

# Mendel, Darwin, and Biodiversity

# Diversity exists within species



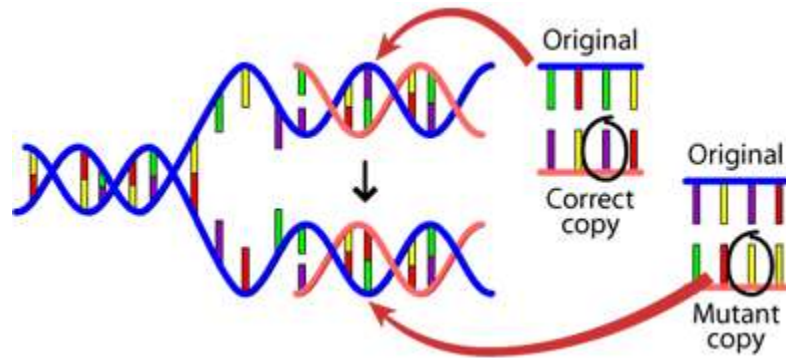
# Willie Shoemaker and Wilt Chamberlain



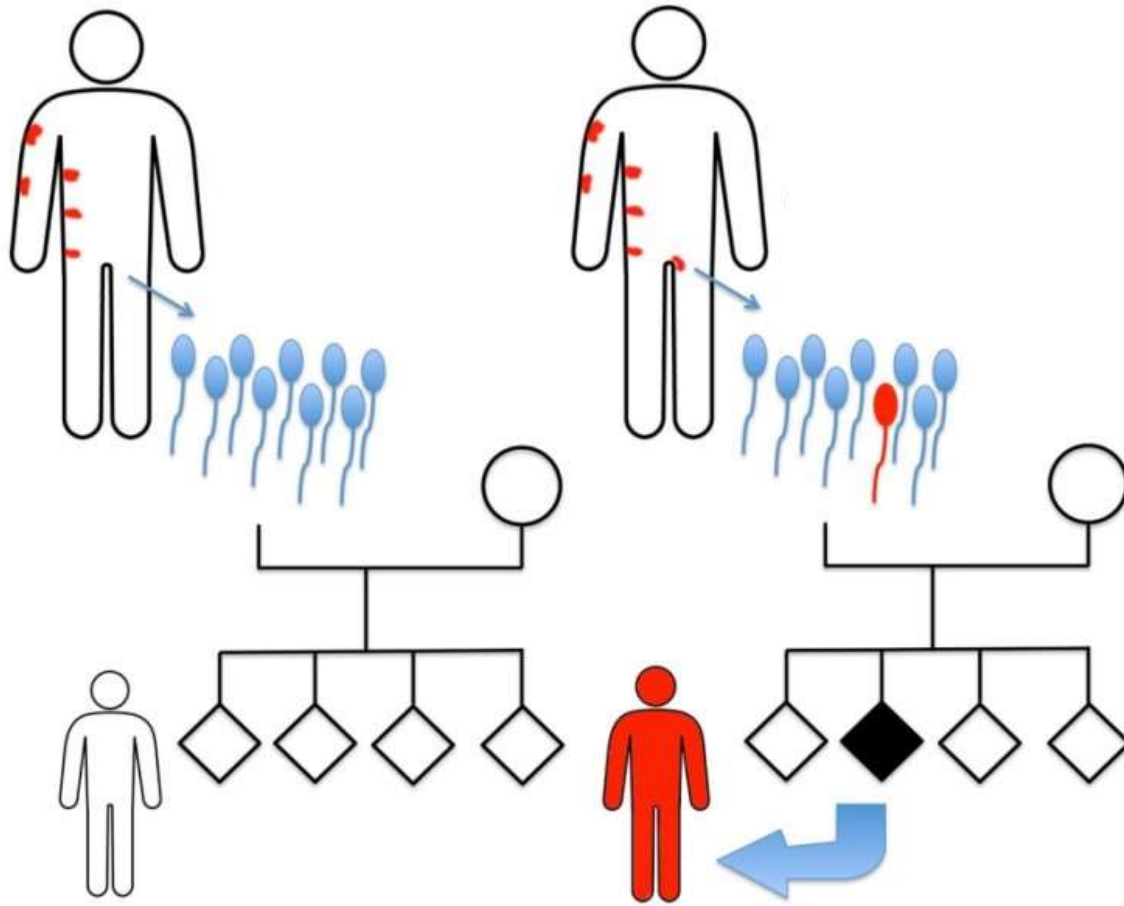
# Why?

- Sexual Reproduction and mutations → variations

# Mutations = changes in DNA



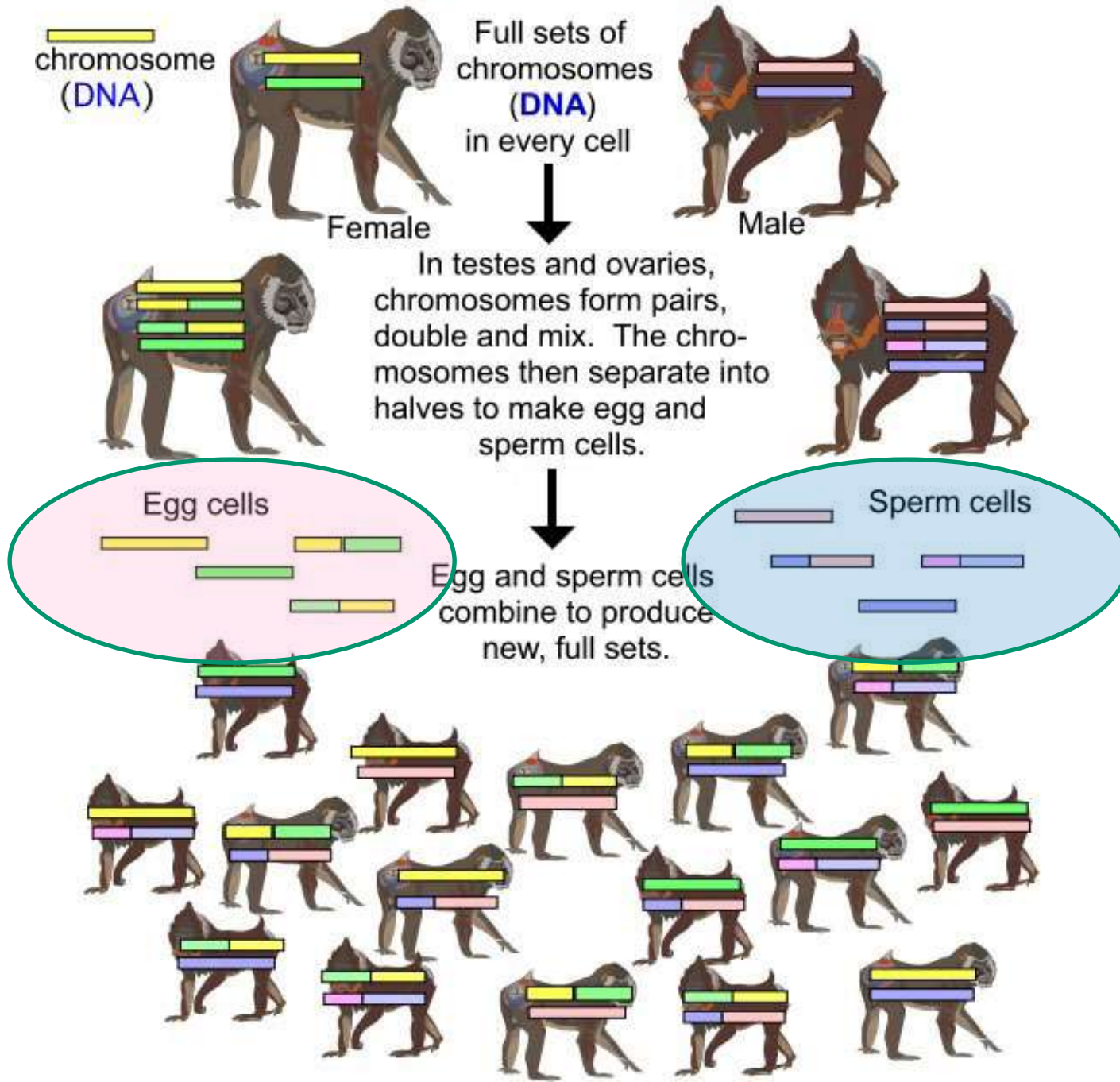
# Mutations in gametes can be inherited



Sexual reproduction → new  
combinations of genes



# Sexual Reproduction: Mixing DNA





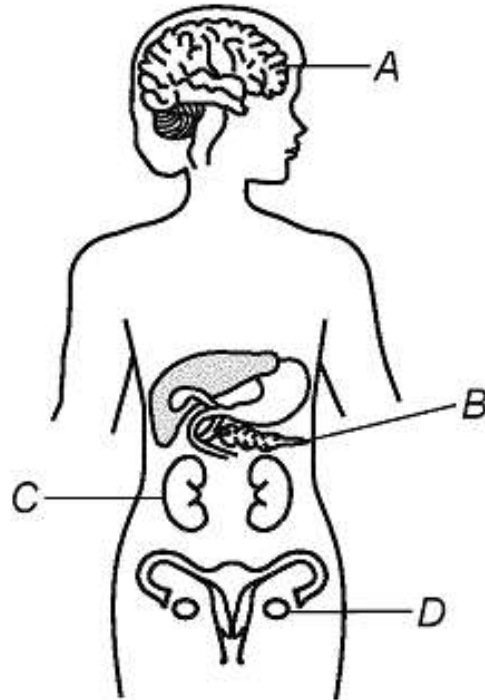
# Review Sexual Reproduction

- 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

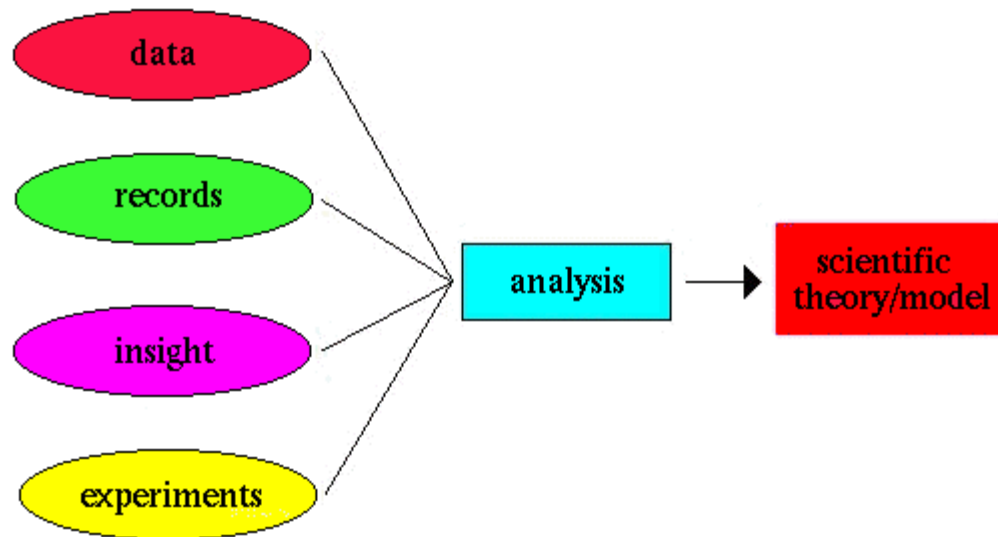
- a) His skin cells only
- b) His male and female children
- c) His male children only
- d) All the cells in his body

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

# Scientists Study Rock Layers

So, to help us comprehend the full expanse of time, scientists have turned to the rocks.





Earth estimated to be ~  
4.54 billion years old



The image shows a close-up of several fossilized trilobites embedded in a light-colored, textured rock matrix. The trilobites are dark brown and show their characteristic three-lobed body structure: a large cephalon (head) with eyes, a segmented thorax, and a pygidium (tail). The fossils are well-preserved, showing the fine details of their exoskeletons. One trilobite is particularly prominent in the center, facing right, with its segmented body clearly visible. Other trilobites are scattered around it, some partially obscured or in different orientations. The rock surface has some natural cracks and variations in color, providing a natural frame for the fossils.

**Fossils = remains of  
ancient organisms**

# Geologic time is described in

- Eons
- Eras
- Period
- Epoch
- Ages

Eon	Era	Period	Epoch	m.y.	
Phanerozoic	Cenozoic	Quaternary	Holocene	1.5	
			Pleistocene		
		Neogene	Pliocene		
			Miocene		
		Paleogene	Oligocene		23
			Eocene		
	Paleocene				
	Mesozoic	Cretaceous	65		
		Jurassic			
		Triassic			
	Paleozoic	Permian	250		
		Carboniferous		Pennsylvanian	
				Mississippian	
		Devonian			
		Silurian			
		Ordovician			
		Cambrian			
		Precambrian		Proterozoic	
	Archean		2500		
Hadean			3800		
				4600	

