

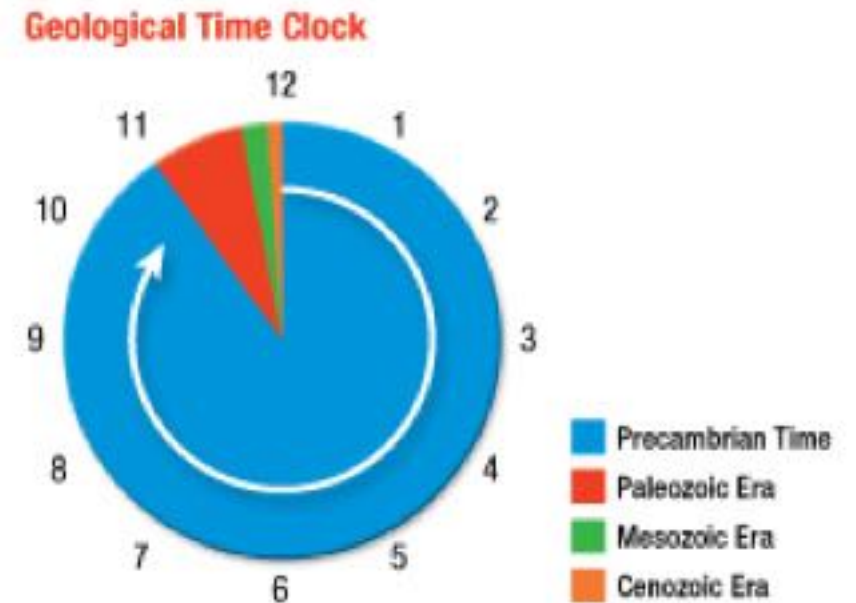
BO101

Topic: Evolution (19-03-21)

Nothing in biology makes sense except in the light of evolution

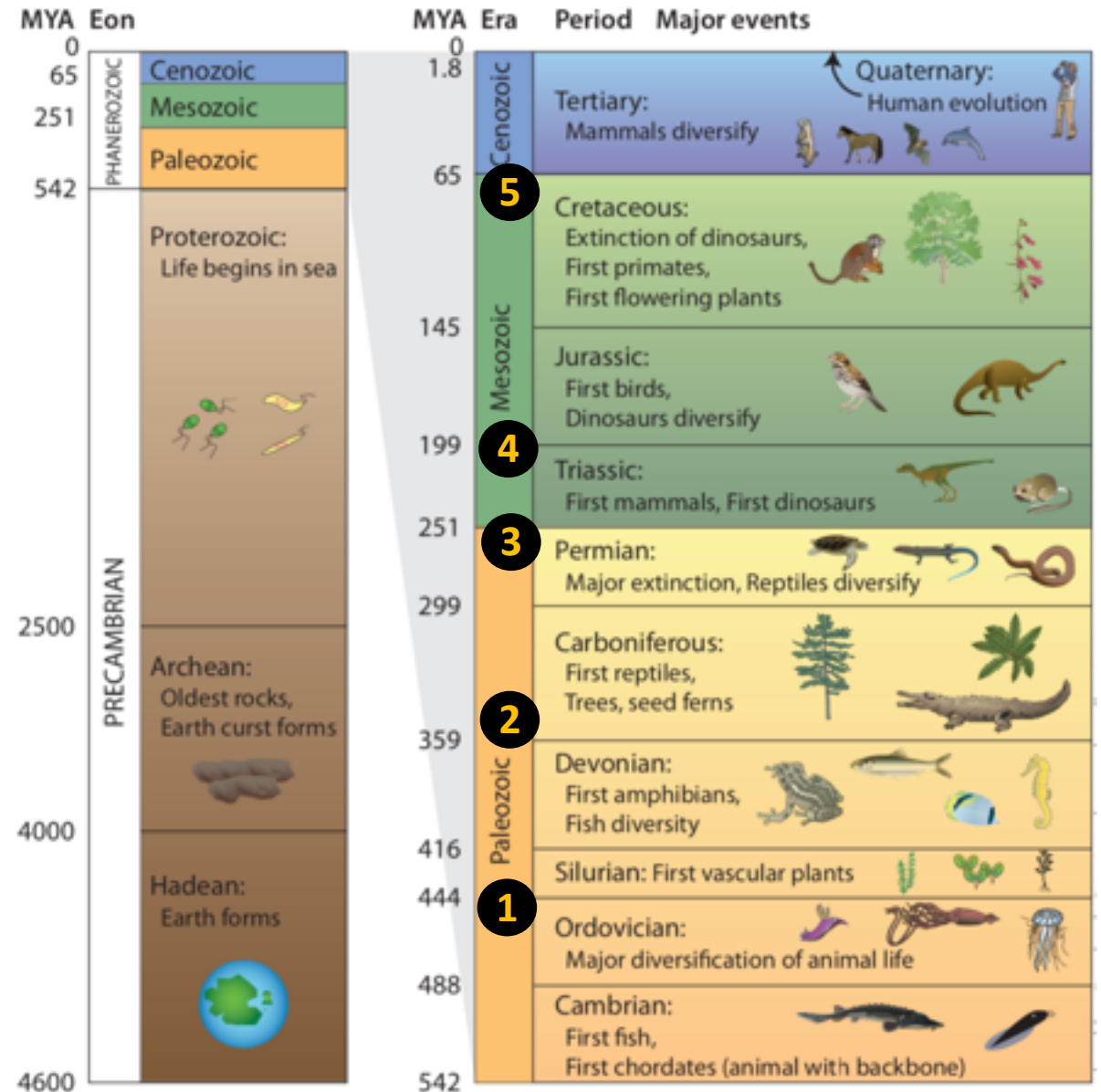
How old is life on Earth? 4 billion years

- Formation of Earth about 4.6 B y ago (**Precambrian** era) Life began about 4 B y ago (Known as Archaea)
- Modern life began 540 M Y ago (**Paleozoic** Era): this era ended about 250 million years ago
- Dinosaurs arrived 251 million years ago (**Mesozoic** Era): this era ended about 65 million years ago
- Modern life began about 65 million years ago (**Cenozoic** Era)
- The Indian subcontinent collided with Eurasia to form the Himalayas. The collision of Africa and Europe resulted in the Alps.



