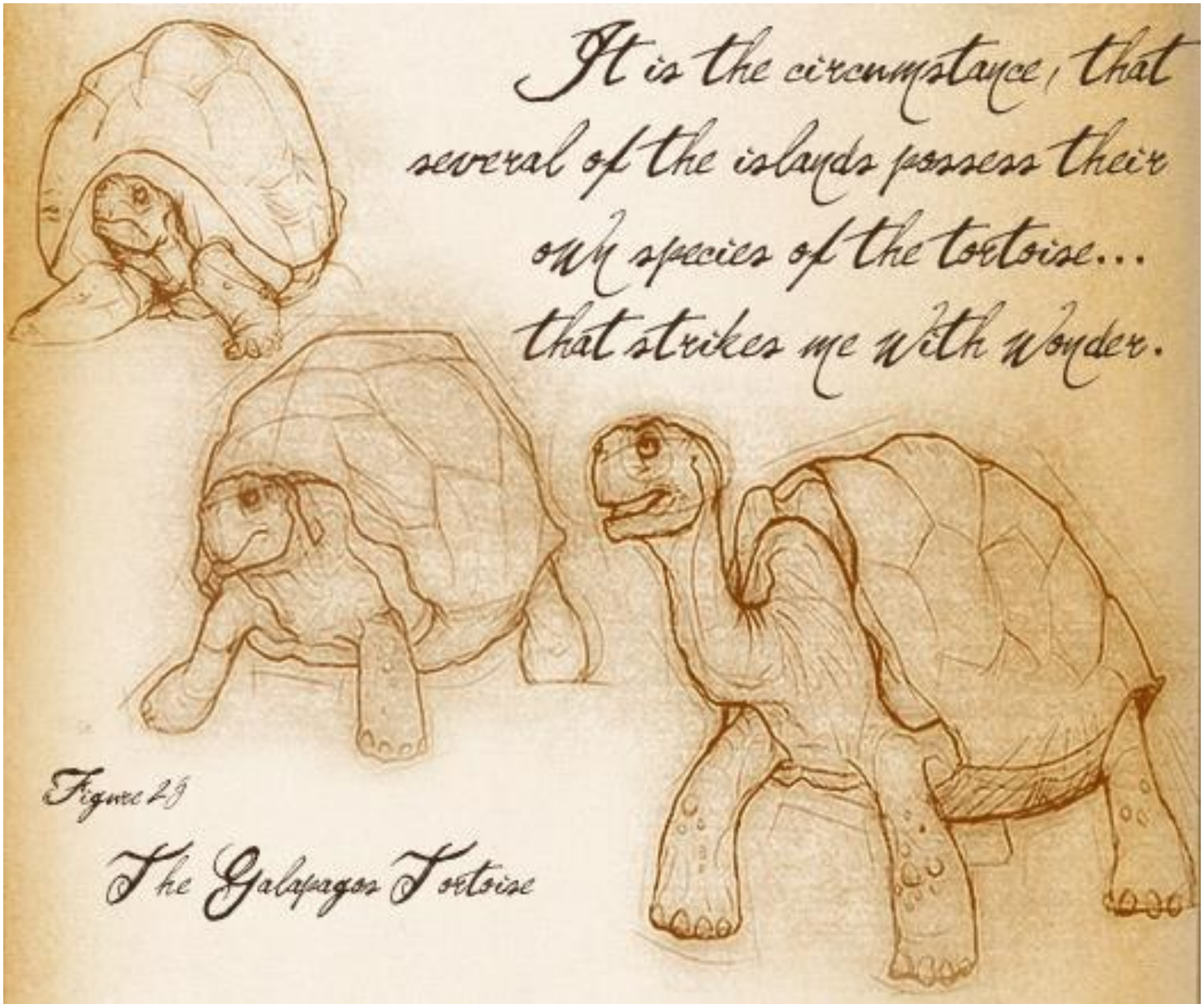
# Darwin's theory of evolution = 3 key ideas