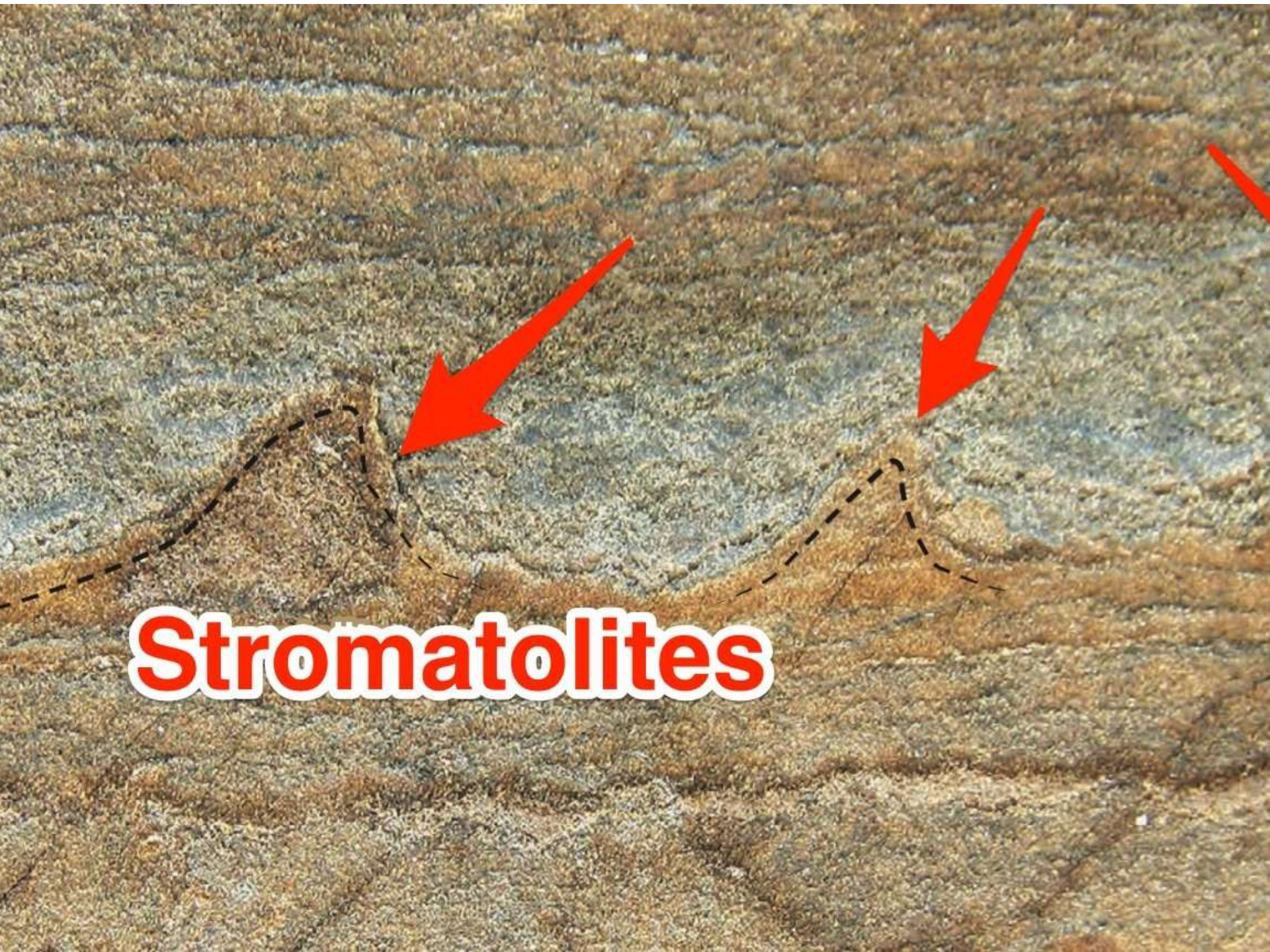




# ARCHEAN EON

3.9 - 2.5BYA





**Stromatolites**





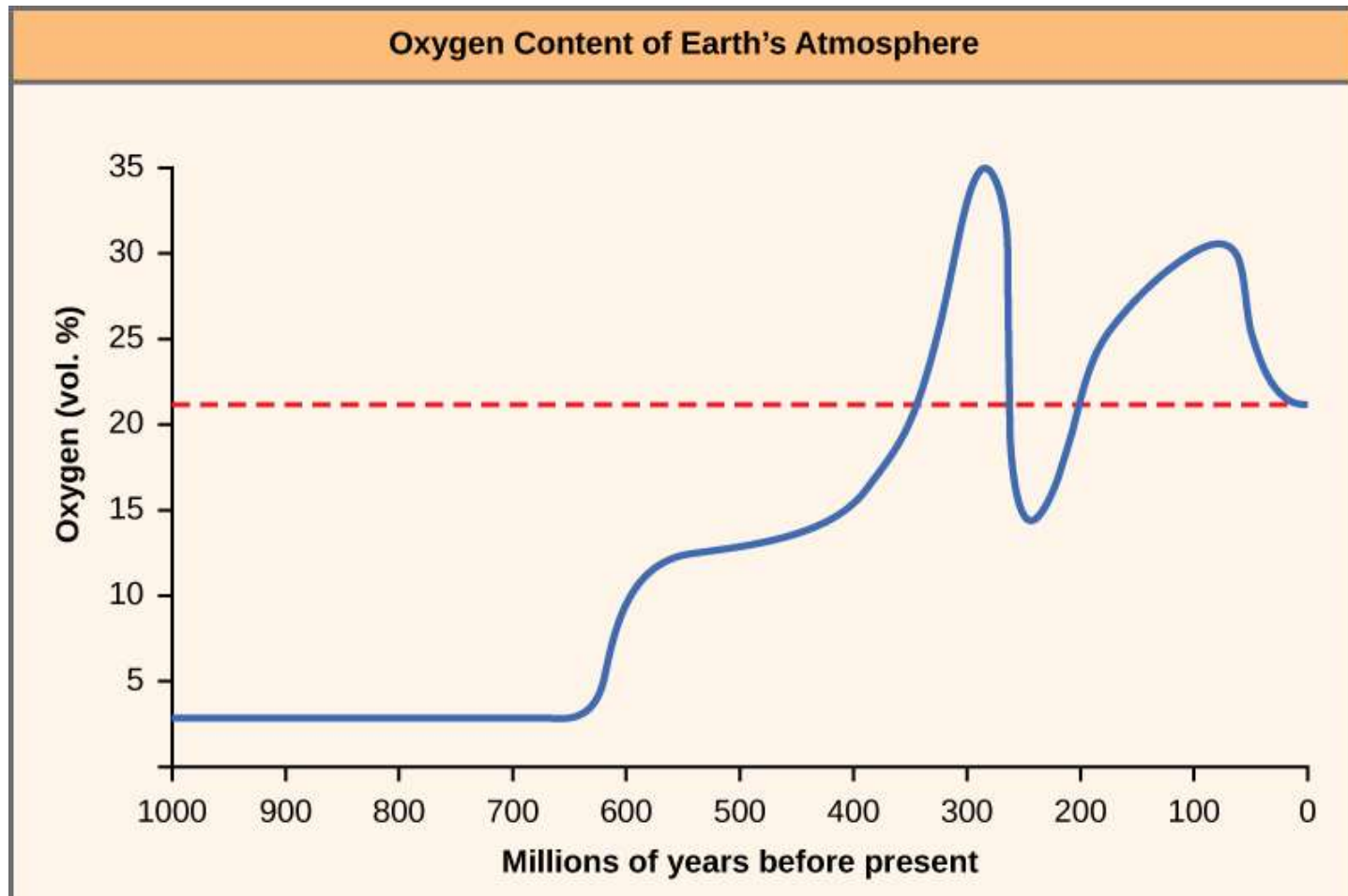
# PROTEROZOIC EON

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



The image shows two fossilized trilobites preserved in a light-colored, textured rock matrix. The trilobite at the top is smaller and more complete, showing its head, thorax, and pygidium. The trilobite at the bottom is larger and more fragmented, with its head and thorax clearly visible. The fossils are brownish-tan in color, contrasting with the greyish rock.

# Explosion of life

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



# The Great Dying







A vibrant, prehistoric landscape under a bright blue sky with scattered white clouds. In the foreground, a large, dark brown crocodile with a long, thin tail is shown in profile, its mouth wide open as if drinking from a stream. To its right, a green lizard is visible. In the background, a brown dinosaur is seen walking through a dense forest of tall, green trees. The overall scene is a rich, detailed depiction of a Mesozoic environment.

**Mesozoic = Age of Reptiles**

# CRETACEOUS- PALEOGENE EXTINCTION EVENT









# 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





# 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?

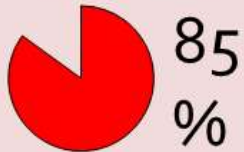
- Animals go extinct
- There have been 5 mass extinctions
  - (over half of the species on the planet went extinct)
- Dominant organisms on the planet have changed.

# MASS EXTINCTIONS:

The biggest disasters in history

## ORDOVICIAN

Death Rate:



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:



Time: 340 million years ago

Likely Causes:

- Asteroid impact(s)
- Rapid global cooling

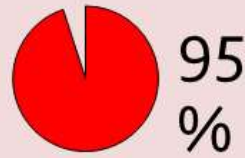
Results:

- Local destruction from debris
- Ocean life affected by temperature



## PERMIAN

Death Rate:



Time: 250 million years ago

Likely Causes:

- Volcanic activity
- Increase in Methane and CO<sub>2</sub>
- Rapid global warming

Results:

- Oxygen removed from oceans
- Desertification of land



## TRIASSIC

Death Rate:



Time: 200 million years ago

Likely Causes:

- Increase in Methane and CO<sub>2</sub>
- Rapid global warming

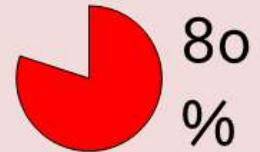
Results:

- Desertification of land
- Frequent heat waves



## K-T

Death Rate:



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"





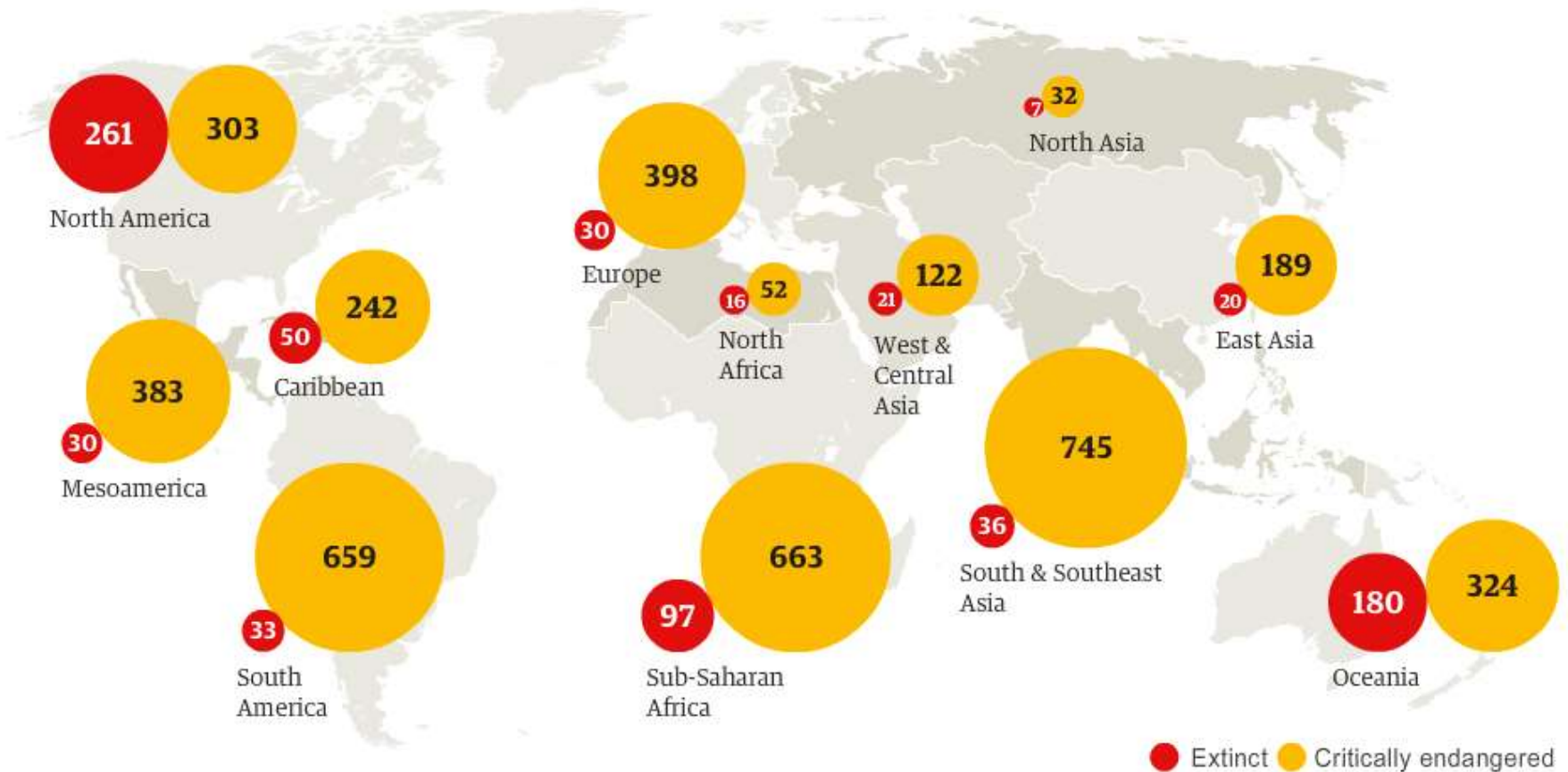
IUCN, International Union for Conservation of Nature



# Extinctions and critically endangered species in numbers

Click on the circles to see more information

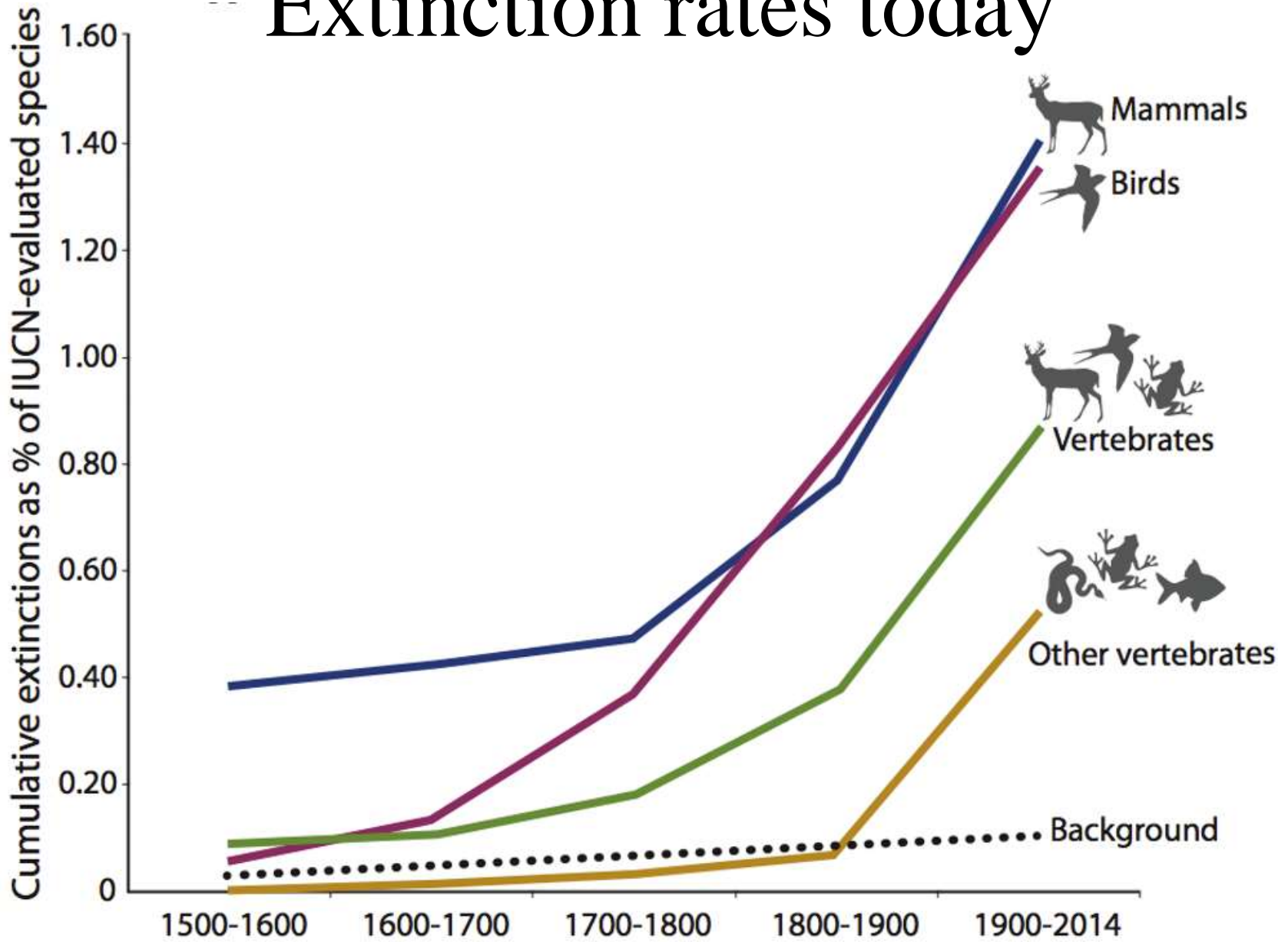
  Extinct species » 
   Critically endangered species » 
   In numbers »