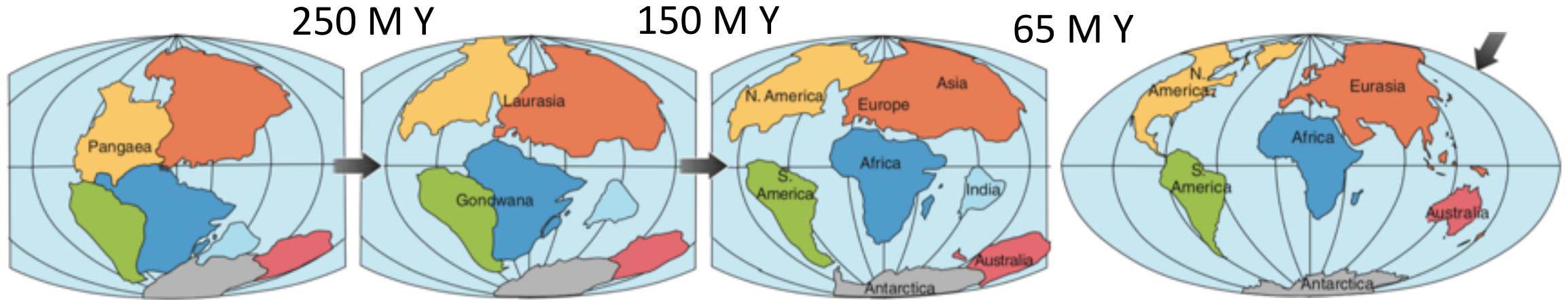
Ancient lives and five mass extinctions

- 1st mass extinction (86% loss)
440 million years ago
- 2nd mass extinction (75% loss)
364 million years ago
- 3rd mass extinction (96% loss)
250 million years ago
- 4th mass extinction (80% loss)
200 million years ago
- 5th mass extinction (76% loss)
65 million years ago



The cause(s) of Mass extinctions

Continental breakups and collisions



Climate change
Increase in sea level
Asteroid impact

Sedimentary Rock

- Sedimentary rock forms by the accumulation and solidification of particles (pebbles, sand, silt, clay)
- The sediment are usually deposited on a riverbed, lakebed, or the ocean floor, accumulate over time and exhibit distinct layers
- Application of sedimentary rock in civil engineering:
 - Sandstone (Red sandstone : Red fort, White: Marble Taj Mahal)
 - Limestone: cement



Fossils

- **Fossils** are the remains or traces previously existing organisms. (The term *fossil* comes from the Latin word *fossilis*, meaning “something dug up.”)
- Few organisms that die become fossils. The formation of a fossil require that an organism be buried quickly by a sediment before decaying
- Fossils under high pressure and high temperature-→ petroleum
- Mostly formed during mass extinctions

Radioactive dating of fossils

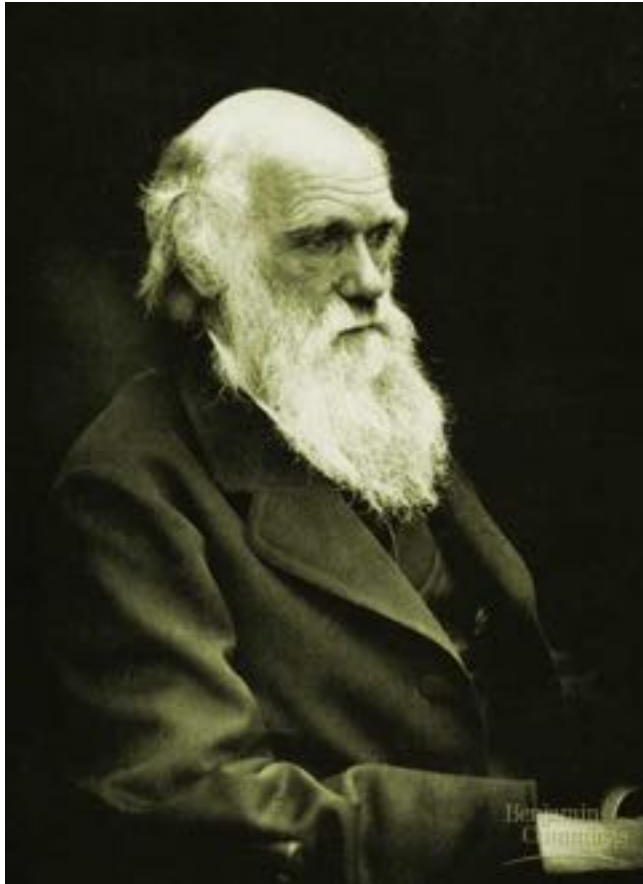
- Several radioisotopes are commonly used to date fossils,
- Example: Isotope: decay product ratio gives the age of the fossil
- Potassium-40 (half-life 1.3 billion years)
- Uranium-235 (half-life 704 million years)
- Carbon-14 (half-life 5730 years): useful for archaeology, not for fossil

Binomial system for naming organisms

- **Taxonomy** is the science of naming and classifying organisms.
- The **species** is a group of organisms with similar structure, function, and behaviour. A species consists of populations whose members are capable of breeding with one another.
- Closely related species are grouped in the next category of classification, the **genus**.
- Dog: *Canis familiaris* and wolf: *Canis lupus* belong to the same genus but separate species
- Biologists have identified about 2 million kinds of living organisms and estimate that several million more remain to be discovered.

How new species arise?

Charles Darwin: proposed a theory about origin of species



Charles Darwin, 1874



The voyage of the *Beagle*

Background of Darwin's theory: Artificial Selection

- Animal breeders can develop many varieties of domesticated animals
- Farmers can produce crop varieties
- They do so by choosing certain traits and breeding only individuals that exhibited those desired traits, a procedure known as **artificial selection**.



Cabbage, broccoli, cauliflower, brussels sprouts, kale, kohlrabi

Background of Darwin's theory: Malthus's theory

- Populations have the capacity to increase geometrically ($1 \rightarrow 2 \rightarrow 4 \rightarrow 8 \rightarrow 16$)
- Food supply, which only has the capacity to increase arithmetically ($1 \rightarrow 2 \rightarrow 4 \rightarrow 8 \rightarrow 16$)
- Conflict between population growth and food supply generates famine, disease, and war, which decreases population growth.

Background: observing the animals in different parts of the world

- Darwin's observed the habits of animals and found that the struggle for existence (as described by Malthus)
- It occurred to Darwin that in this struggle inherited **variations favourable to survival would tend to be preserved**, whereas **unfavourable ones would be eliminated**.
- The result would be **adaptation**
- Eventually, the accumulation of modifications might result in a new species.