# 1) Different environments → increase different traits

- Ex: <u>islands with different food sources → different finch beaks</u>

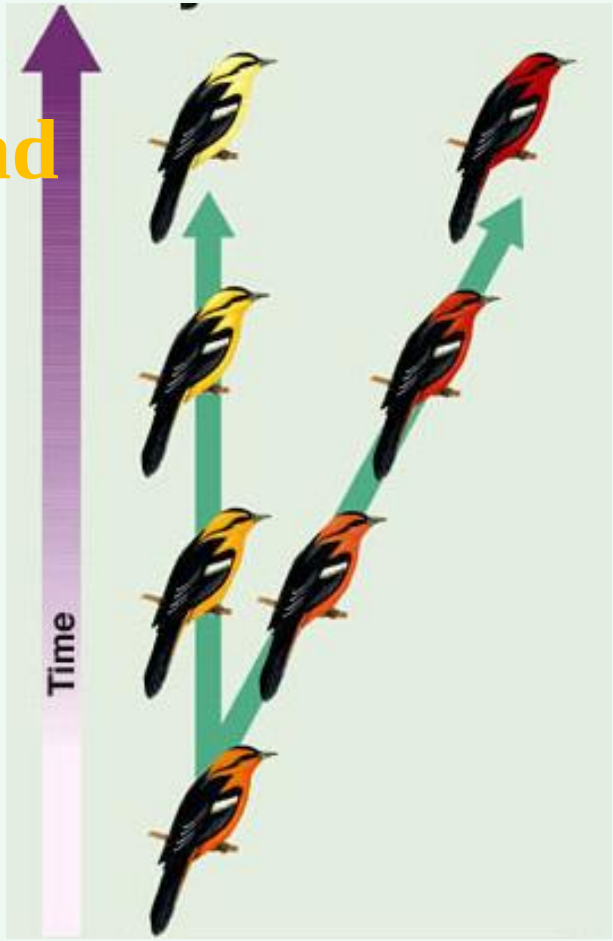


2) Speciation = new species evolve in different environments



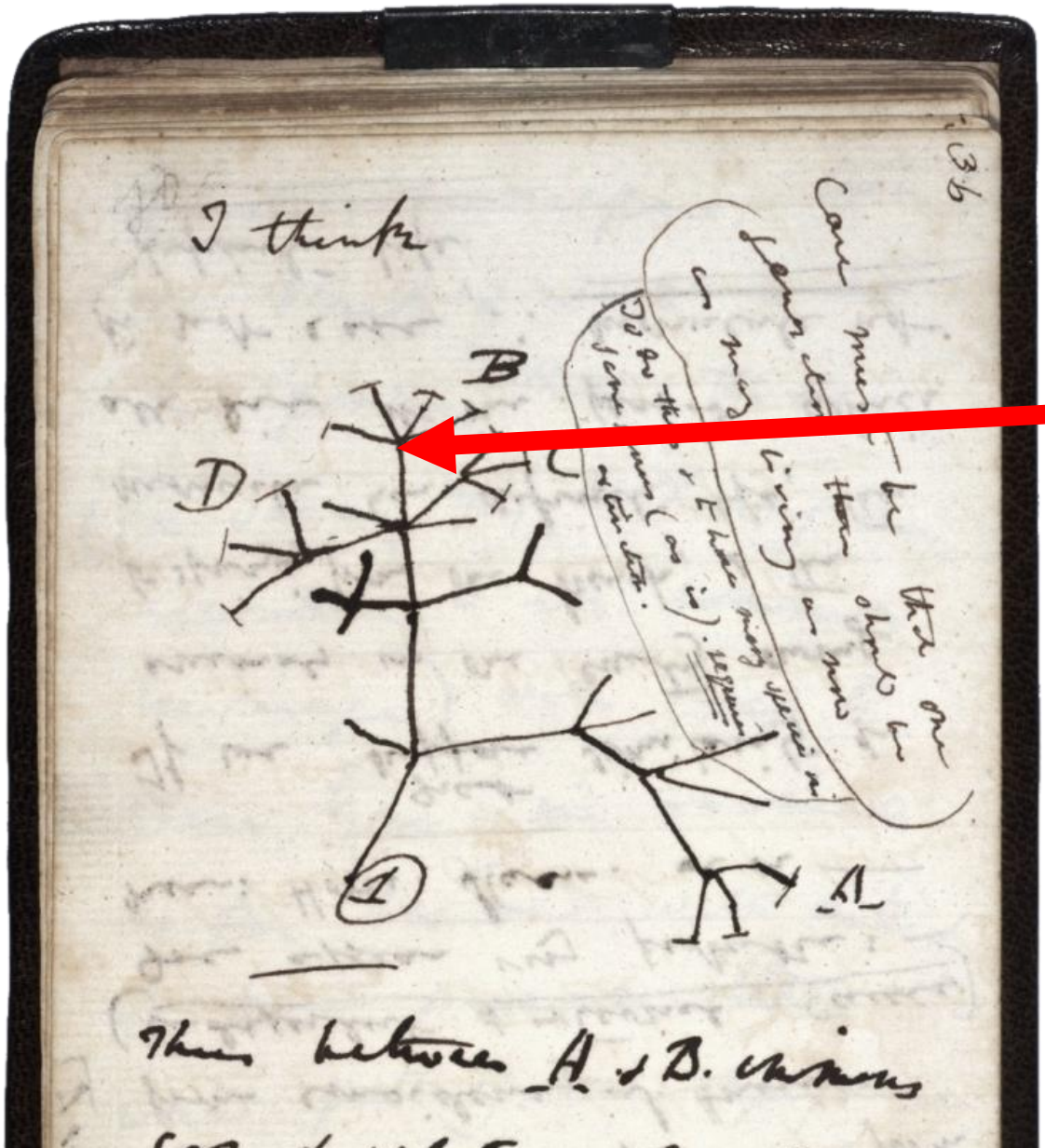
# Change in the environment → evolution of new species