SOURCE: IUCN RED LIST

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

# Extinction rates today



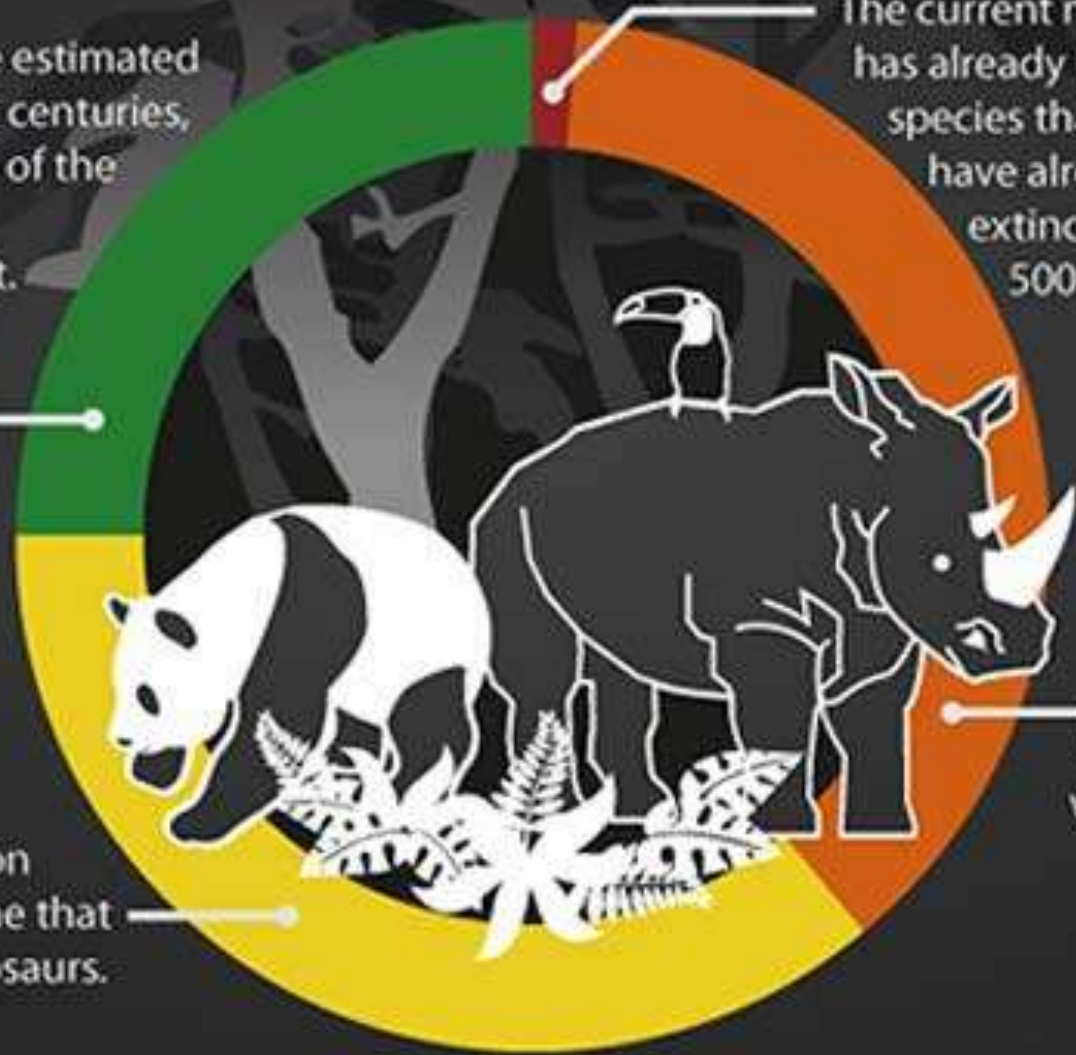
# WE ARE IN THE MIDST OF A 6<sup>TH</sup> MASS EXTINCTION

**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.

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

Almost 20,000 more species are threatened with extinction.



# IUCN Red List

© Zanoni Luca - Storie di Natura

IUCN, International Union for Conservation of Nature



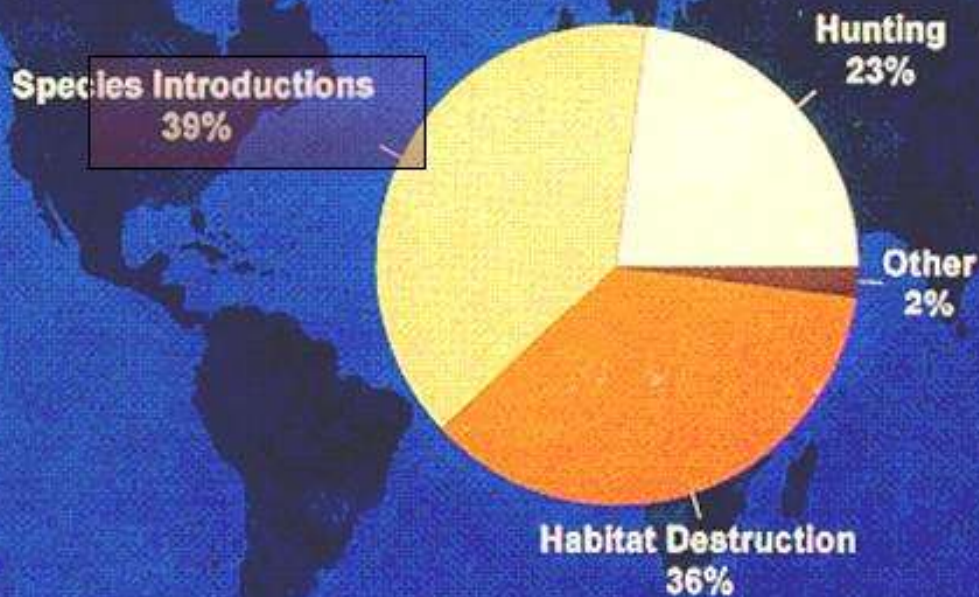
# Direct causes of extinctions today

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

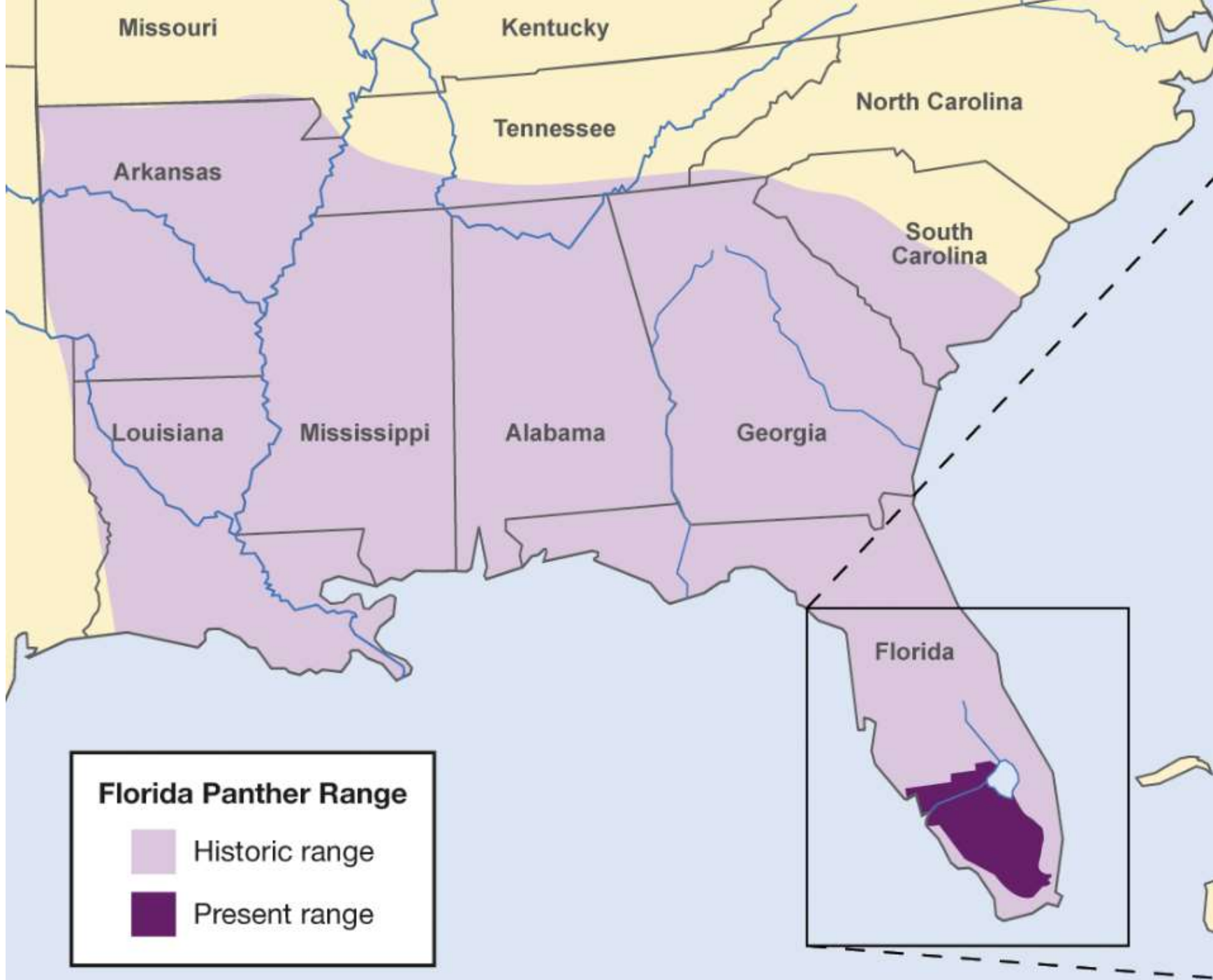


## Florida Panther Case Study:

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

Inbreeding →  
undescended  
testicles, kinked  
tails, and heart  
defects





# Conservation History

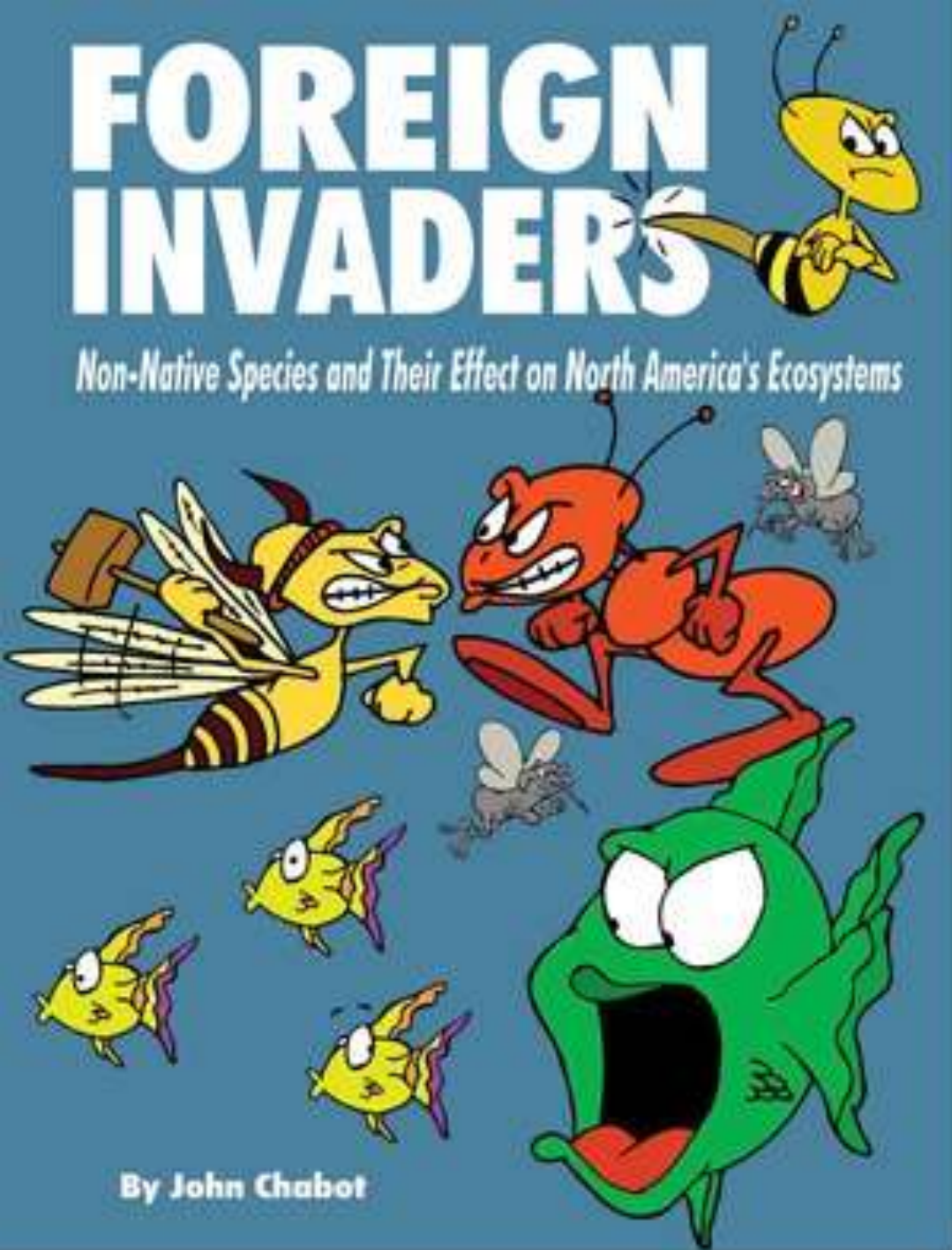
- 1970s and 80s only 20 – 30 left
- Introduced 8 female pumas from Texas
- Rebounded → 120 – 230 Hybrid panthers today





# FOREIGN INVADERS

*Non-Native Species and Their Effect on North America's Ecosystems*



#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](http://fisc.er.usgs.gov/Tracking_Invaders/in_depth/zebra_mussel.jpg)

- Asian Longhorned Beetles  
threaten trees



<http://www.dec.state.ny.us/website/dif/privland/forprot/health/alb.html> 008.0345056

- 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



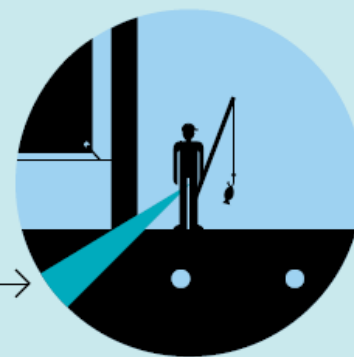
# Case Study: Passenger Pigeon

- 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

There are more and bigger fishing vessels than ever before



The biggest vessels catch  
**65%**  
of all fish,  
but only employ  
**4%**  
of fishers

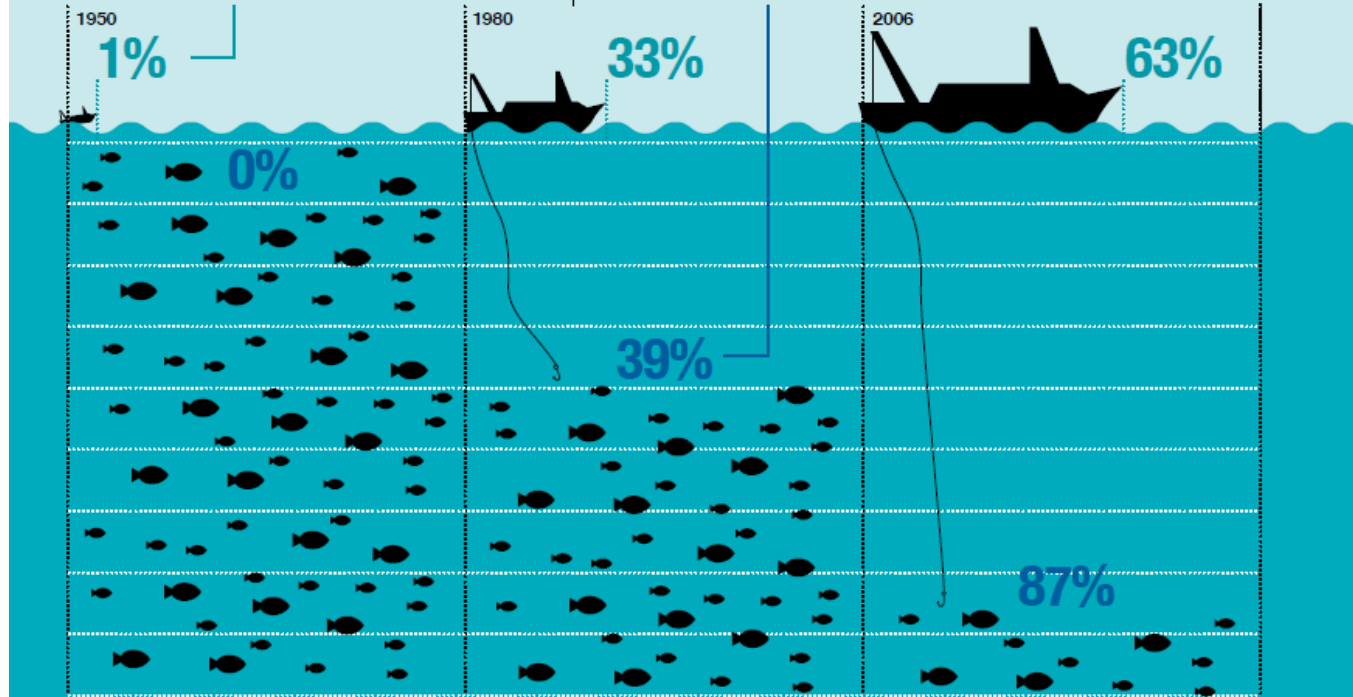


But productivity – the amount of fish they catch per ship – has never been lower

## There are fewer fish in the sea than ever before

Percentage of high seas fished in each year

Percentage of species exploited, overexploited or collapsed



<sup>o</sup> 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 = Climate Change and Pollution

- Pollution (air, water, etc.)
  - Insecticides (DDT, biomagnification)
  - Endocrine disruptors (PCB's, dioxins, BPA)
  - Oil spills and plastics in the ocean

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...