Ground finch



Cactus finch



woodpecker finch



grass finch

Darwin's theory of Natural selection

- When a group of animal first reaches new habitat, no animals will be present, so there will be little competition → population growth
- Population increases → Genetic **variation** increases
- Now, if the environment changes, or the population moves to a new habitat (due to scarcity of food), animals of certain **variation** will be able to adapt and survive; others will perish
- Survival of the fittest

Variation and Natural Selection

- When population increase, the available resources cannot support all these individuals
- Competition for the limited resources creates selection pressure
- individuals that are best adapted to their environment are more likely to survive and reproduce, thereby passing on their hereditary information.
- **The source of variation in a population is random mutation.**

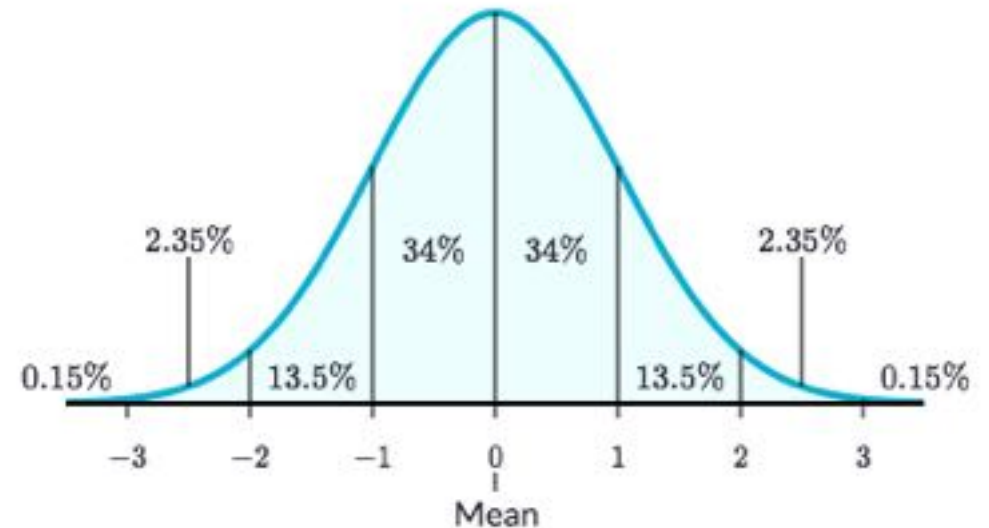
Selection pressure: Differential reproduction due to predator & Climate

- Climate/predator could **remove** a selection pressure or **increase** a selection pressure
- Cold blooded animals became extinct during ice age and warm blooded animal survived
- Birds without the hunting predators (snakes) evolved to be flightless. E.g., **Penguins**

How new species arise? Natural Selection

- Natural selection preserves favorable variations and the rejects injurious variations required to adapt to the environment.
- Natural selection is all about survival, and those organisms with traits that help them survive are more likely to reproduce

Normal distribution



Natural selection: example

- Moths (*Biston betularia*) exist in two distinct polymorphic forms: light colour & dark colour
- In an unpolluted environment, the trees are covered by a pale-coloured **lichen**, which provides camouflage (protection) for the lighter moth from predators (birds)
- In a polluted environment, sulphur dioxide kills the lichen while soot blackens the bark, providing **camouflage** for the dark moth



Unpolluted Environment



Polluted Environment

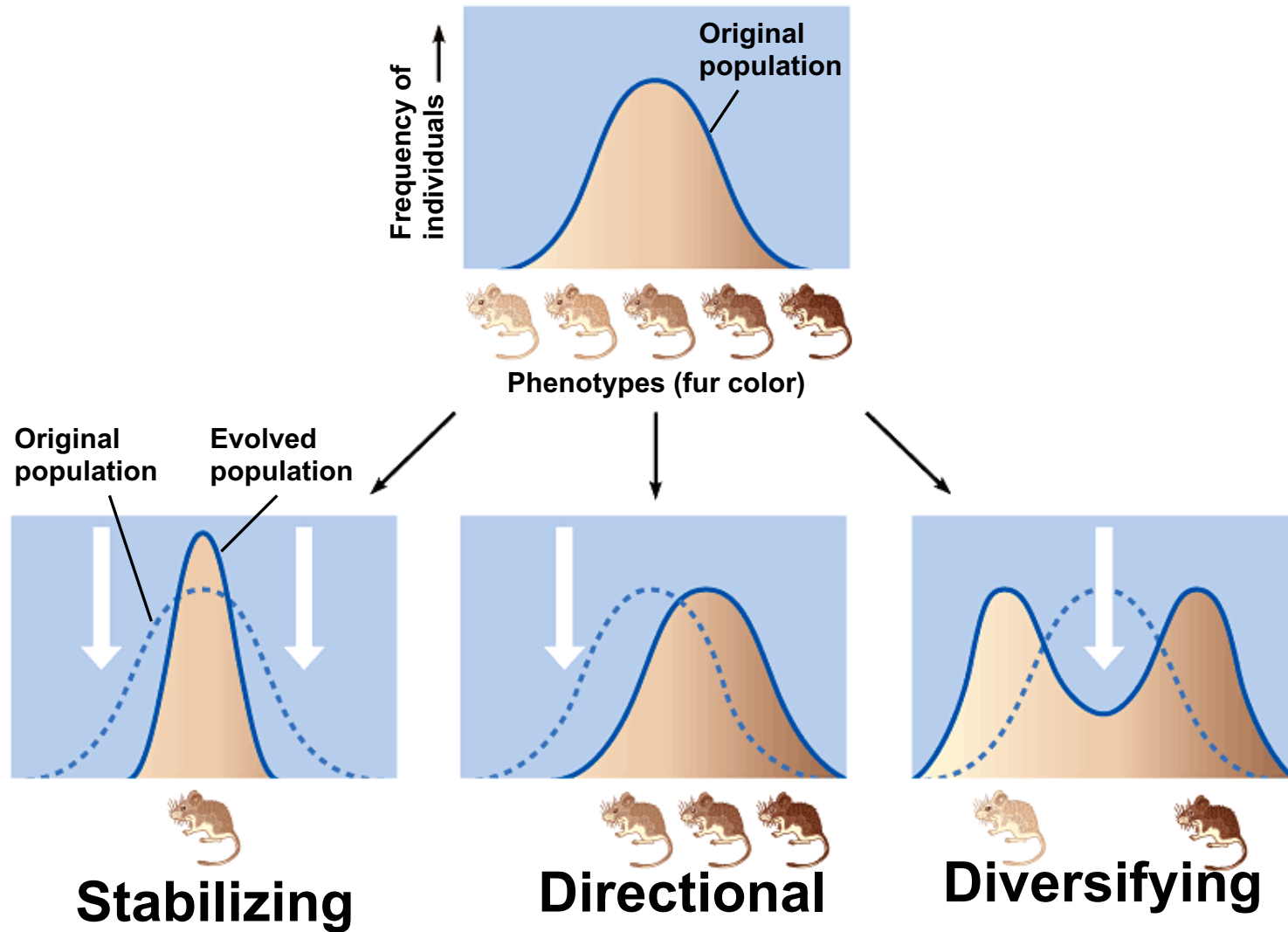
Natural selection: conditions apply*

- Natural selection can only work on existing variation:
Variation cannot be created **on demand**
- Some species lack range of variation (due to small population size) to support enough variation: → **THEY are likely to be EXTINCT**
- Organisms with variation of traits best suited to the environment will survive

Types of Natural Selection

- Stabilizing Selection -- Selection that eliminates the extremes of a trait causing a reduction in variation of a species.
- Directional Selection -- Natural selection that proceeds in a given direction
- Disruptive selection -- Selection that preserves the extremes of a trait causing elimination of median traits.