**Mainland birds**



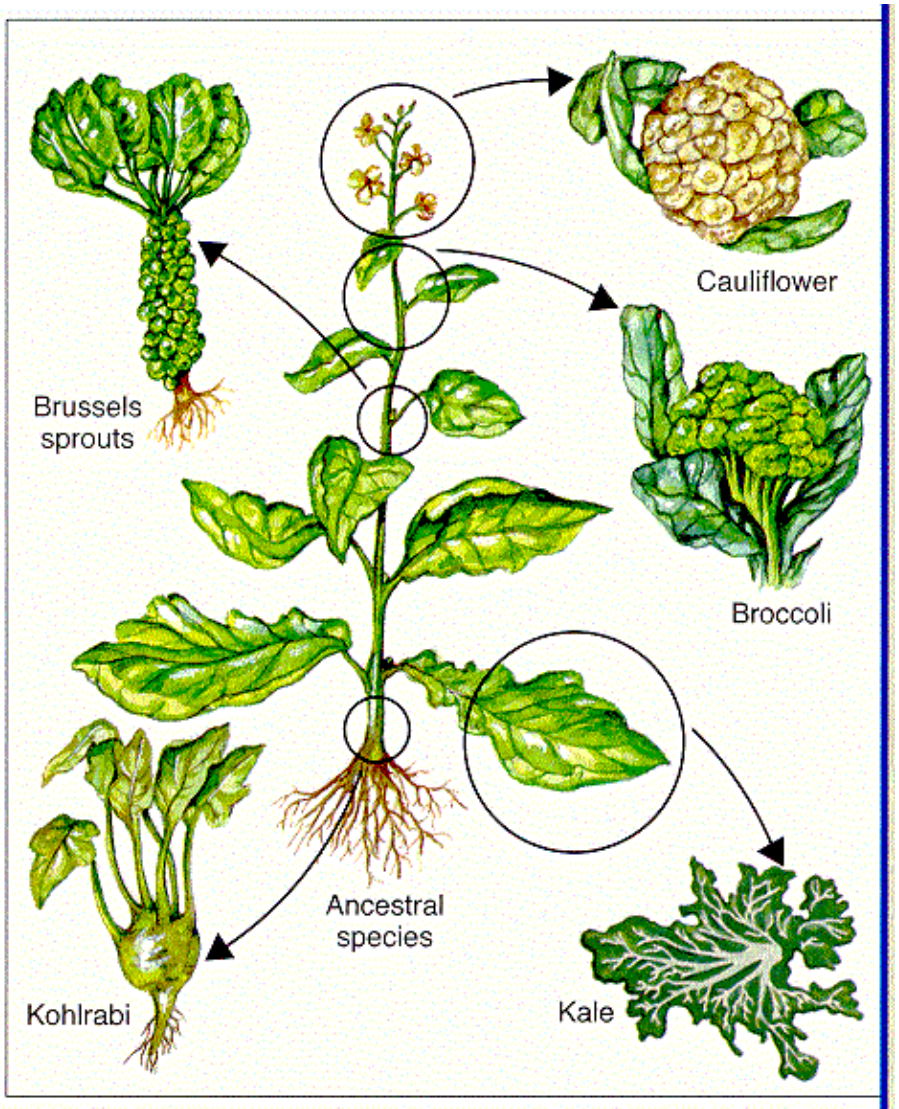

**Island birds**

# 3) All organisms share common ancestors




Common ancestor

# Selective breeding from one common ancestor → many different plants



# Evolution vocabulary

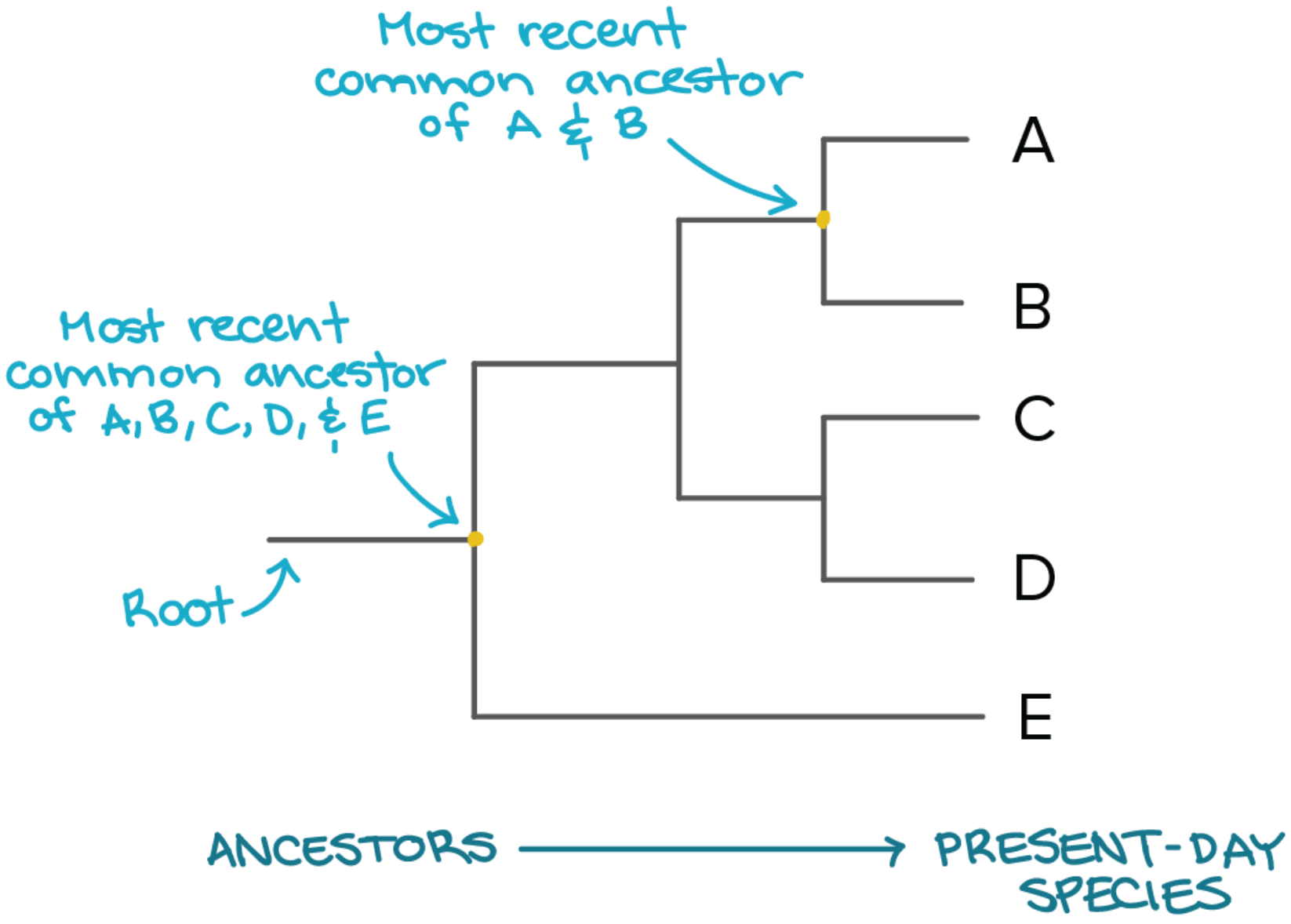
- Struggle for existence =
- Organisms compete for resources

- Survival of the fittest =
- Best fit for the environment survive and reproduce

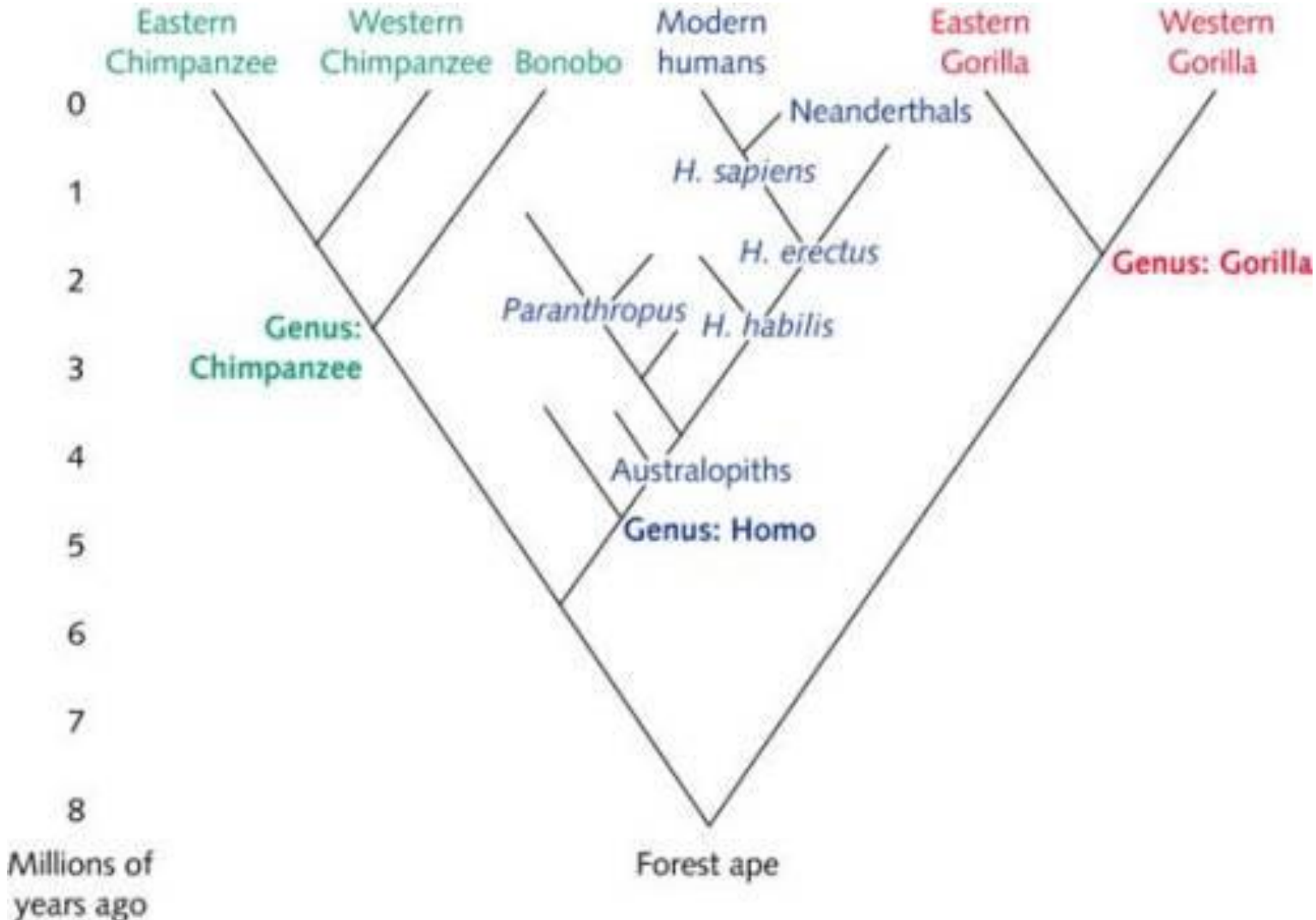
- Adaptation =
- Inherited trait that increases survival rates