# Charles Darwin and the Theory of Evolution





# Key terms for this unit

- Darwin, evolution
- Variation, fossil record
- Survival of the fittest, competition
- Best adapted,
- natural selection, selective breeding

**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*)

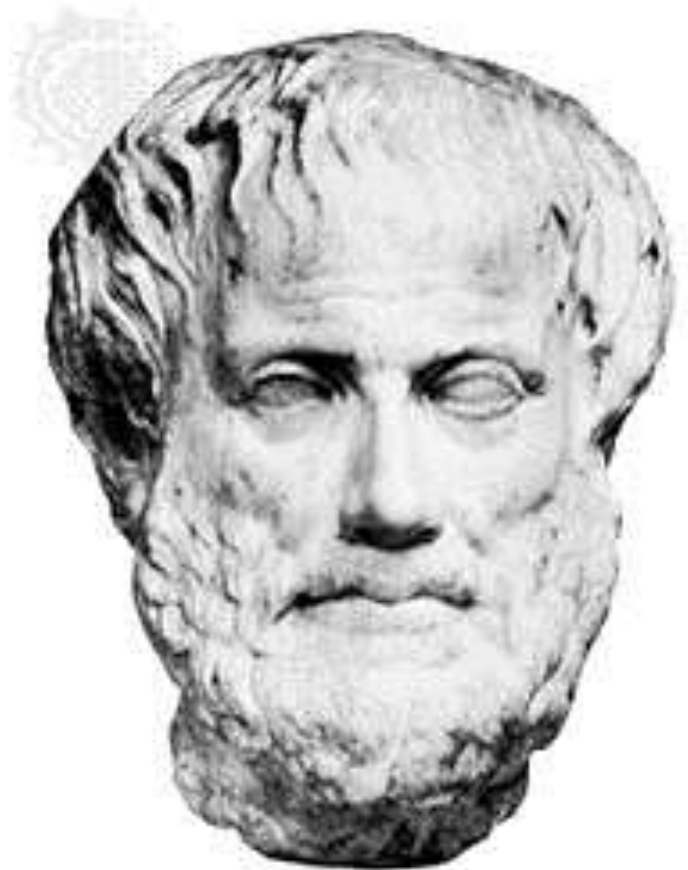
- Explains why overuse of antibiotics has led to new antibiotic resistant strains of bacteria
- Explains why spraying with pesticides results in pesticide resistant pest populations



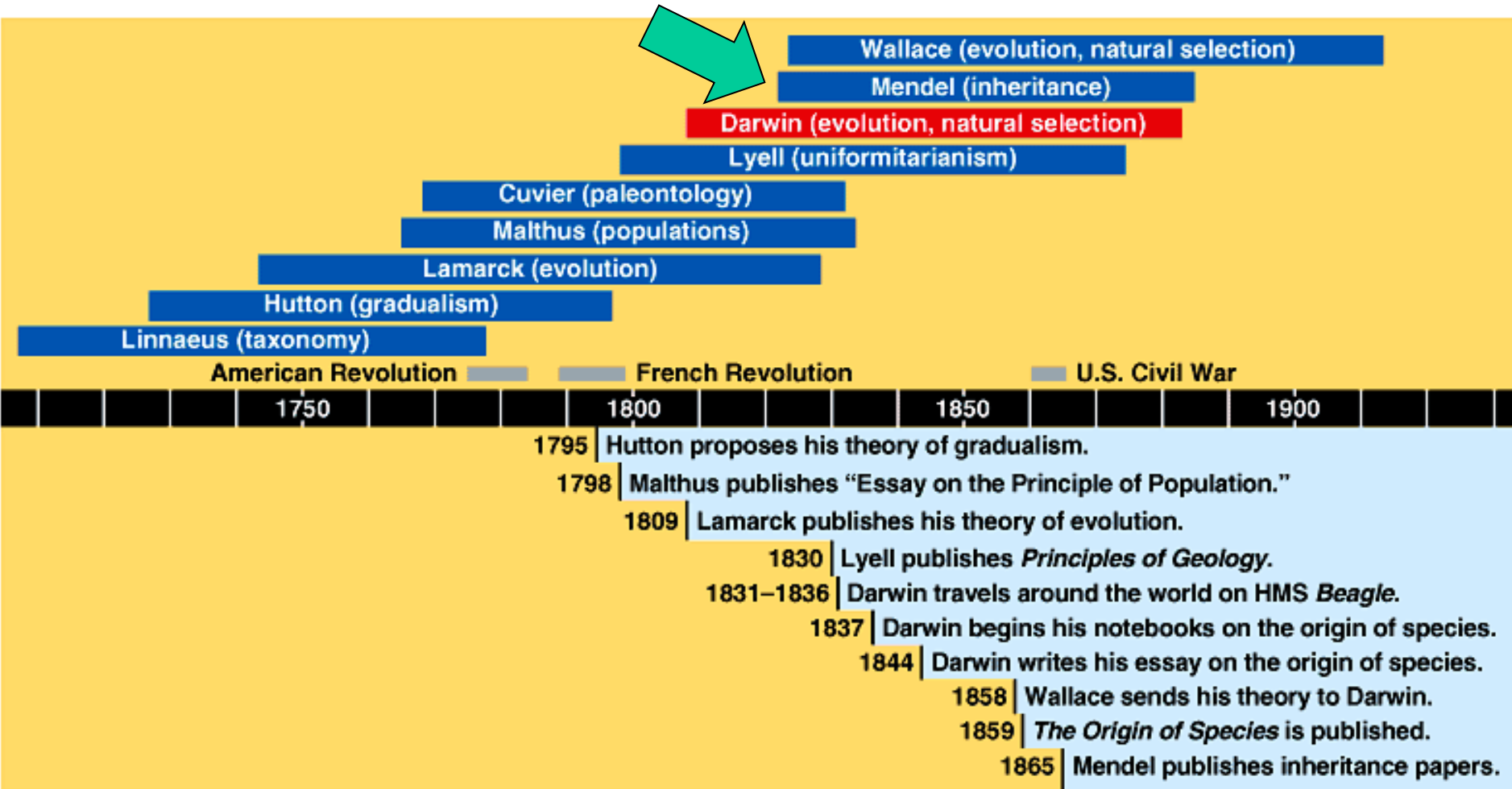
# History of Evolutionary Thought

# 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



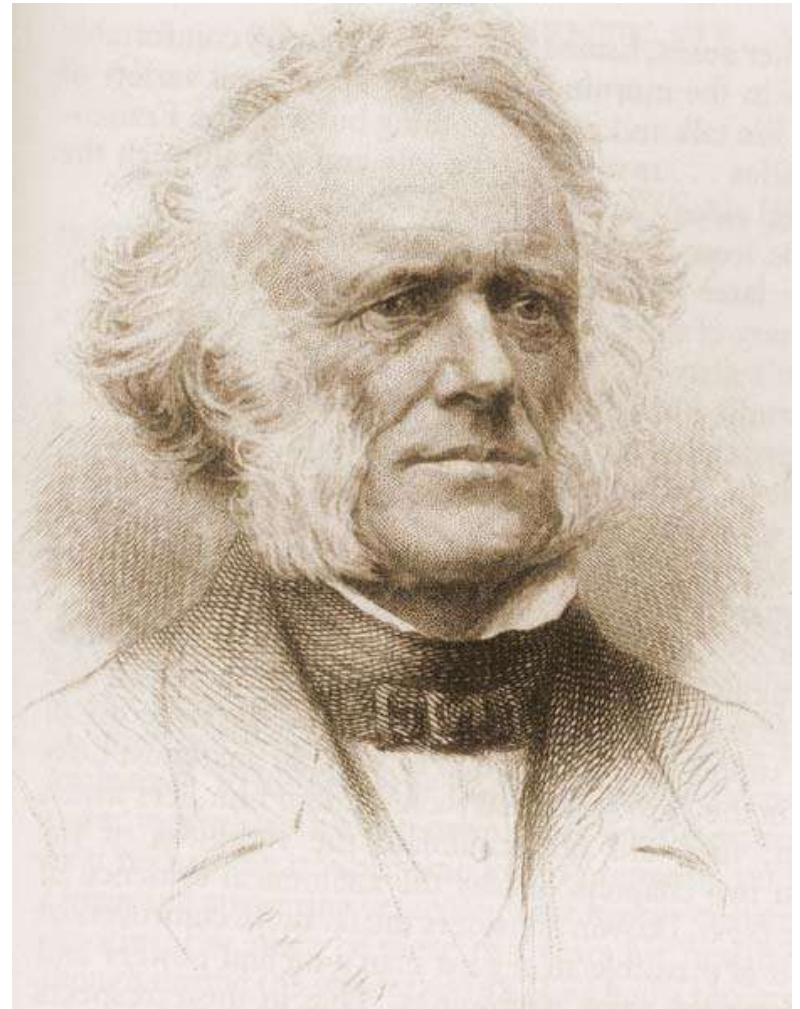
# **Contributor's to Darwin's thinking included:**

- 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



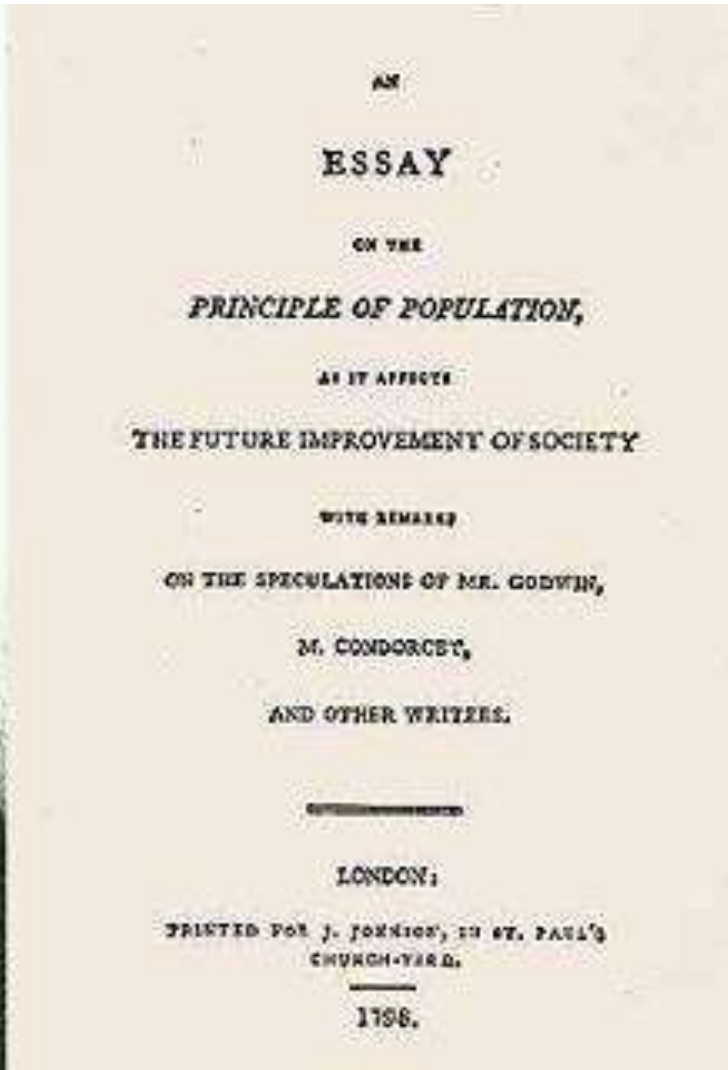
# Fossil Record

- Fossil record → proof of mass extinctions
- Cuvier stated that species disappear due to a catastrophic event of the earth's crust (volcanoes, climate changes...)