Types of Natural Selection



Types of Natural Selection



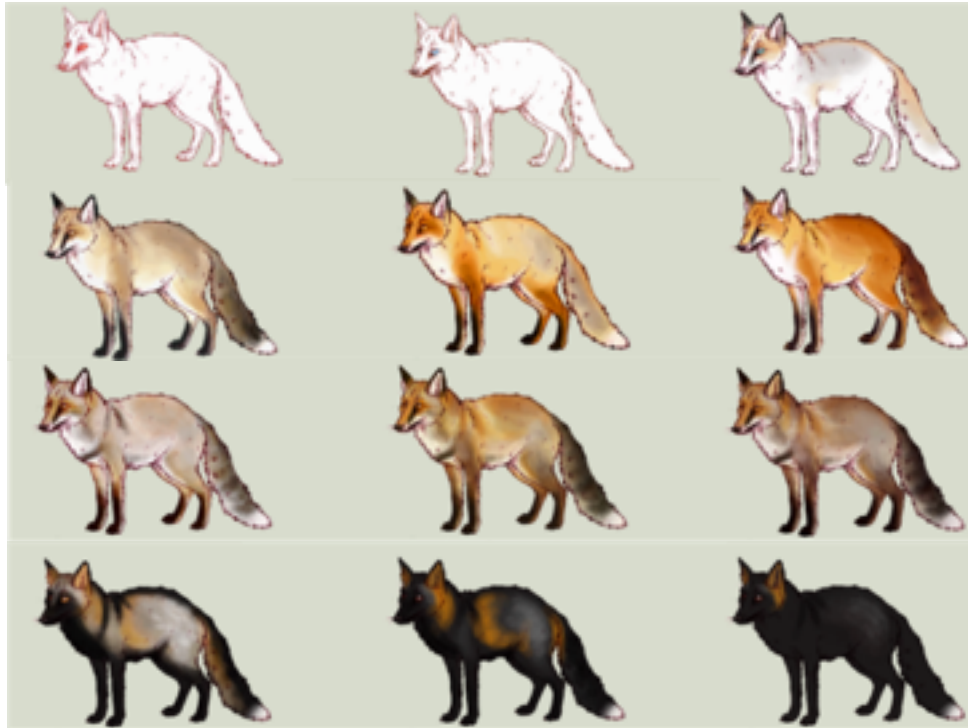
Early fox
population



Environmental
condition of
forests gave
advantage to
brown
fur color
advantage of
camouflage



Types of Natural Selection



Early fox
population

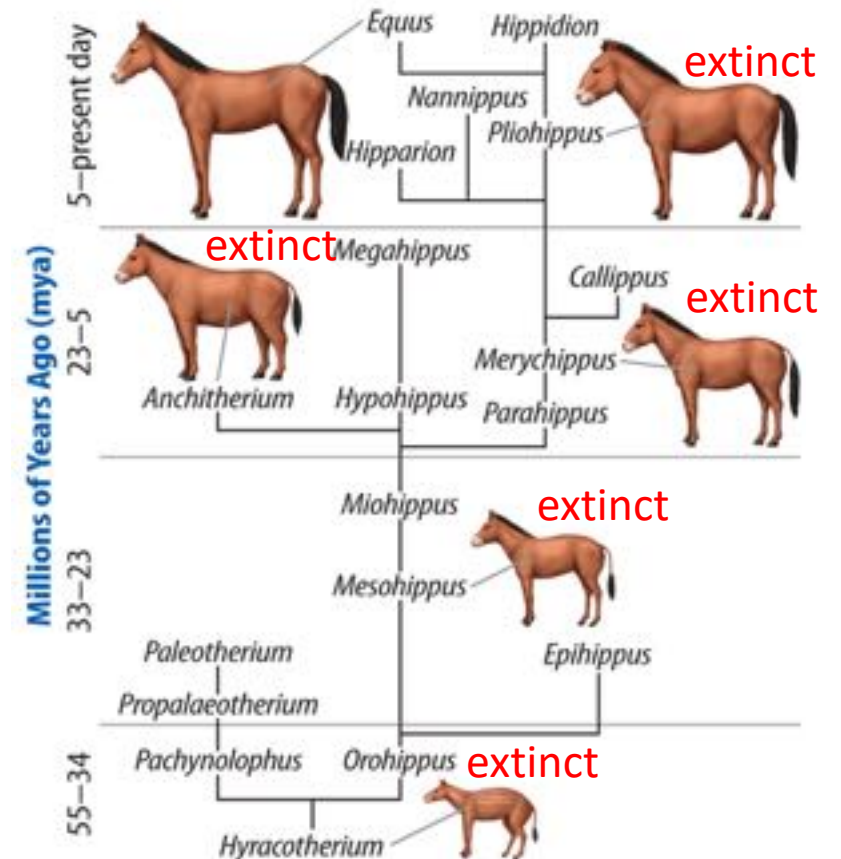


Environmental
condition of **snow**
gave advantage to
white fur color
advantage of
camouflage



Types of Natural Selection

- **Horse- gradual increase in their size**
- Ancestor species lived in forests, and ate leaves from plants. These animals were only about the size of a dog
- Migrated to grass lands; Had to adapt to surviving almost solely off of grasses. But needed larger legs to escape predators (difficult hide in grass)
- This adaptations allow them to avoid competition among other species



How giraffes got long necks ?