- Natural selection →
- traits → survival increase in populations over time

Evolutionary trees → relationships between species


Most recent common ancestor of A & B
Most recent common ancestor of A, B, C, D, & E
Root
A
B
C
D
E
ANCESTORS
PRESENT-DAY SPECIES

# Answer questions in notes



# Natural Selection

- Driving force for evolution
- During the struggle for resources, best adapted survive & reproduce
- Favorable variations are more likely to increase in frequency in populations

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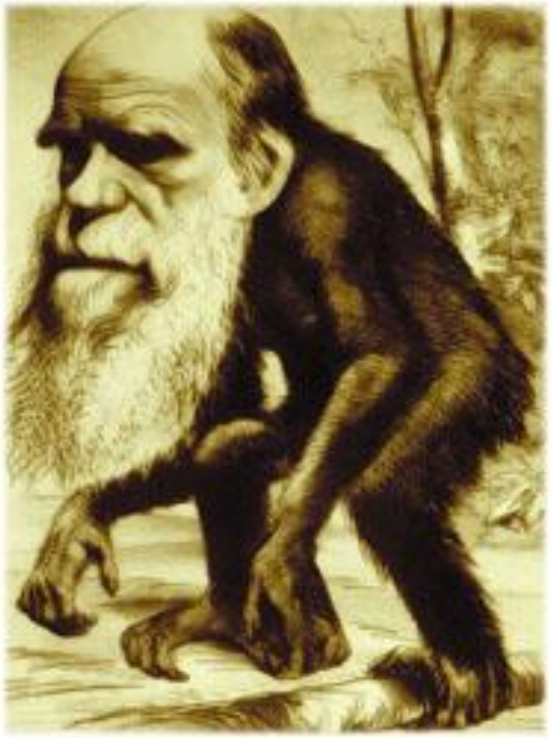
# Publication of “On The Origin of Species”

- **Darwin knew that his theory challenged established religious & scientific beliefs so he did not publish for 25 years**

# Opposition to the Theory of 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**



# Support for Darwin's claims

1. Alfred Wallace
   - Fellow Naturalist
   - Independently Developed The Same Theory

# WALLACE & DARWIN - VOYAGES TO EVOLUTION

Operation Wallacea
Conservation research through academic partnerships

WALLACE100

**A**

In 1831 Darwin joined HMV Beagle on a round the world expedition as the ship's naturalist. It was during this 5 year voyage that Darwin began to realise that life on earth was not unchanging nor species immutable, but rather that gradual change over time was leading to the creation of new species. In September 1835, the Beagle arrived at the Galapagos Islands and Darwin noticed how the giant tortoises on the different islands differed in form and later on examining the bird specimens he had collected, that the finch species seemed to be different on the various islands and all closely related to South American species.

**B**

In May 1858 Wallace and his friend Henry Bates who had first introduced him to entomology, arrived at Para at the mouth of the Amazon. Wallace was to spend 4 years exploring the Amazon whilst Bates spent 11 years collecting and became famous for his description of Batesian mimicry.

**C**

After working together for a short period in the Amazon, Wallace and Bates worked independently, with Wallace spending most of his time in the middle Amazon and exploring the main northern tributary of the Amazon - the black water Rio Negro. On his return to England, Wallace published a detailed map and description of the Rio Negro and its wildlife

**D**

In 1852 when Wallace returned to Para he found most of his collected specimens still on the dock waiting to be shipped. On 6 August on his return voyage to England, the ship with all his specimens caught fire and sank and Wallace survived for 10 days in a leaking lifeboat until he and the other survivors were picked up by a passing cargo ship. Wallace arrived back in England with none of his collections from the previous 4 years.

**E**

In April 1854 Wallace leaves England for a collecting expedition to the Malay archipelago. He was to remain in the region for 8 years and to visit each of the main islands becoming the foremost authority on the fauna of the region. During this time he described what became known as Wallace's line – a line running between Bali and Lombok and Borneo and Sulawesi. The line followed the course of a deep ocean trench which marked the eastern extent of Asian fauna since the islands to the east of trench were never joined to the mainland of Asia. Later workers found a similar deep trench on the far side of Sulawesi and other islands preventing them from ever being contiguous with Australasia even in periods of low sea levels. These islands formed many new species and the whole area is now known as the Wallacea region.

**F**

In February 1855, whilst in Sarawak, Wallace wrote a paper entitled 'On the Law Which Has Regulated the Introduction of New Species'. This paper was published in September 1855 and proposed the following law: Every species has come into existence coincident both in time and space with a pre-existing closely allied species. The paper clearly describes how species were changing over time, with some species becoming extinct and new species being created from antecedent species. It also describes how volcanic islands are populated by species from adjacent areas and only when isolated for very long periods do new species form. The paper written at a time when the general belief was that species were immutable and unchanging, is a prescient description that evolution was occurring. At this stage Wallace still cannot see the mechanism for how species change. Lyell whose work on how substantial geological changes to the Earth had occurred over time had inspired Wallace to his theory, sees this paper and brings it to the attention of Darwin.