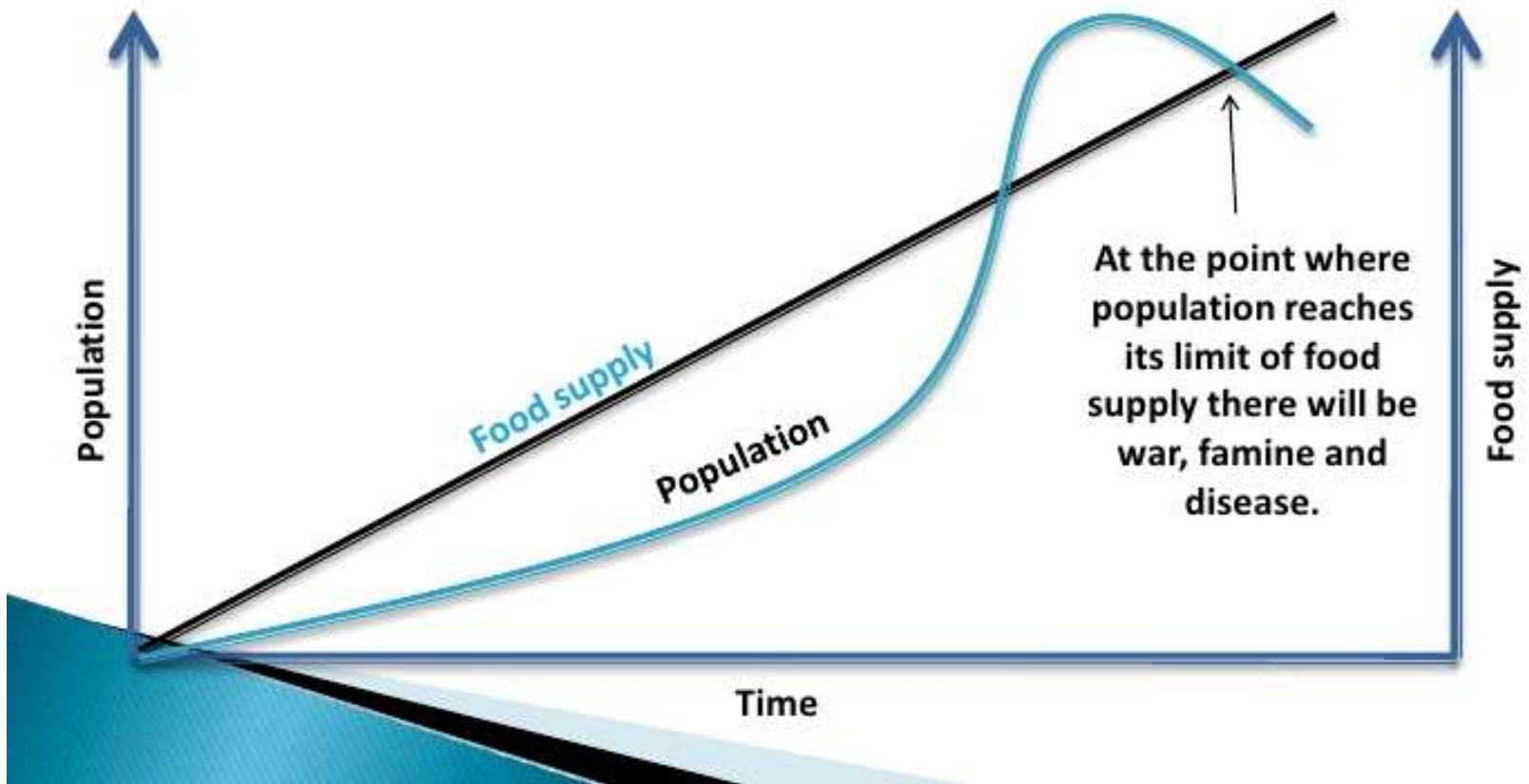


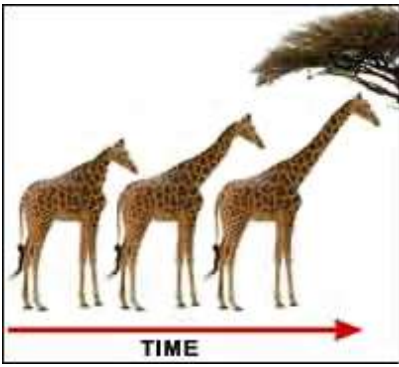
# Thomas Malthus theory

Struggle for existence → population crashes



# 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



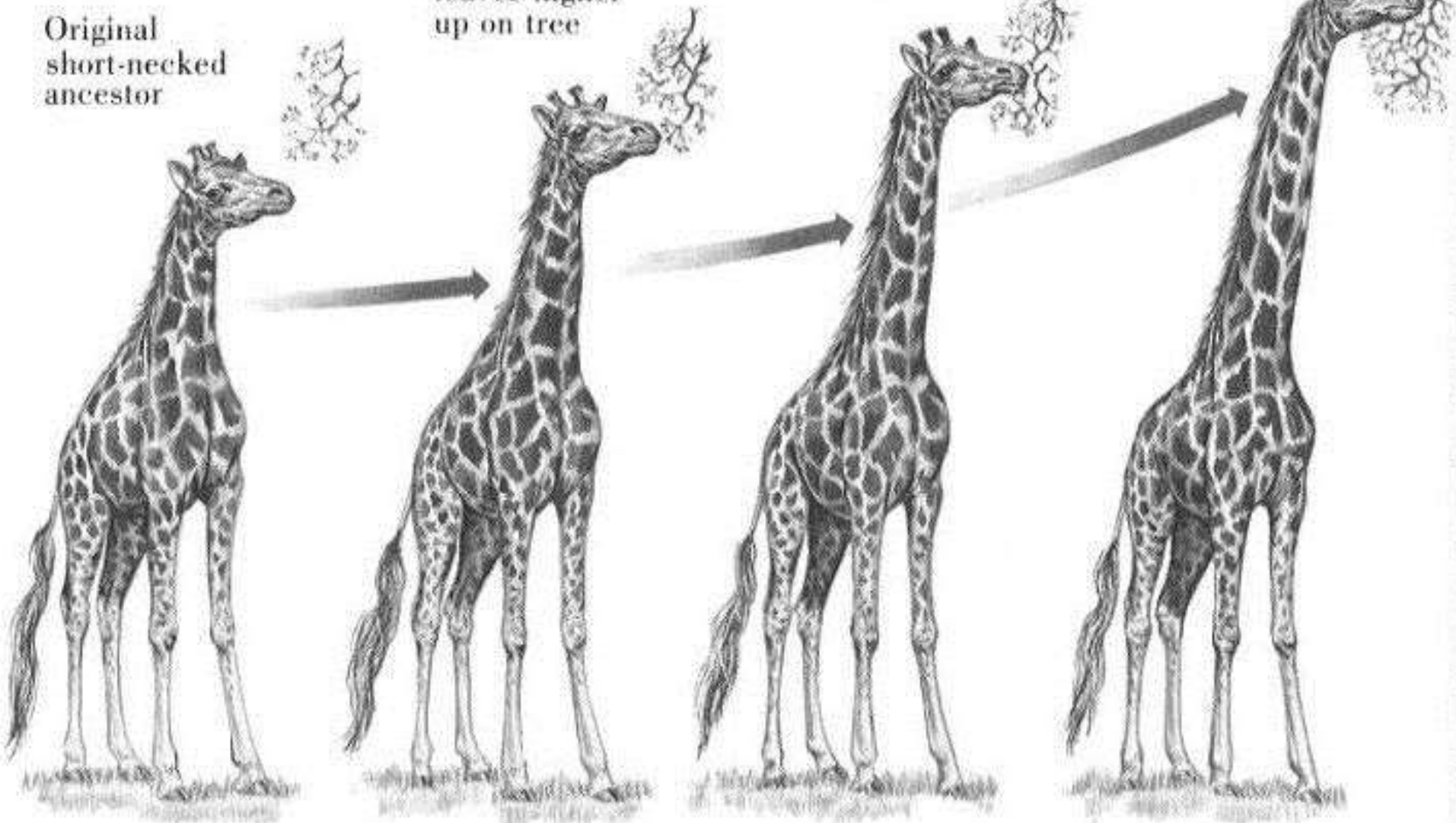
# LAMARCK'S GIRAFFE

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

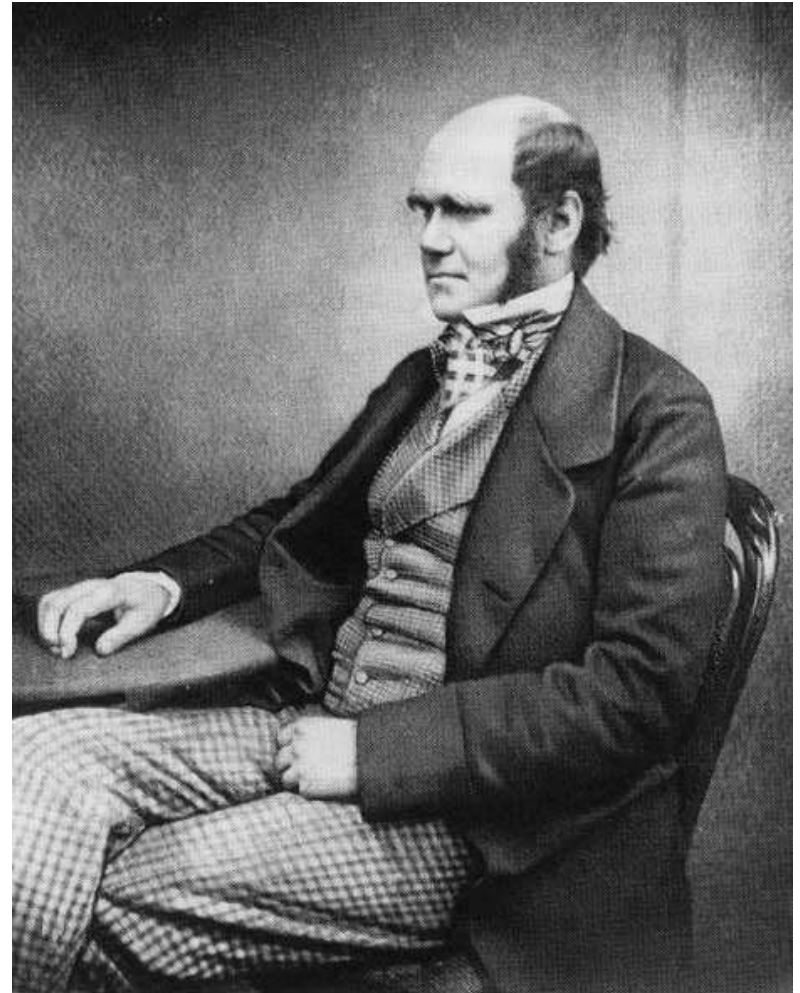


**A reconstruction of the HMS Beagle sailing off Patagonia.**

# 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

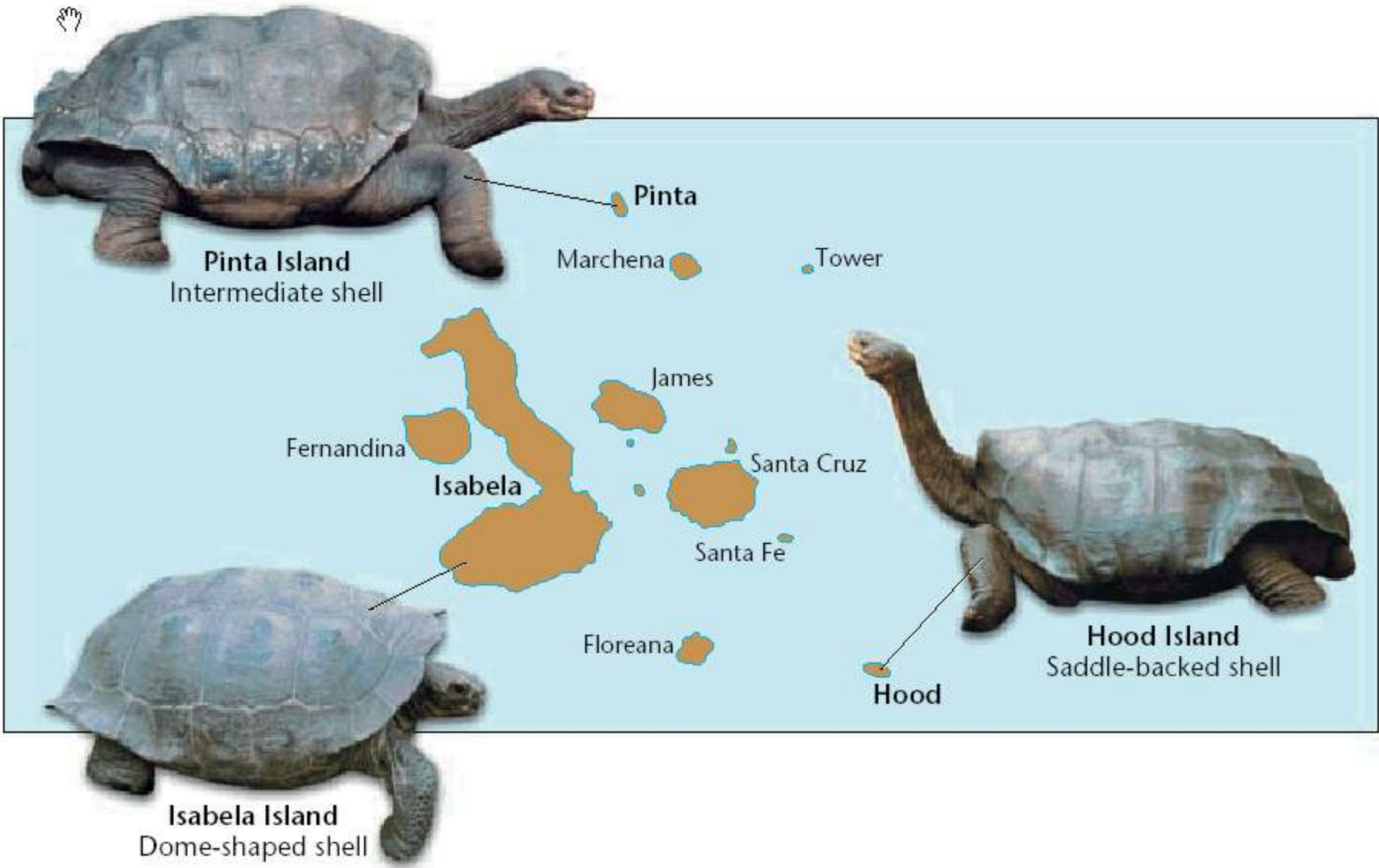


**Darwin returned 5 years later in 1836**

# 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











© D.Cavagnaro/DRK Photo • © M.Cavagnaro/DRK Photo



## Galápagos Islands Finches

<b>Shape of Head and Beak</b>						
<b>Name</b>	Vegetarian tree finch	Large insectivorous tree finch	Woodpecker finch	Cactus ground finch	Sharp-beaked ground finch	Large ground finch
<b>Main Food</b>	Fruit	Insects	Insects	Cactus	Seeds	Seeds
<b>Feeding Adaptation</b>	Parrotlike beak	Grasping beak	Uses cactus spines	Large crushing beak	Pointed crushing beak	Large crushing beak
<b>Habitat</b>	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) All species are capable of producing more offspring than the environment can support

Left unchecked, organisms can overproduce because they reproduce exponentially

1-2-4-8-16-32...



**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

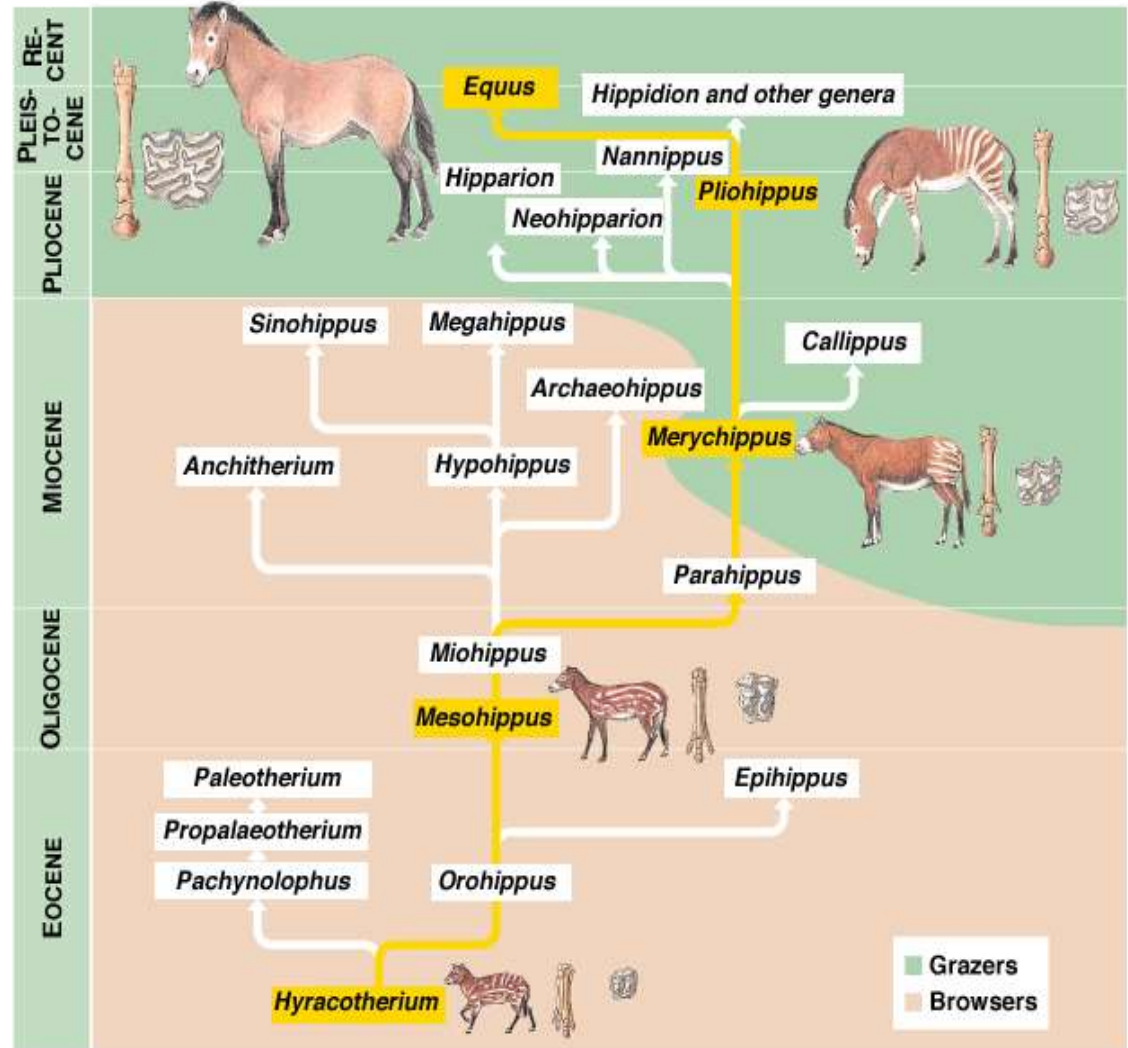
- Resources are limited → competition and struggle for existence
- Survival of the Fittest = Only the best adapted survive and reproduce each generation



# 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!!!



Organisms  
don't adapt (not in an  
evolutionary sense);  
Organisms HAVE  
adaptations.