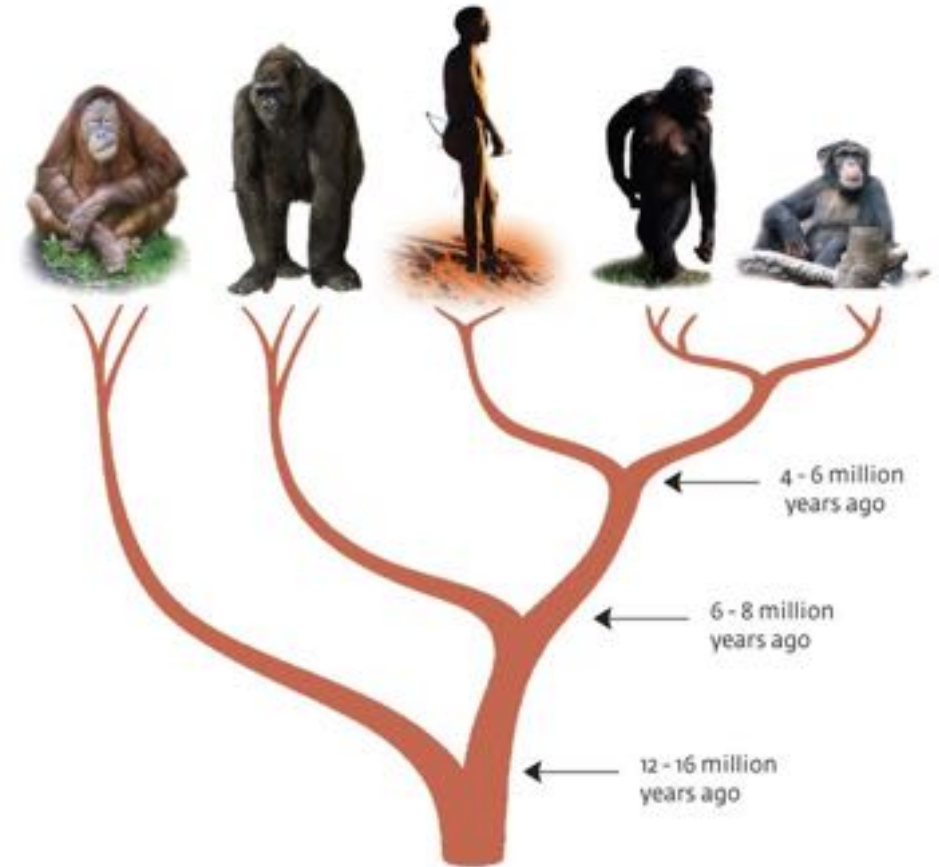
Savanna (mixed **woodland-grassland** ecosystem)



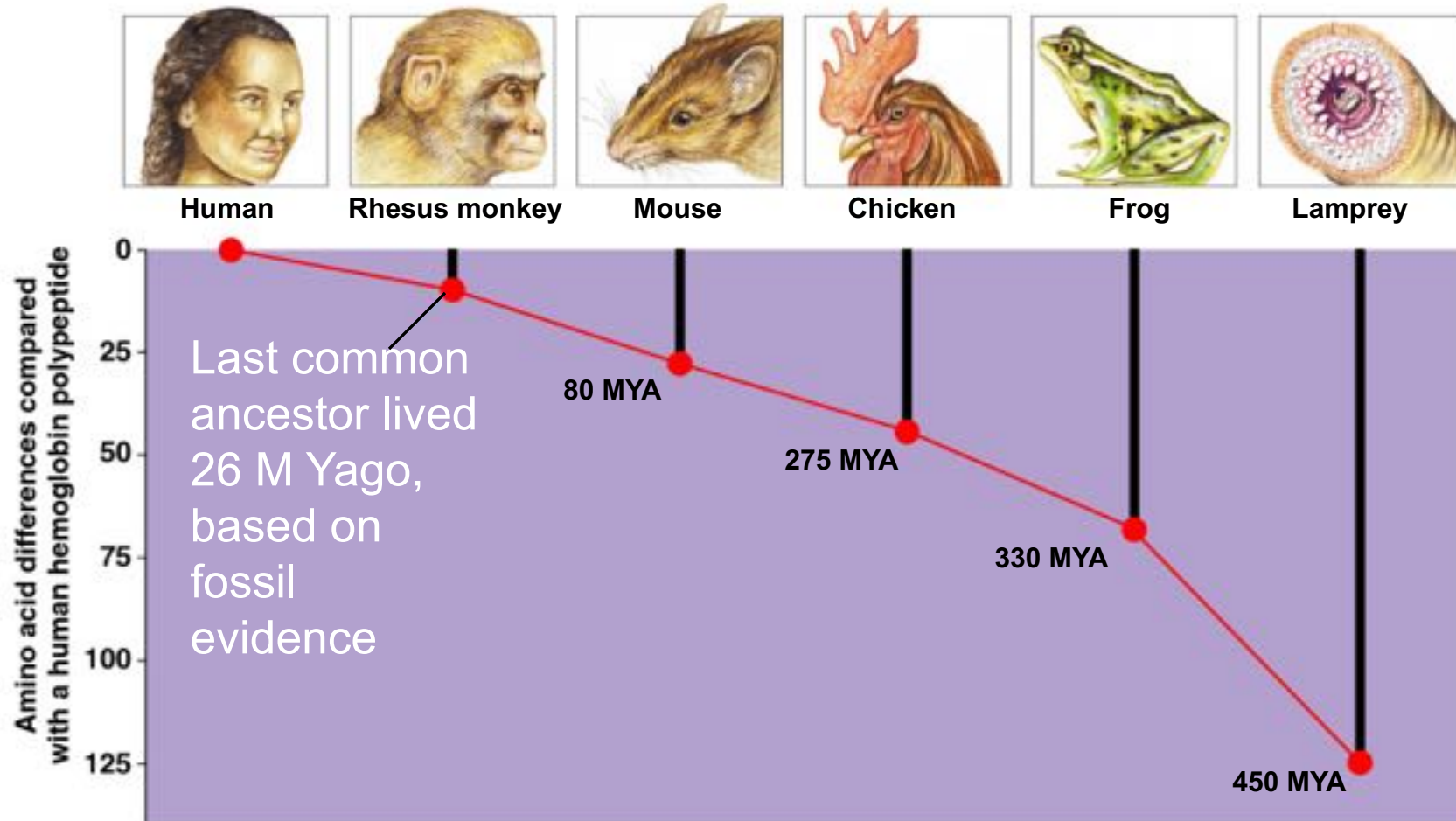
- Primitive giraffe population had tall, medium and short giraffe
- When food became scarce, they migrated to Savanna
- Longer neck variants of giraffe survived, short and medium neck giraffes couldn't reach leaves from the tree

Darwin's theory of biological evolution

- Modern species have descended from **pre-existing** ancestral species with variation
- The primary force driving speciation is “**natural selection**”
- OVER TIME, this process repeated multiple times to form multiple **species**
- **Misconception:** Early humans were chimpanzees
- **Darwin's theory:** Humans and chimpanzees shared a common ancestor