**G**

In February 1858 whist recovering from malaria, Wallace suddenly realises how new species were being formed. As soon as he has recovered he drafts a letter to Darwin entitled 'On the Tendency of Varieties to Depart Indefinitely From the Original Type' and asks Darwin to show it to Lyell. This paper when received by Darwin in June 1858 is exactly the same theory he has been working on, so persuaded by Lyell, the paper from Wallace was submitted to the next meeting of the Linnaean Society in July 1858 as well as extracts from Darwin's work. These papers were the first papers ever published on the mechanism by which new species were evolving.

**H**

The bombshell resulting from Wallace's letter and his clear description of the theory of evolution by natural selection caused Darwin to hurriedly finish his book 'On the Origin of Species' which was published 18 months after the Linnaean Society papers. At the time Wallace was regarded as co-originator of evolutionary theory although over time the role of Wallace has been downplayed to such an extent that evolutionary theory is now known solely as Darwinism.

PORTSMOUTH
AZORES
TENERIFE
CAPE VERDE
PARA - BELEM
GALAPAGOS
BAHIA
CALLAO - LIMA
RIO DE JANERIO
VALPARAISO
MONTEVIDEO
FALKLAND ISLANDS
CAPE TOWN
MAURITIUS
COCOS (KEELING) ISL.
KING GEORGE'S SOUND
SYDNEY
HOBART
THE WALLACE LINE

DARWIN'S VOYAGE OF THE BEAGLE | WALLACE'S TRAVELS IN THE AMAZON | WALLACE'S TRAVELS IN THE MALAY ARCHIPELAGO | RESEARCH SITES

## Alfred Russel Wallace 1823 - 1913

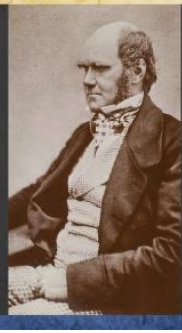
Alfred Russel Wallace was born in Usk, Monmouthshire to a middle class family who fell on hard times financially. His early life was as a surveyor and a teacher but after meeting Henry Bates who introduced him to collecting natural history specimens, the pair departed for the Amazon intent on funding their expedition by collecting specimens and selling them to collectors in Victorian Britain. His first expedition was a financial disaster since most of Wallace's collection was lost when the ship on which he was returning home sank. However undeterred, Wallace used the experience to write of his explorations and the species encountered and established a sufficient reputation that he obtained a grant to travel to Singapore on what would be an 8 year expedition to the Malay archipelago. It was on this expedition that Wallace began to write about how species were changing over time and then when recovering from a bout of malaria he realised the mechanism by which species were changing. Wallace continued collecting for a further 4 years after the letter to Darwin that had caused such an impact and by the time he returned to Britain he was regarded not only as the co-originator of the theory of evolution by natural selection, but also as the originator of the discipline of biogeography.

## OPERATION WALLACEA

Why not follow in the footsteps of these great Victoria explorer naturalists and help university academic teams over your summer break with biodiversity surveys in some of the most exciting and remote areas of the World? Operation Wallacea (www.opwall.com) is running biodiversity research programmes that are available to high school groups with teachers in attendance at the following sites:

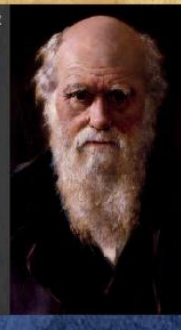
1. **Mexico** - Mayan forests and Caribbean coral reefs biodiversity research (spider monkey behavior and biodiversity research in the lowland forests with turtles at the marine site)
2. **Cuba** - coral reef and mangrove biodiversity research (manatees, shark tagging and stereo videos surveys of reefs)
3. **Honduras** - cloud forests and Caribbean coral reefs biodiversity research (rare amphibian research, learning to access the canopy on ropes, genetics lab and access to two contrasting marine research sites)
4. **Dominica** - Caribbean Island and coral reef biodiversity research (learning to abseil/rappel, electrofishing and sperm whales)
5. **Ecuador** - cloud and lowland forest biodiversity research (camera trapping for spectacled bears and large cats, brown headed spider monkeys)
6. **Guyana** - Lowland Guiana Shield forest and rivers biodiversity research (effects of selective logging on biodiversity with jaguars, tapirs, and giant river otters)
7. **Peru** - Amazonian biodiversity research (living on research ships and working on river dolphins, piranhas and caiman)
8. **Transylvania** - Carpathian mountain foothills biodiversity research (effects of changes in traditional farming practices on biodiversity with brown bears and wolves)
9. **France & Italy** - Alpine and Mediterranean ecology
10. **Greece** - Island ecology with sea mammal and herpetofauna studies plus a dive training course
11. **Madagascar** - endemic rich dry forest and coral reef biodiversity research (chameleon, lemur and endemic birds)
12. **South Africa** - wildlife management of low veld reserves (on foot with armed guards in reserves to study effects of elephant on vegetation)
13. **China** - Tibetan plateau and mountain valley biodiversity research (cranes and Pryczewalski's gazelles and baseline biodiversity surveys of the Qinling mountains)
14. **Indonesia** - lowland forests and coral reefs (endemic rich forests and largest marine research times working in the centre of the Coral Triangle - the most biodiverse rich reefs in the world)

NOTE additional research sites are being added each year so please visit www.opwall.com for details. Students joining these projects can use their time on site and access to university academics to complete their Extended Essays and get CAS points if doing IB or to gain UCAS points by doing an EPQ if they are doing A levels or Highers. For those going on to US universities then university course credit with a marked transcript is available for joining the research programmes and for those going to UK universities then participation in the programme results in a University Award