# 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



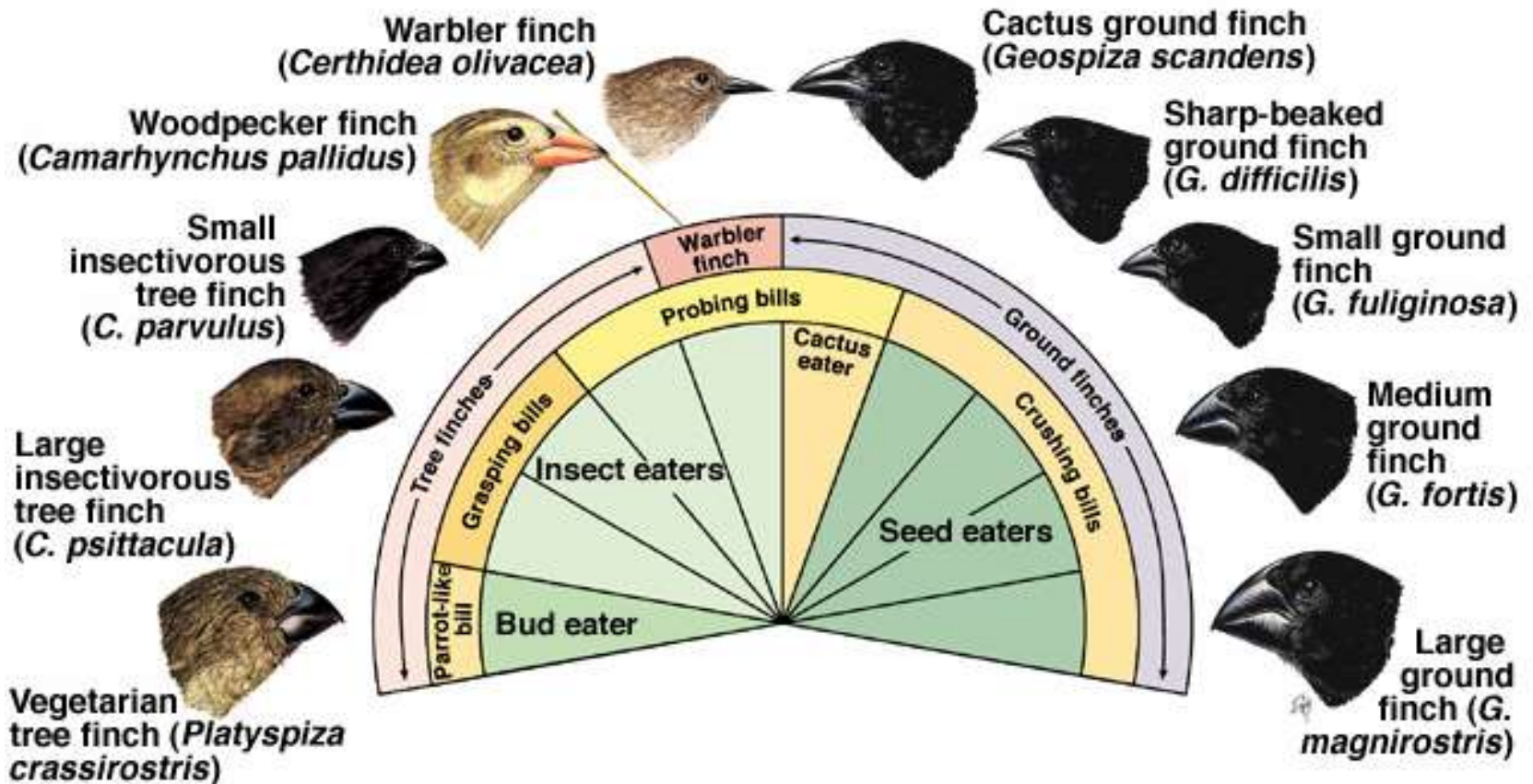
# Practice Evolution Questions

**Darwin's book  
“Origin of Species”**

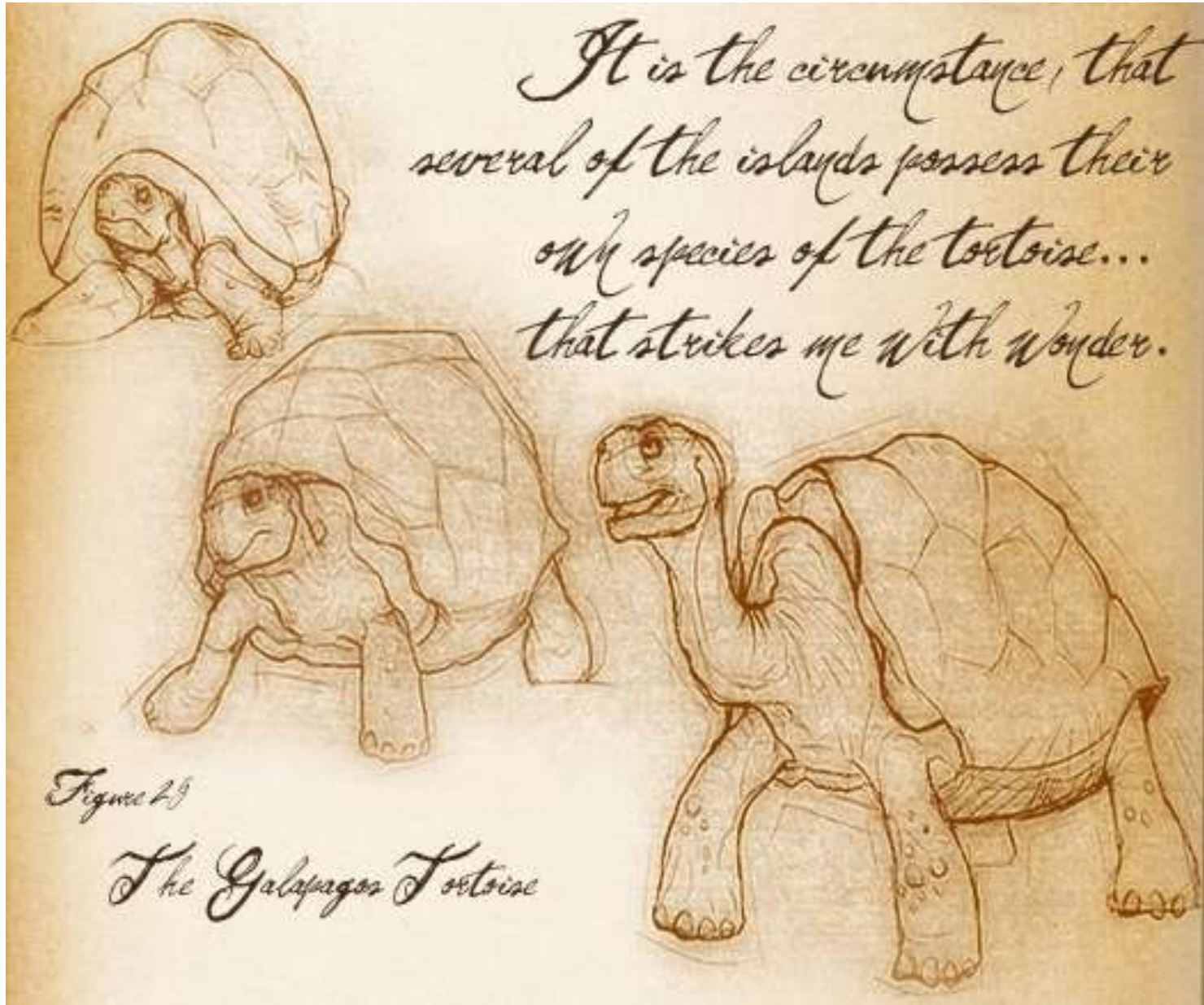
Darwin's theory of evolution =  
3 key ideas

# 1) Different environments → increase different traits

- Ex: Finch beaks determined by type of food

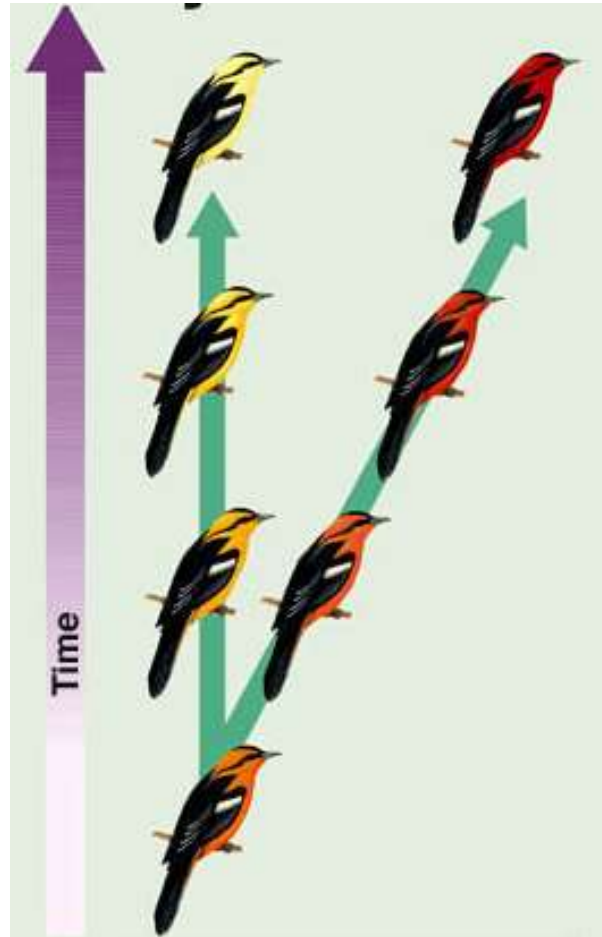


## 2) Speciation = new species evolve in different environments

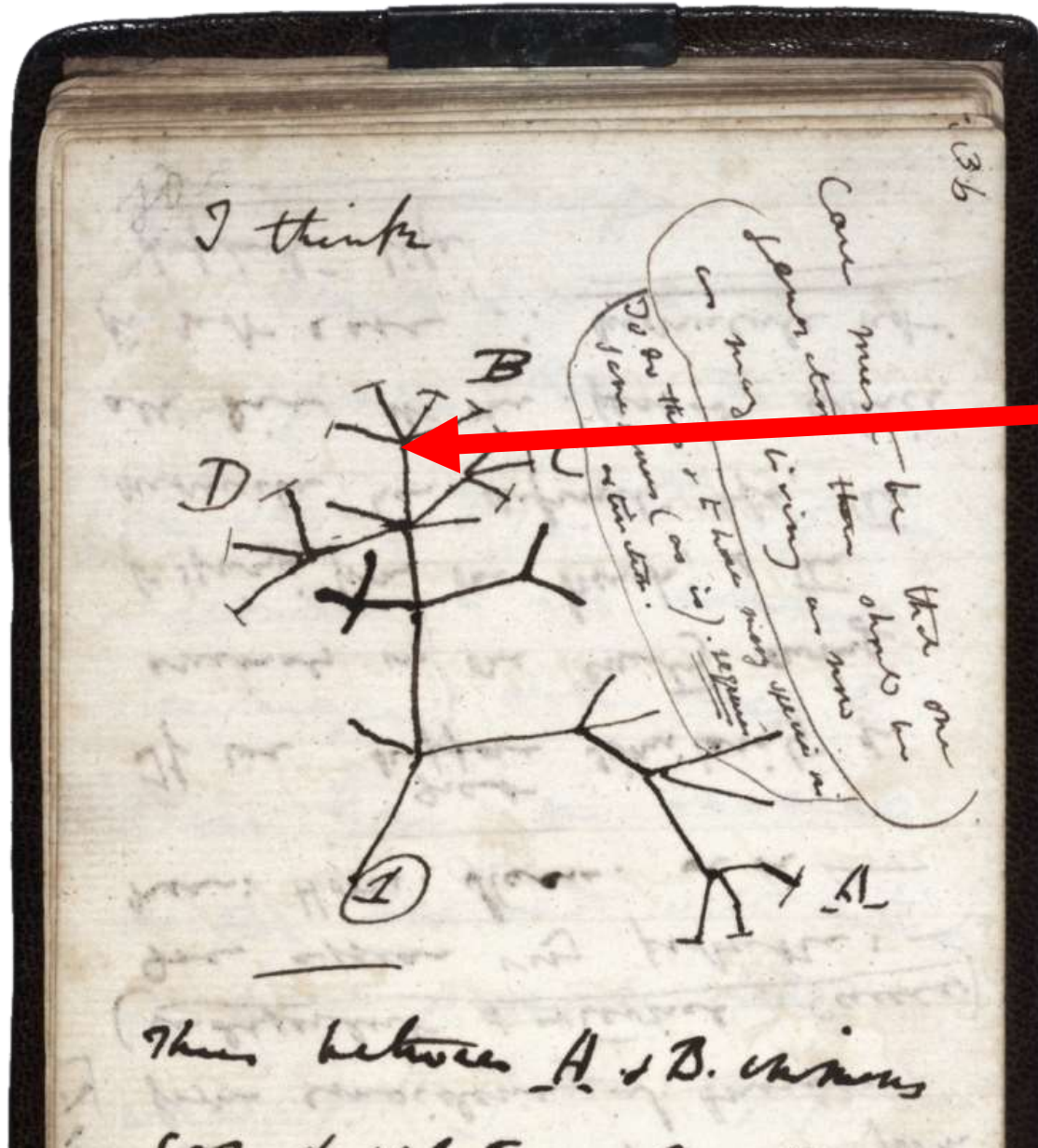




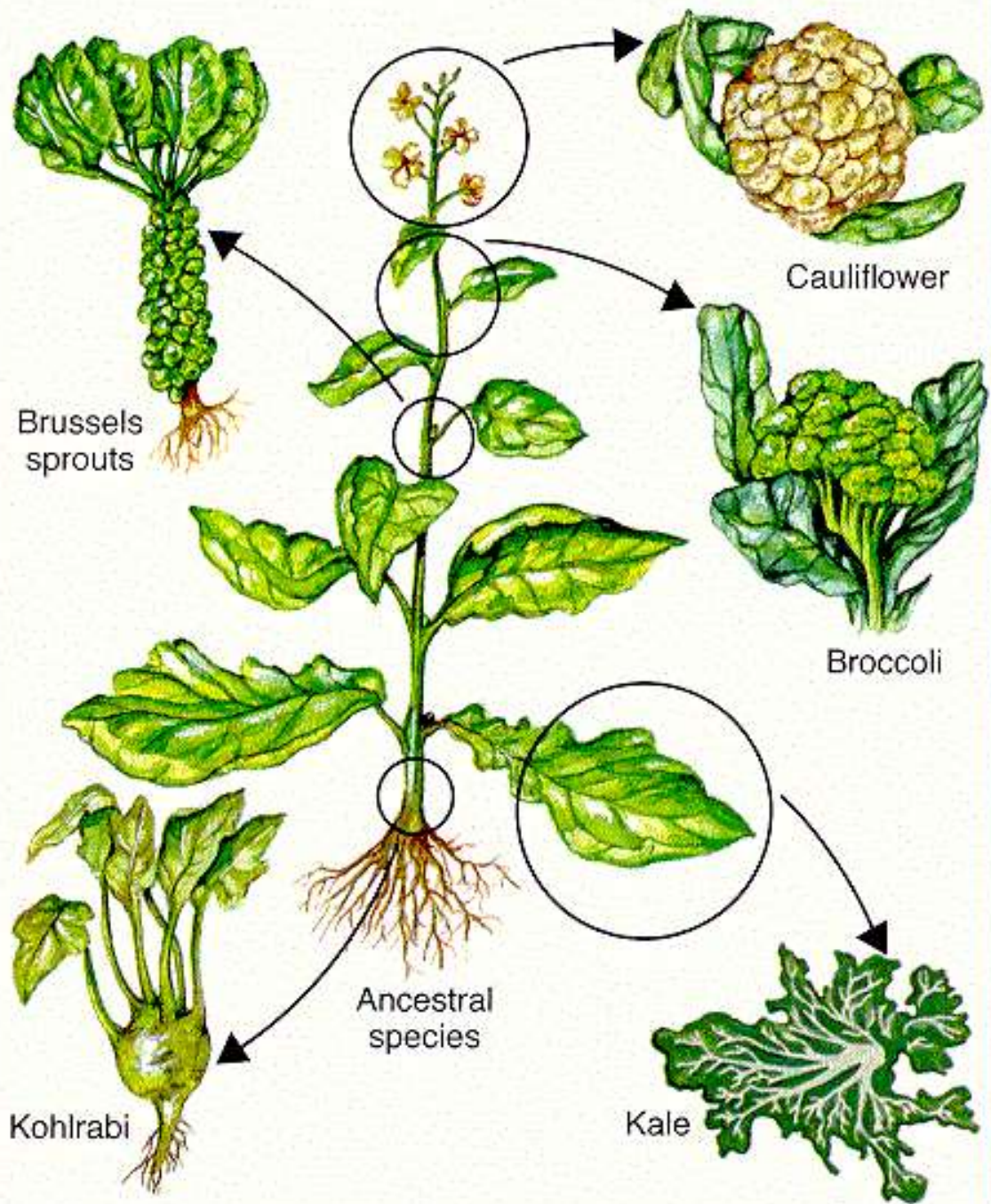
# Change in the environment → evolution of new species