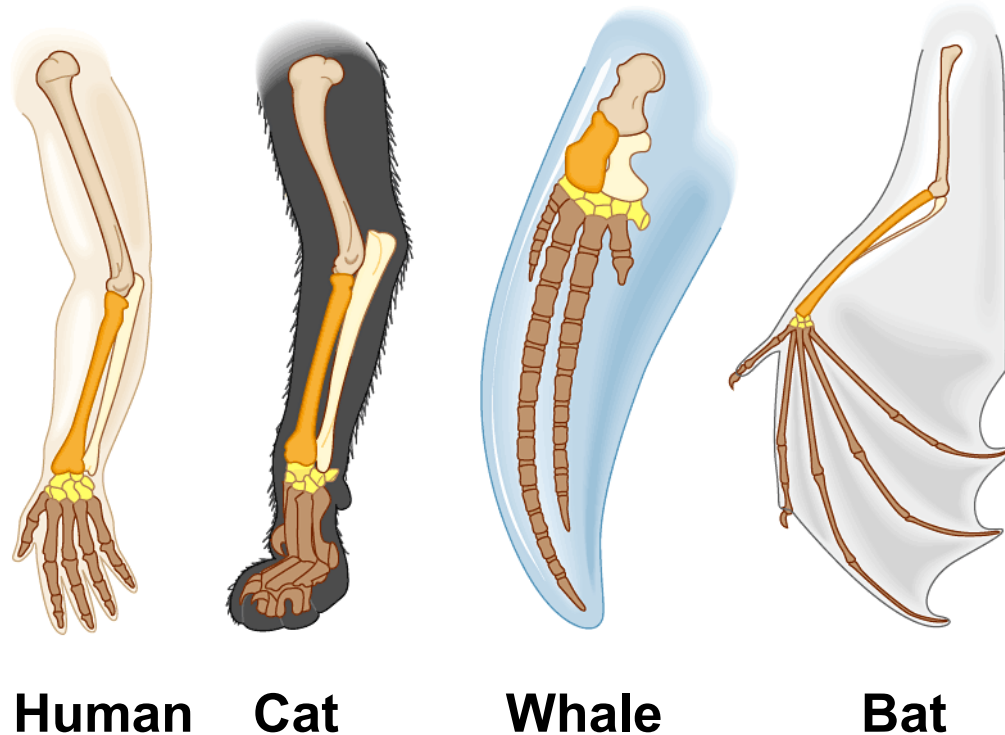


Darwin's theory of biological evolution



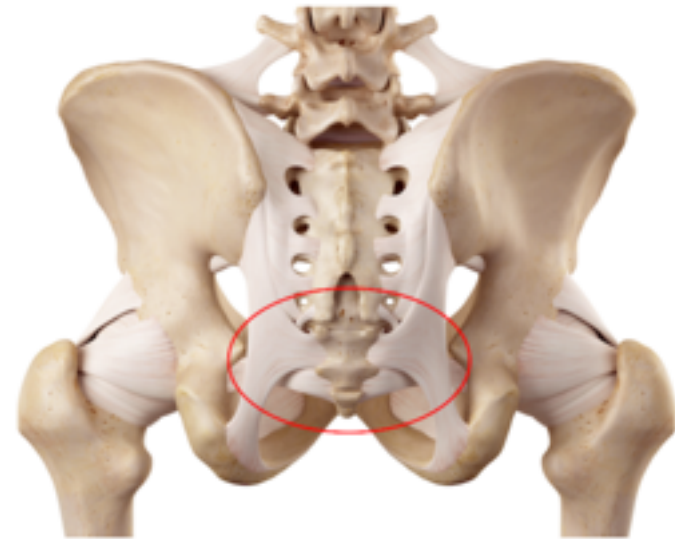
Evidence for evolution: Homologous structure

- Four-limbed vertebrate animals all have the same bones in the forelimbs, but the bones are shaped differently.
- This suggests a shared set of bones arising from common ancestry.



Evidence for evolution: Vestigial organ

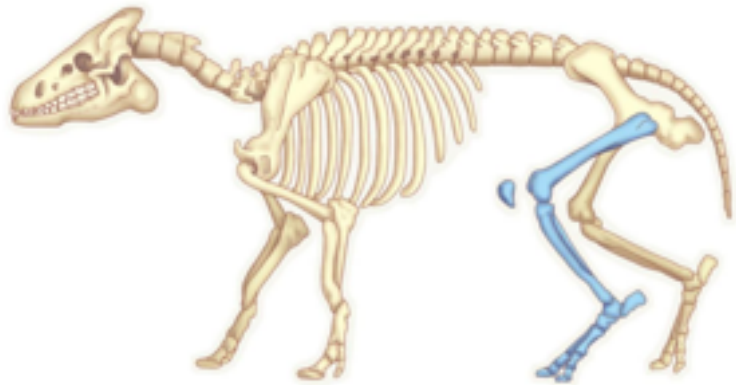
- A human **tailbone** is a vestigial organ. Tailbone doesn't connect to any muscles that we use
- Tailbone is useful in primates who have tails & can use their tails for balance



Evidence for evolution: Comparative anatomy

- **Extinct Fossils resemble modern animals**
- **This shows a common ancestry**

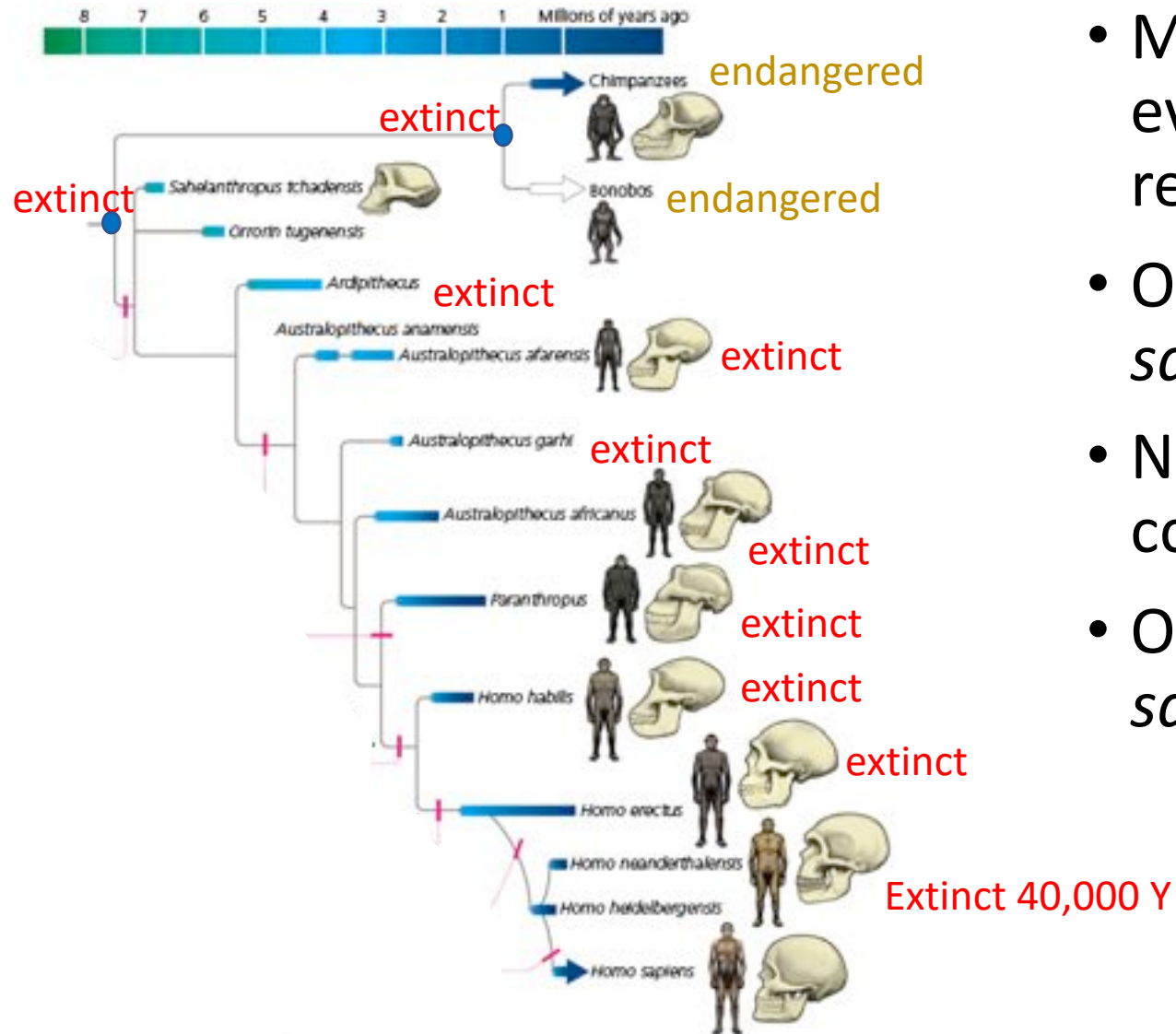
30 million years old fossil of *Elomeryx*
1st known terrestrial mammal