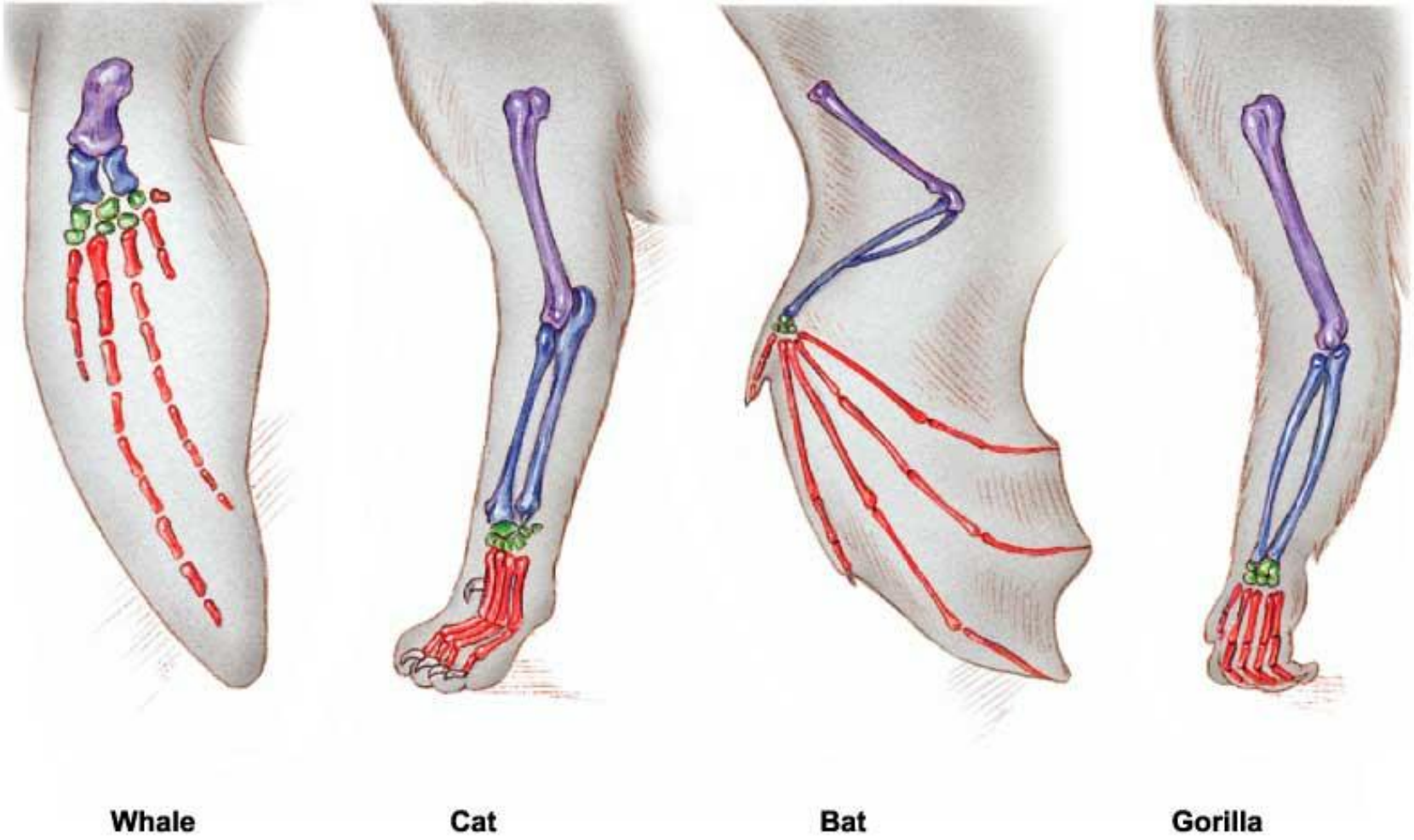
## Charles Robert Darwin 1809 - 1882

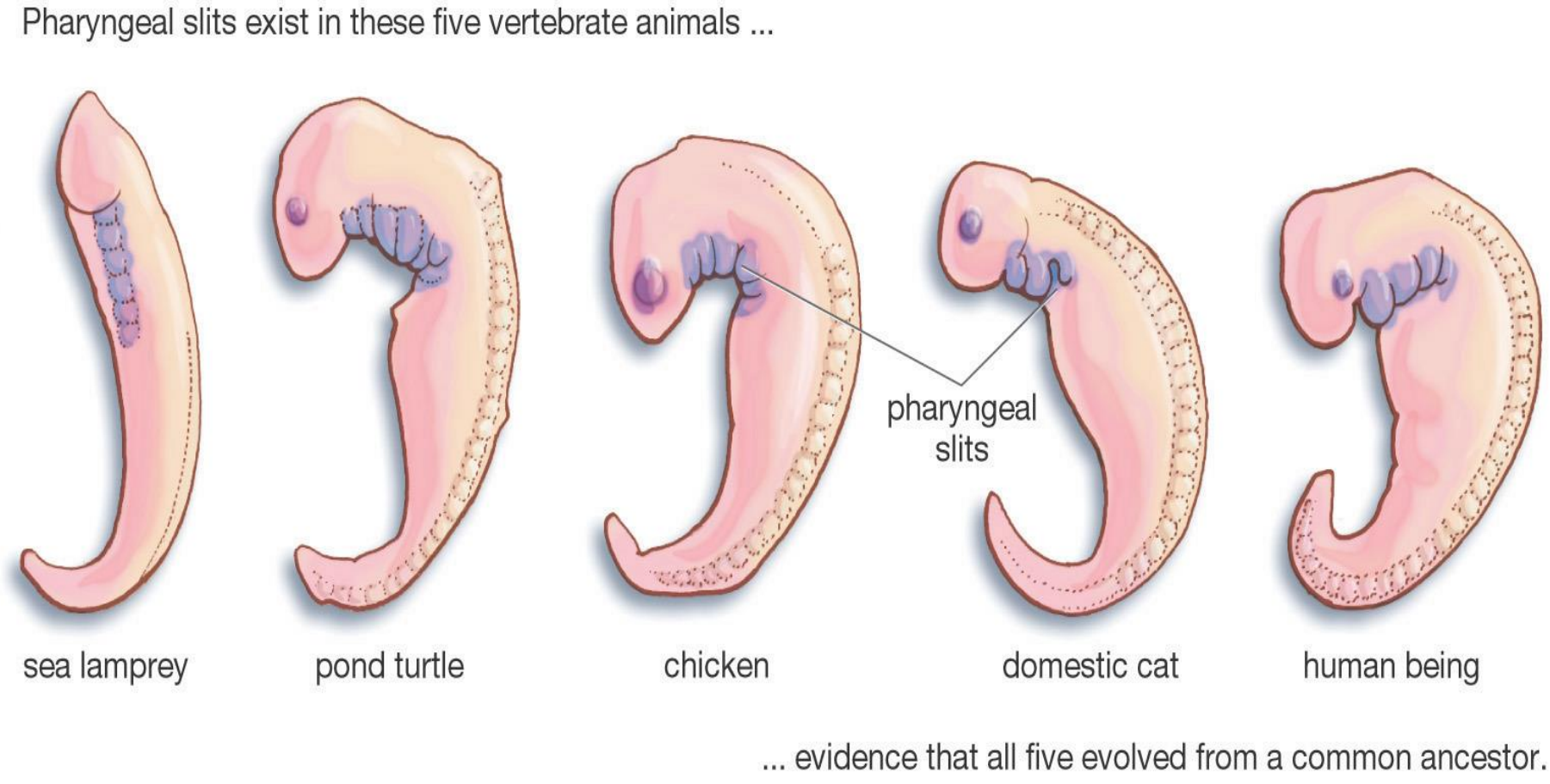
Charles Darwin was born in Shropshire to a wealthy family. He studied medicine initially at Edinburgh but was not cut out for a medical career and so instead did a degree at Cambridge so he could enter the clergy. At Cambridge Darwin became fascinated with natural history and in 1831 having graduated Darwin joined a survey expedition on the HMV Beagle and was to spend the next 5 years travelling around the world. Darwin had read Lyell's book on the Principles of Geology that had first argued that the world was not unchanging as had been thought previously and was the result of millions of years of gradual change. Darwin became convinced on his travels around the world that Lyell was correct and even built on Lyell's ideas describing how coral atolls formed. On his return to England Darwin was convinced that species were evolving and he spent the rest of his life studying the mechanism of change. As early as 1838 Darwin after reading an essay by Malthus on population growth had begun thinking about the possibility of what was to become known as natural selection. However, only on receiving Wallace's letter in 1858 was he forced into publishing his initial thoughts and then hurriedly finished his book in 1859 On the Origin of Species.