### 3) All organisms share common ancestors



Common ancestor



# 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 →
- increase in traits → survival

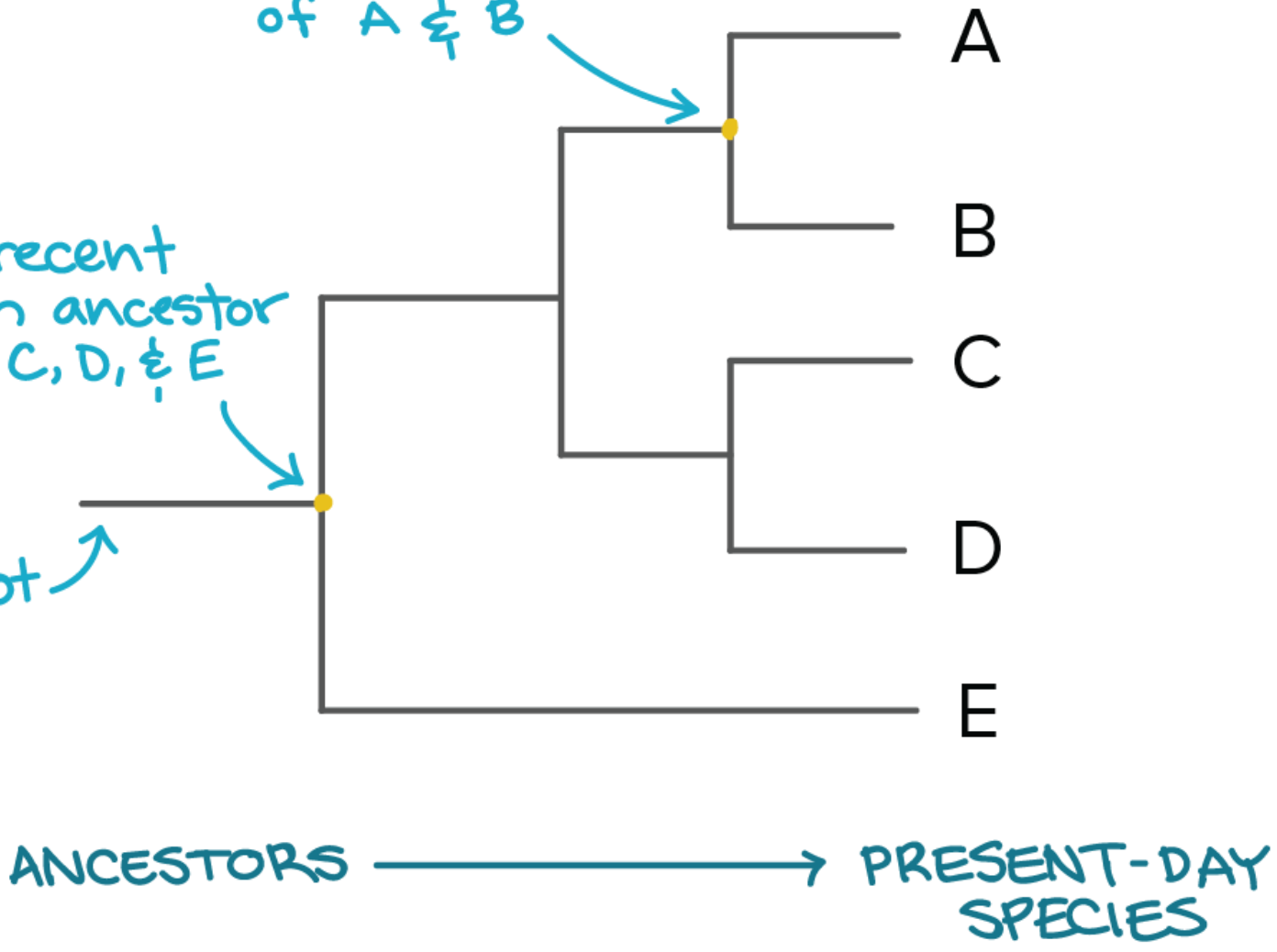


Evolutionary trees →  
relationships between species

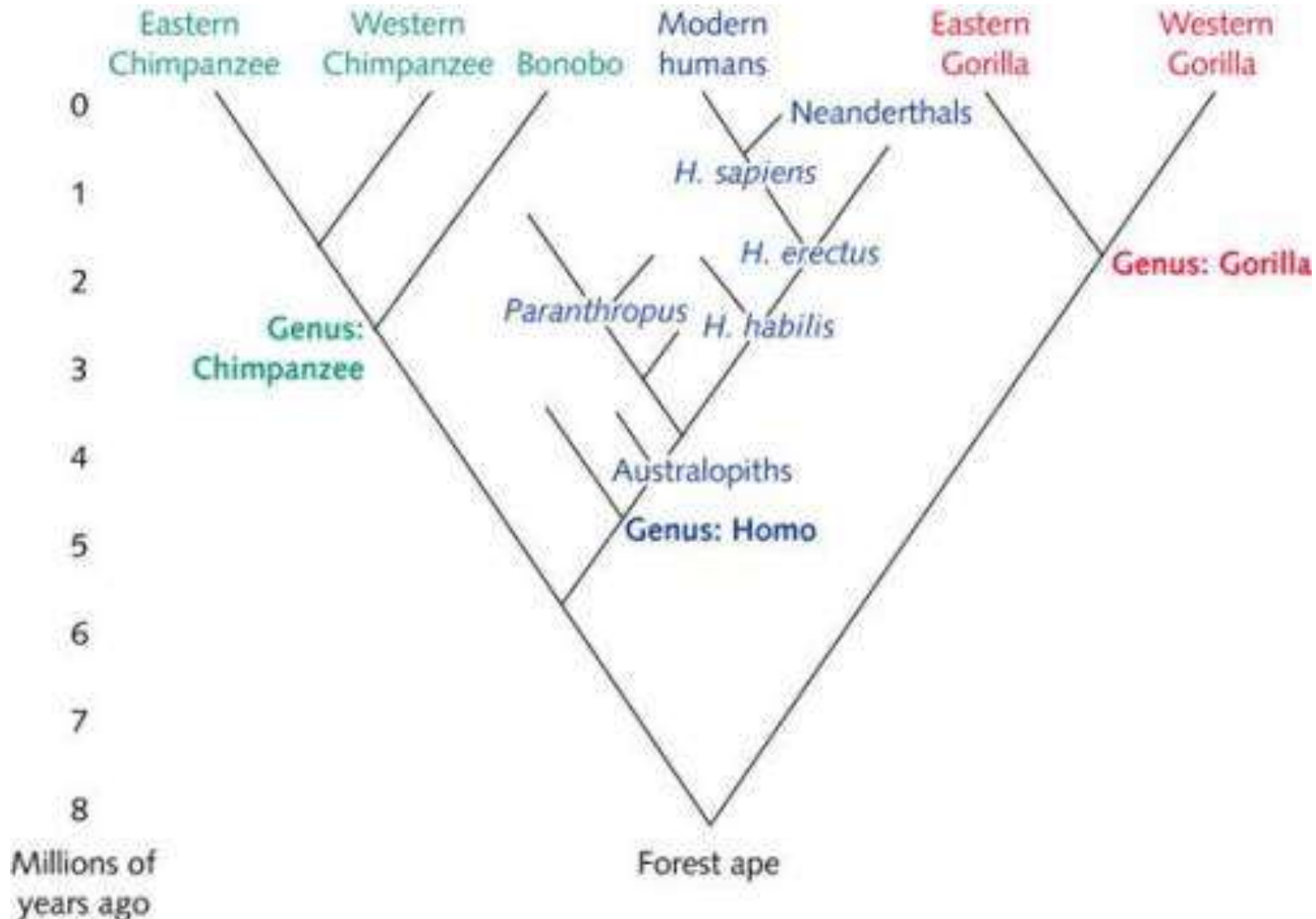
Most recent  
common ancestor  
of A & B

Most recent  
common ancestor  
of A, B, C, D, & E

Root



# Answer questions in notes



# Natural Selection

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

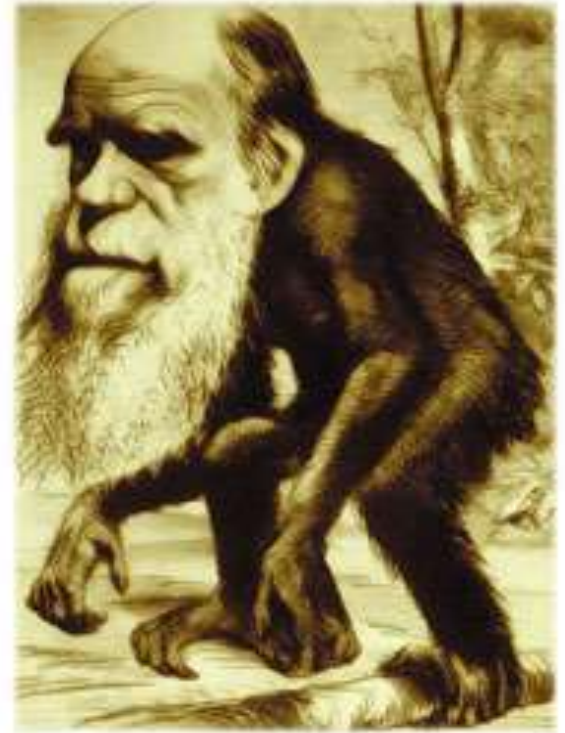
# **Publication of “On The Origin of Species”**

- **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**

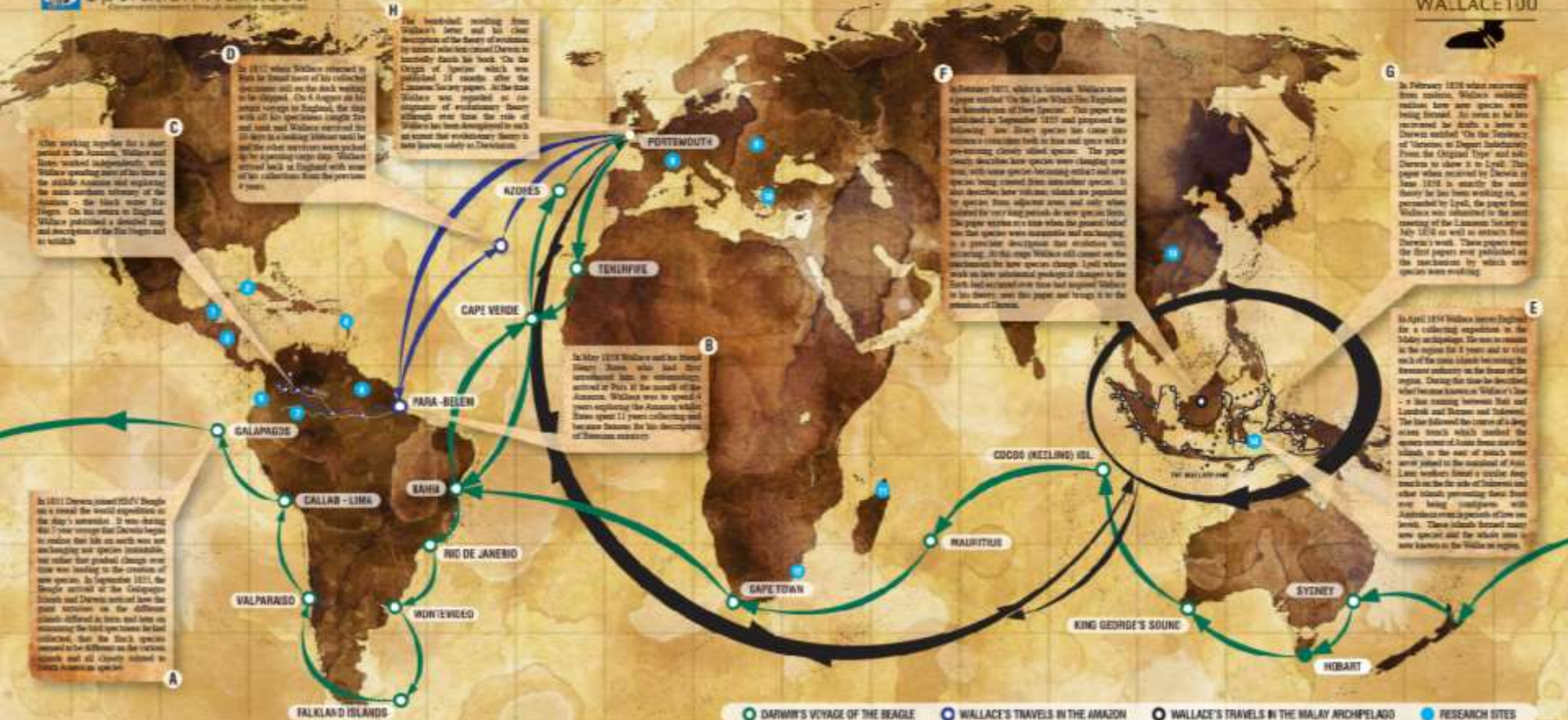


# Support for Darwin's claims

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



# WALLACE & DARWIN - VOYAGES TO EVOLUTION



○ DARWIN'S VOYAGE OF THE BEAGLE ○ WALLACE'S TRAVELS IN THE AMAZON ○ WALLACE'S TRAVELS IN THE MALAY ARCHipelAGO ● RESEARCH SITES



**Alfred Russel Wallace 1825 - 1913**  
 Alfred Russel Wallace was born in WA, Massachusetts to a middle class family who did not have financially. His early life was as a surveyor and a teacher but after leaving school, Wallace had ambitions for a career in collecting natural history specimens, the job paid for the Amazon, since he had the reputation for his "free" work. He was required to be a financial officer since much of Wallace's activities were for his own benefit. Wallace began to collect specimens and publish papers in the 1840s. He was required to be a financial officer since much of Wallace's activities were for his own benefit. Wallace began to collect specimens and publish papers in the 1840s. He was required to be a financial officer since much of Wallace's activities were for his own benefit.



**OPERATION WALLACEA**  
 Why not follow in the footsteps of these great Victorian explorers, collectors 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.wallacea.com](http://www.wallacea.com)) is running biodiversity research programmes that are available to high school groups with teachers in attendance at the following sites:

- Wallace - Mazon Forest** and **Castellon de la Plana** - Collect and record birds, insects, plants, and other organisms. Conduct field research in the Mazon Forest and Castellon de la Plana.
- Laiba** - Collect and record birds, insects, plants, and other organisms. Conduct field research in the Laiba area.
- Sumatra** - Collect and record birds, insects, plants, and other organisms. Conduct field research in Sumatra.
- Malagasy** - Collect and record birds, insects, plants, and other organisms. Conduct field research in Malagasy.
- South Africa** - Collect and record birds, insects, plants, and other organisms. Conduct field research in South Africa.
- China** - Collect and record birds, insects, plants, and other organisms. Conduct field research in China.
- Indonesia** - Collect and record birds, insects, plants, and other organisms. Conduct field research in Indonesia.
- Thailand** - Collect and record birds, insects, plants, and other organisms. Conduct field research in Thailand.