Skeleton of modern dog



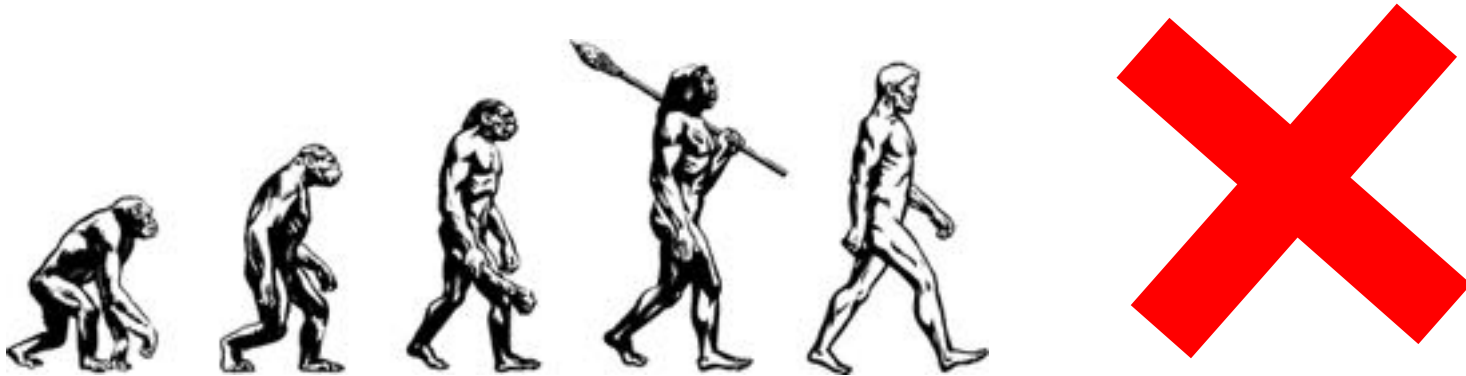
Darwin's theory of biological evolution



- Multiple human ancestor species evolved in different geographic regions
- Only two human species survived (*H. sapiens*, *H. neanderthalensis*)
- Neanderthals had large Brains (1600 cc, larger than our 1200 cc brains)
- Overlapped in geography with *H. sapiens* in Europe and Asia

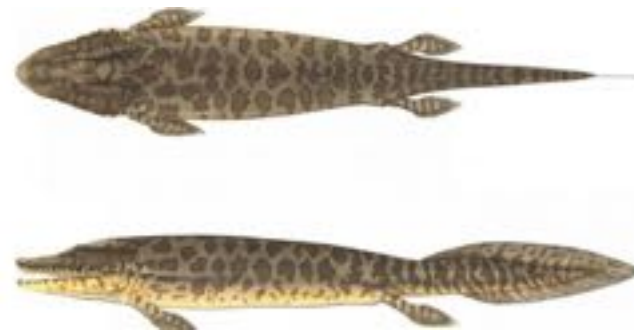
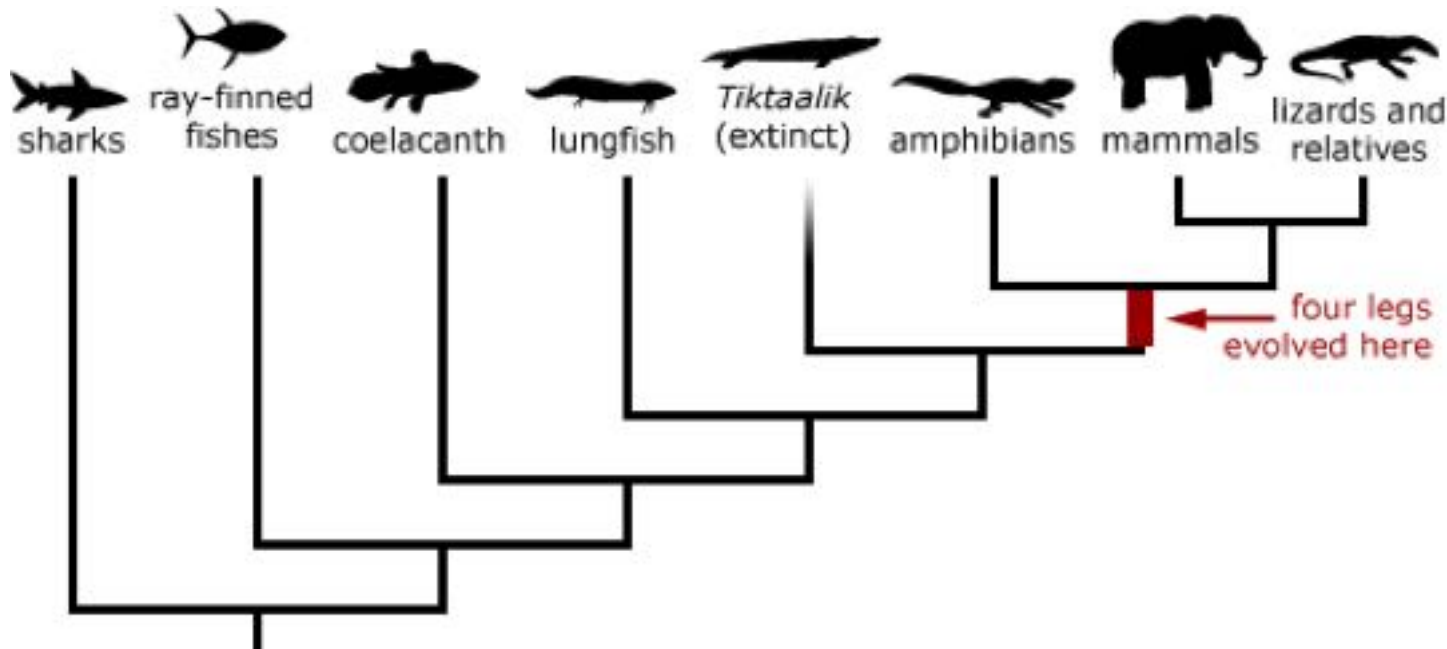
What is NOT evolution