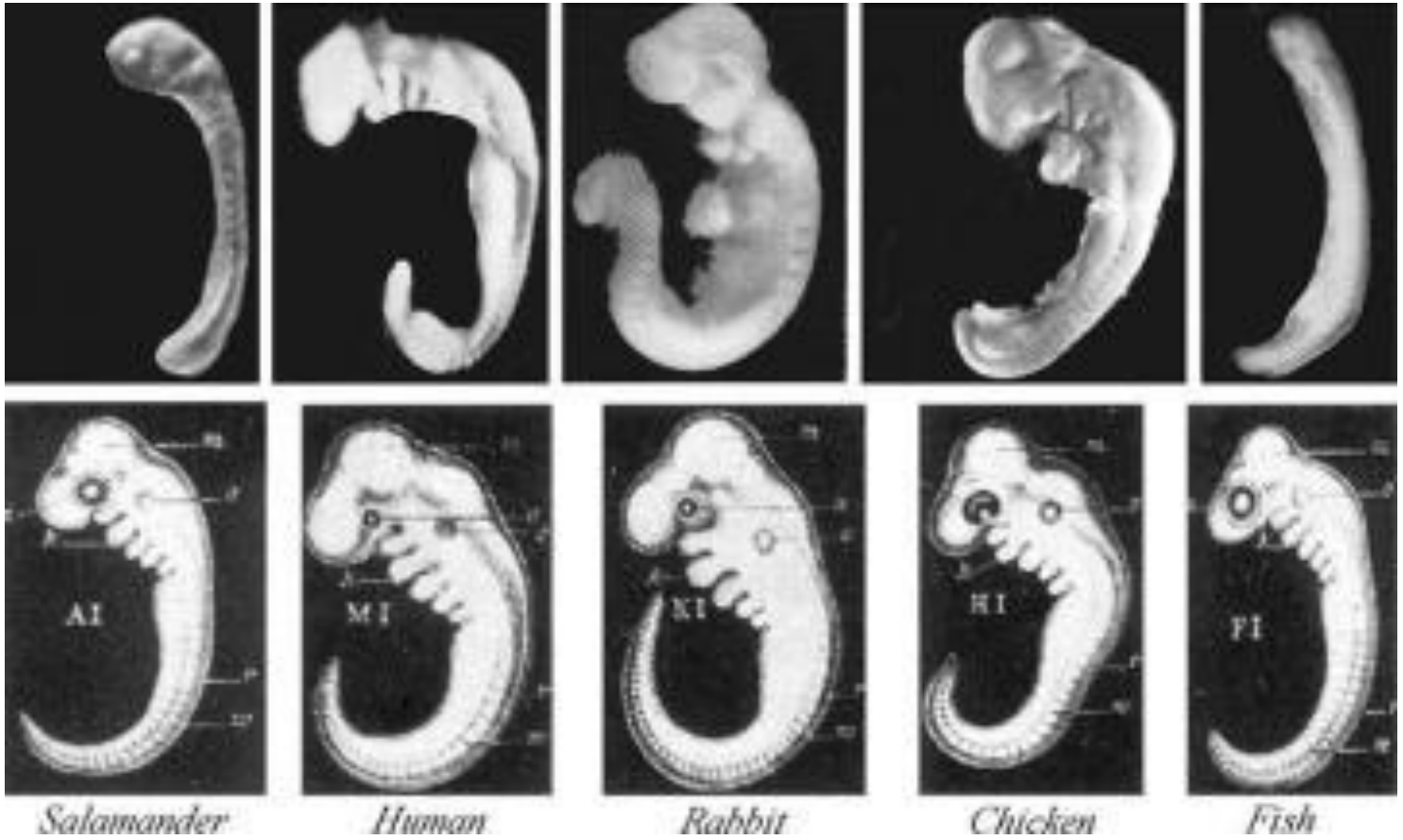
Operation Wallacea → scientific expeditions in 15 countries