**Charles Robert Darwin 1809 - 1882**  
 Charles Darwin was born in Shropshire as a wealthy family. He studied medicine initially in Edinburgh but discovered that he was not cut out for it. He then studied at Cambridge as he wanted to become a naturalist. Darwin became interested in the study of the earth and natural history. He was required to be a financial officer since much of Wallace's activities were for his own benefit. Wallace began to collect specimens and publish papers in the 1840s. He was required to be a financial officer since much of Wallace's activities were for his own benefit.



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# Operation Wallacea → scientific expeditions in 15 countries



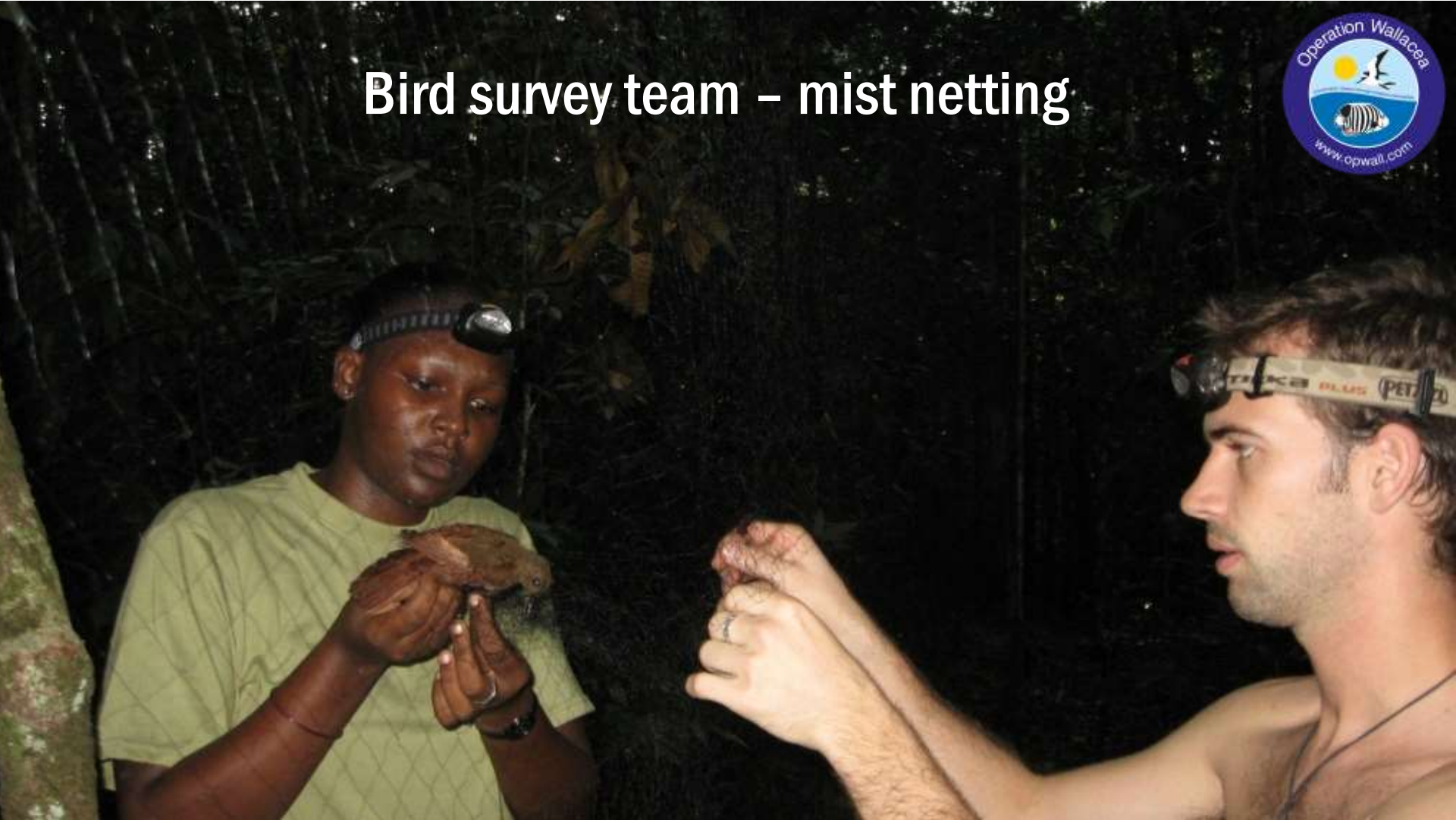


# Biodiversity monitoring - invertebrates

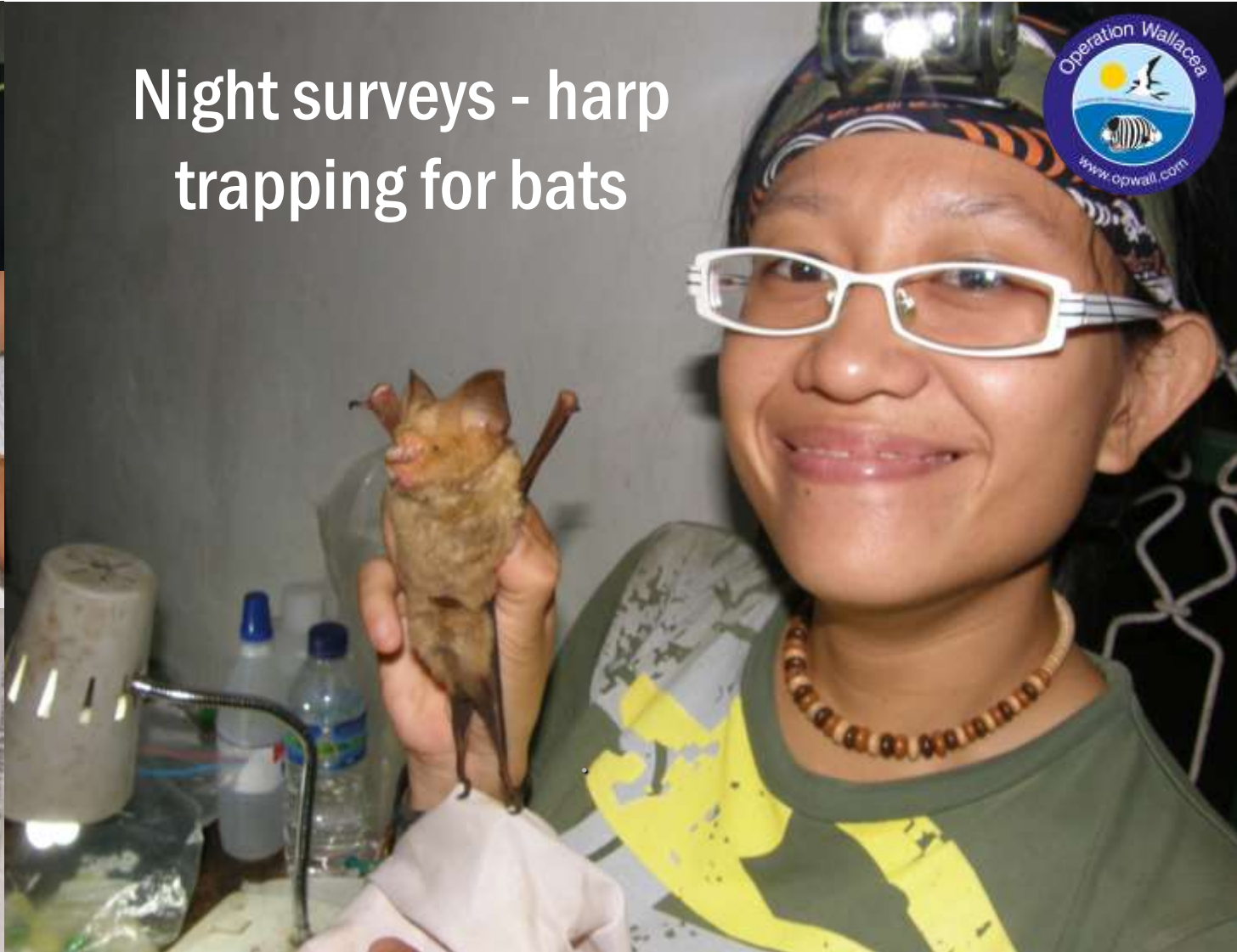




# Bird survey team – mist netting



# Night surveys - harp trapping for bats



## 2) Homologous Body Structures



Whale

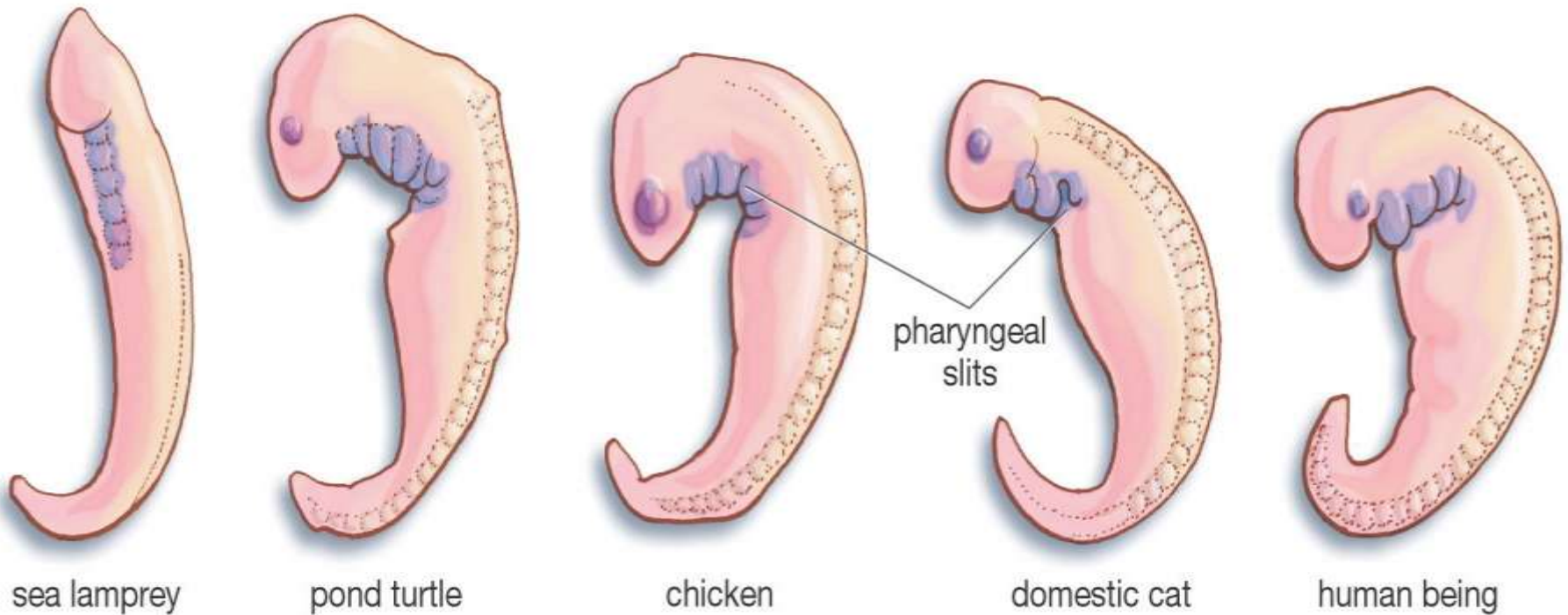
Cat

Bat

Gorilla



Pharyngeal slits exist in these five vertebrate animals ...



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

### 3) Similarities In Embryonic Development

Chicken



Turtle



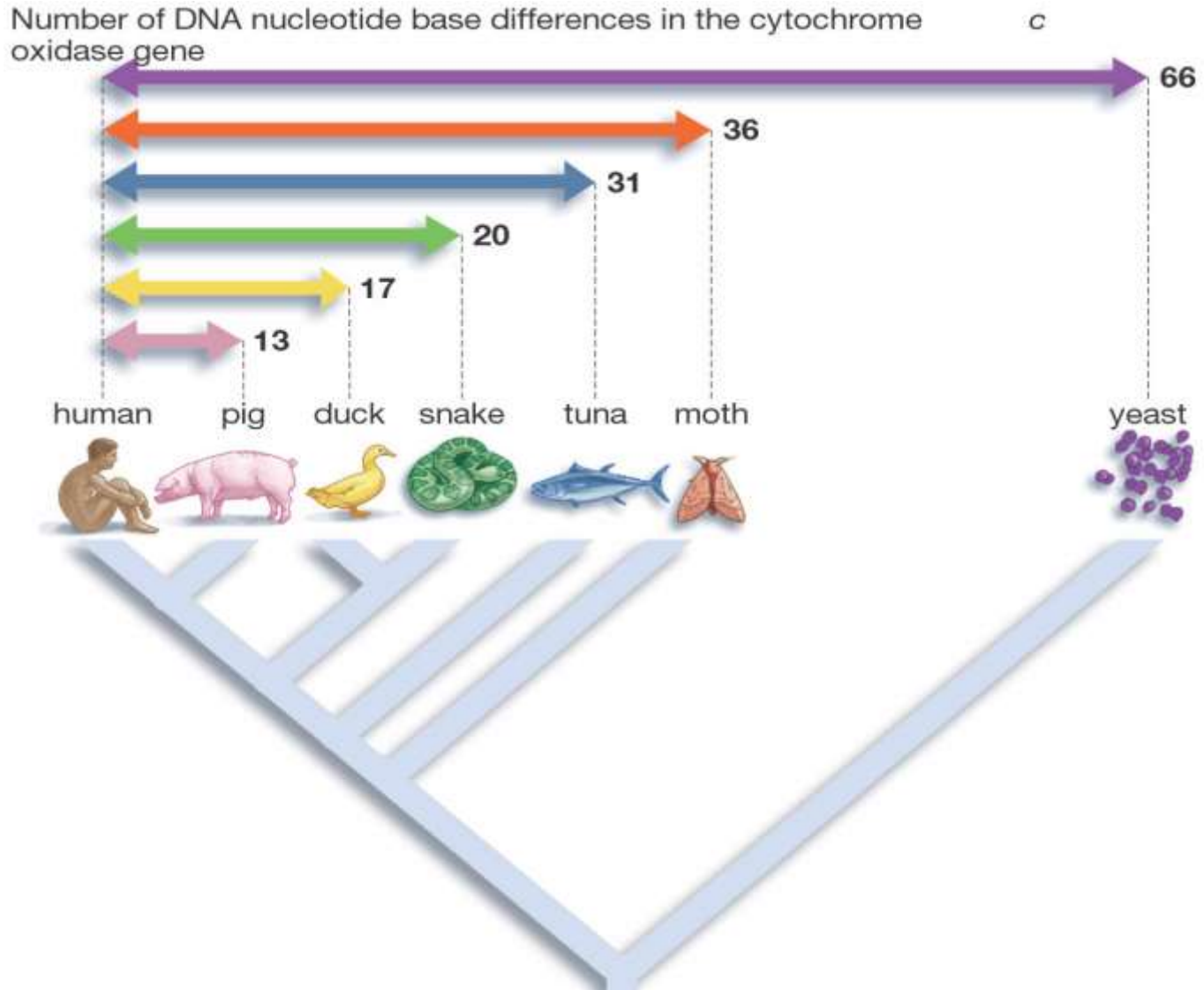
Rat





# 4) Similarities in DNA Sequence

Number of differences out of 648 base pairs



# Living proof of natural selection

- Antibiotics → Antibiotic resistance in bacteria
- Pesticides → Pesticide resistance in insects