- Evolution is **NOT** progressive improvement of species

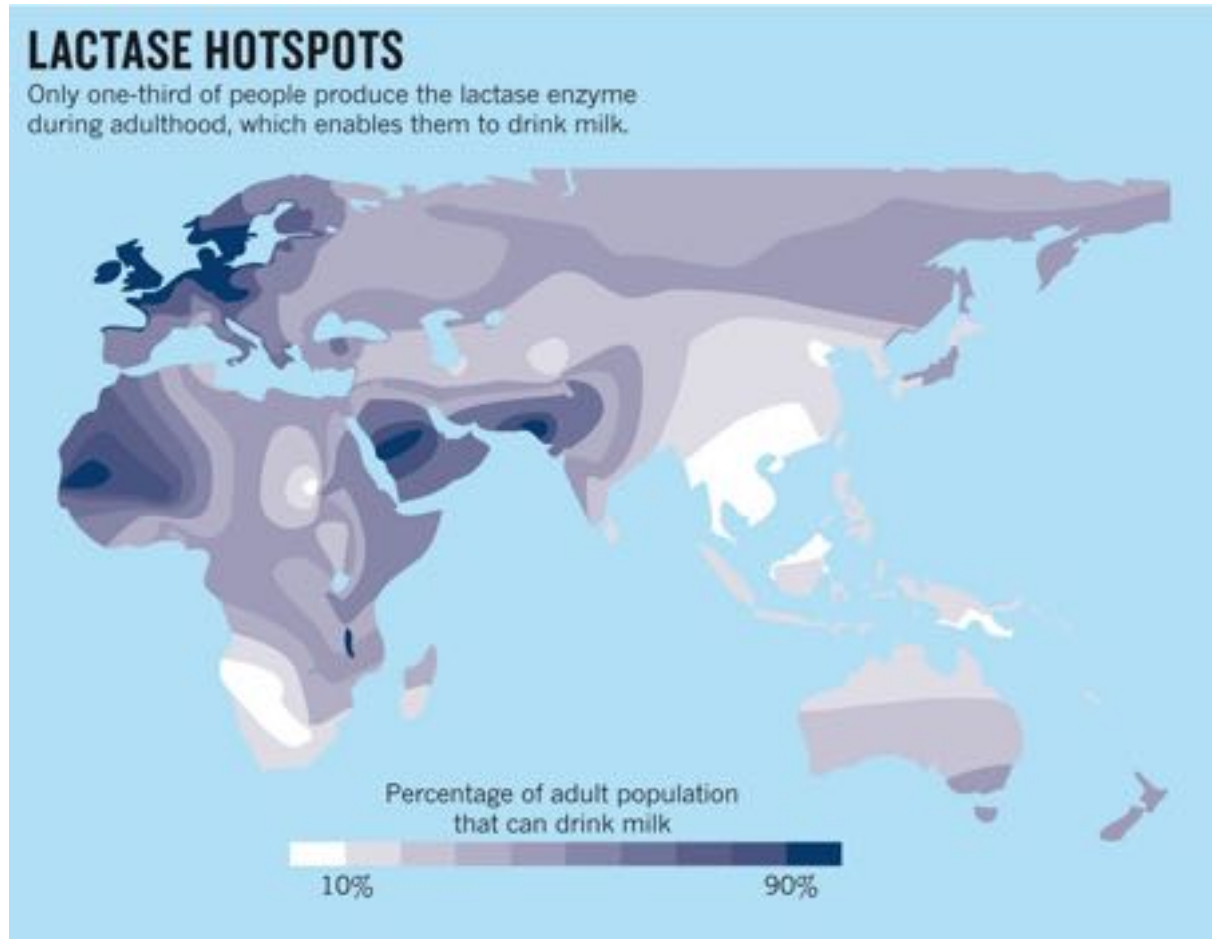


Evidence for evolution: transitional fossils (missing link)

- **Tiktaalik: head of a crocodile and the gills of a fish and four limbs**
- "missing link" between **fish** and land animals
- Existed 400 million years ago



Human variations



Now 65% of the human population can digest lactose beyond the age of about 7-8 years

Most people who cannot digest milk **as adult**: milk is a toxin

This ability is 10,000 years old

Human variations

Sickle Hb HOTPOTS



Malaria HOTPOTS



Human hemoglobin has 2 variation:
Hb (normal) Hbs (sickle)

Malaria parasite (*Plasmodium falciparum*) **cannot infect sickle hemoglobin**



Normal red blood cell



Sickled red blood cell

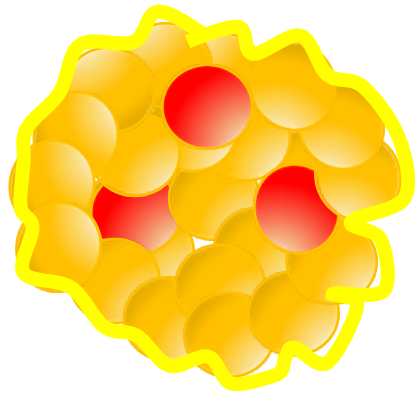
In areas where malaria is prevalent, people with sickle hemoglobin has a survival advantage.

Virus variations

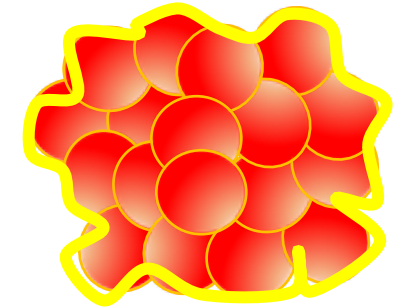
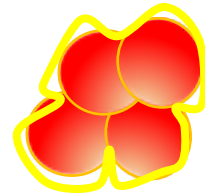
- As virus spread in more people, more variation arise
- Virus that will be able to prevent immune system (selection pressure) will survive



Drug resistant cancer



Chemotherapy drug



Within a tumor, genetic diversity exists among the cells. Some cells may be resistant even before they are exposed to the drug

When treated with a drug only susceptible cells die and the tumor shrinks

However, resistant cells continue to divide and the tumor re-grows following treatment