# 2) Homologous Body Structures

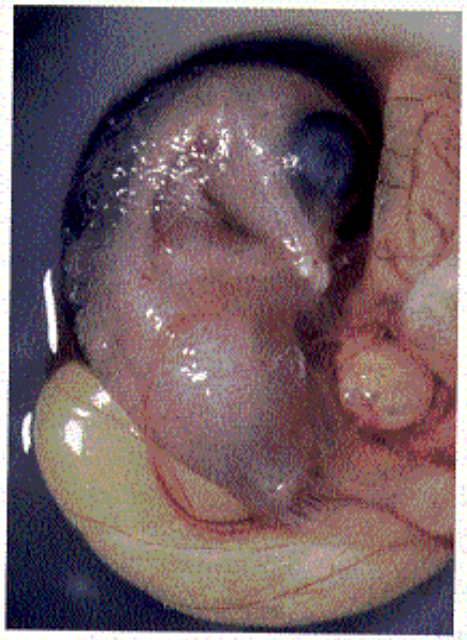





# 3) Similarities In Embryonic Development


AI
MI
RI
HI
FI
Salamander
Human
Rabbit
Chicken
Fish

Chicken



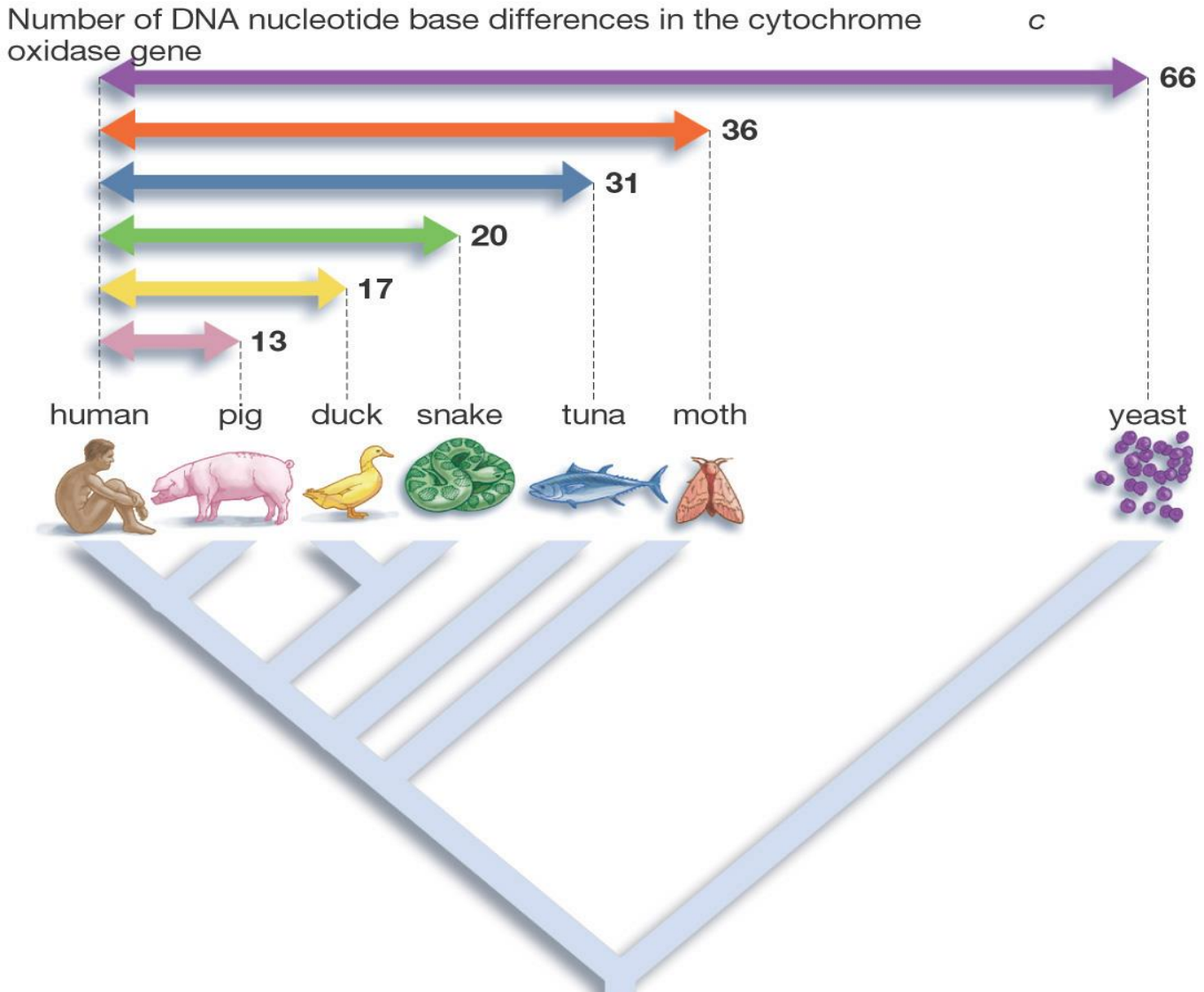
Turtle

Rat


Human 41 day old

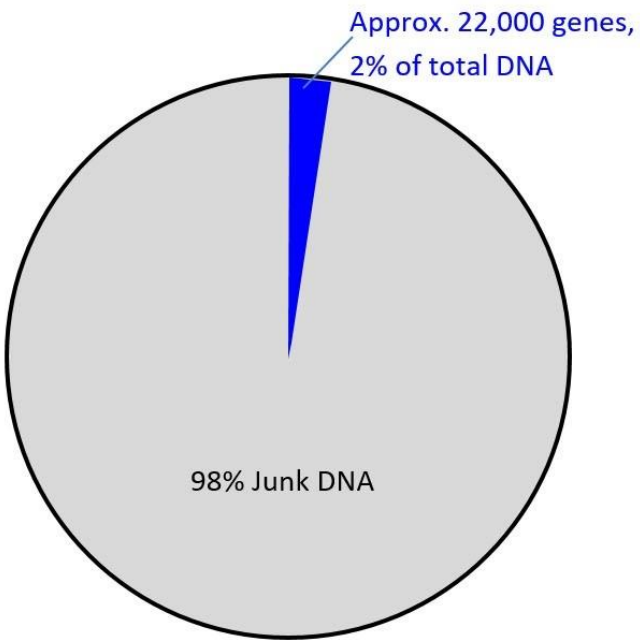
# 4) Similarities in DNA Sequence

Number of differences out of 648 base pairs

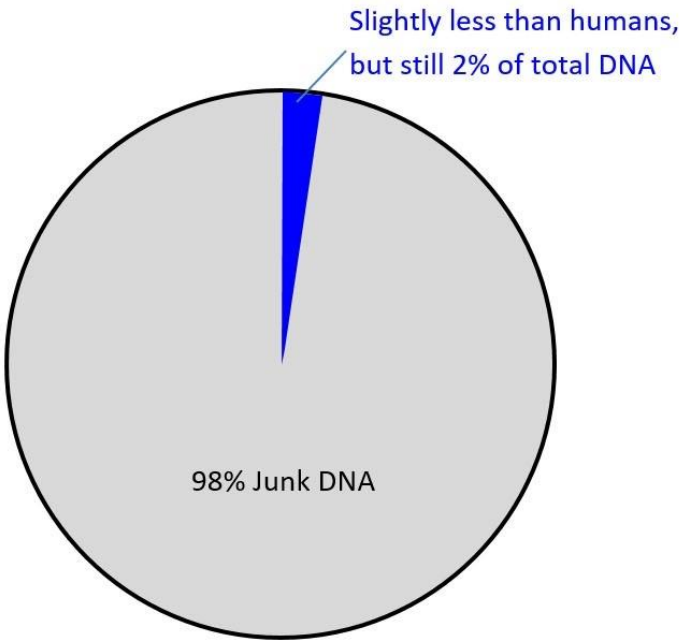


# Humans vs Chimps

**Human Genome**
(3 billion base-pairs)




**Chimpanzee Genome**
(2.8 billion base-pairs)



# Living proof of natural selection

- Antibiotics → Antibiotic resistance in bacteria

- Pesticides → Pesticide resistance in insects