

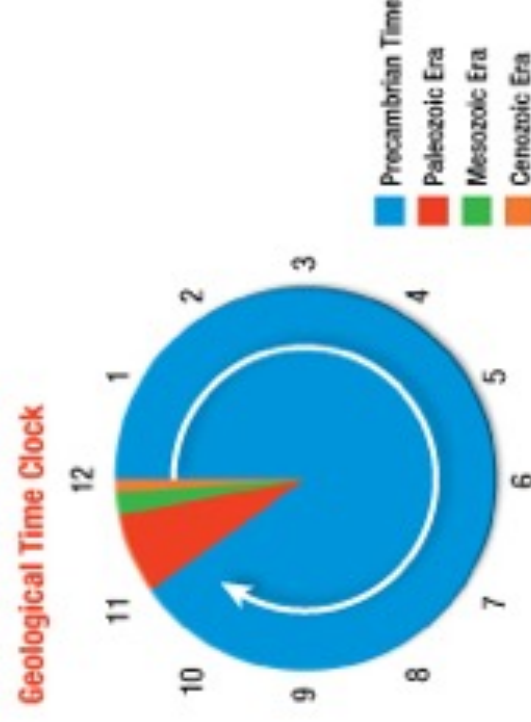
BO101

LECTURE 2

- **Nothing in biology makes sense except in the light of evolution**

How old is life on Earth? 4 billion years

- **Precambrian** time began with the formation of Earth about 4.6 billion years ago.
- **Paleozoic** Era began about 540 million years ago when most major groups of organisms first evolved. The era ended about 250 million years ago
- **Mesozoic** Era was dominated by dinosaurs. The few mammals were very small.
- **Cenozoic** Era began about 65 million years ago
- The Indian subcontinent collided with Eurasia to form the Himalayas. The collision of Africa and Europe resulted in the Alps.

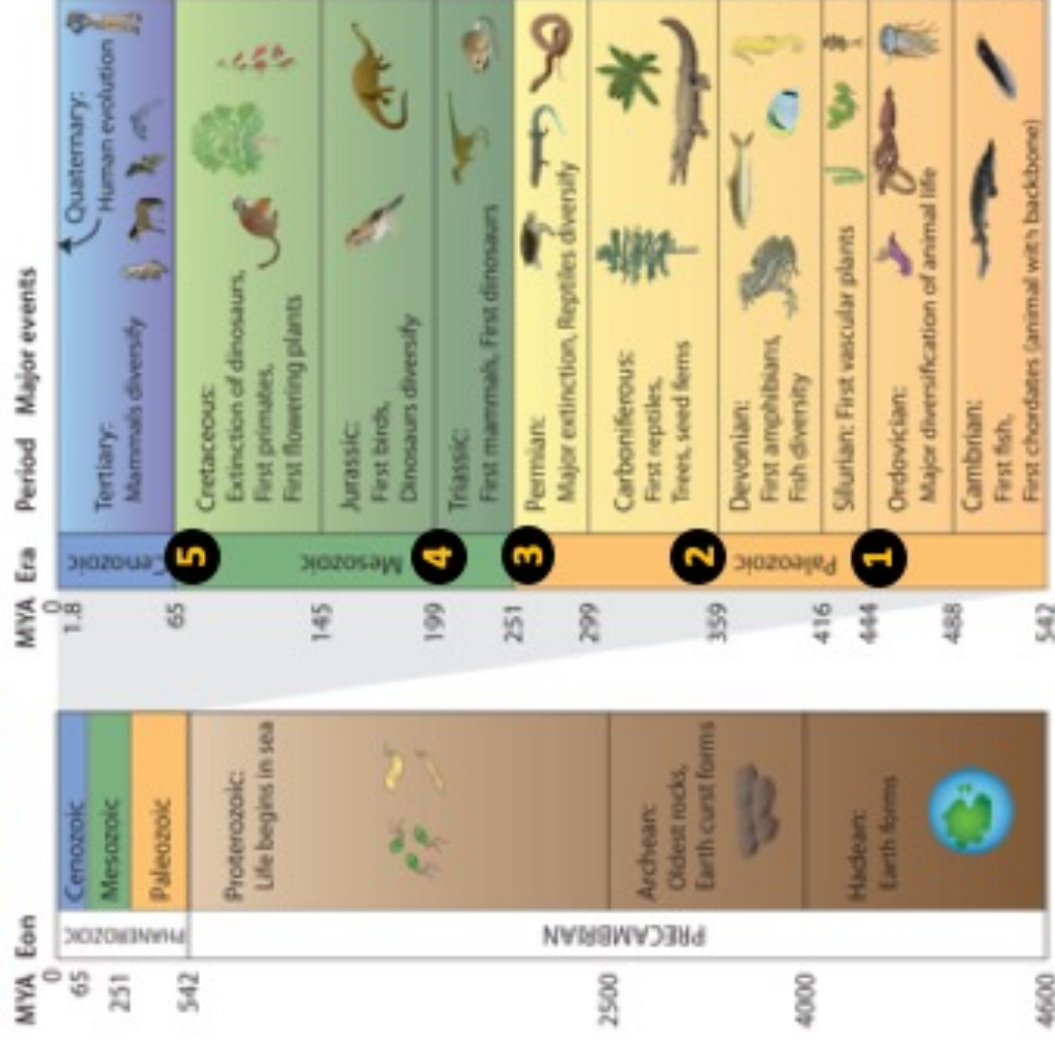


Ancient lives & 5 mass extinctions

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

6th ? 11% of all plants, 12% of all birds, 24% of all mammals

International Union for the Conservation of Nature (IUCN)



The cause(s) of Mass extinctions

- Climate change
- Increase in sea level
- Continental drift that changed ocean to land
- Asteroid impact

Tethys sea ammonite extinct during
The Cretaceous mass extinction are
found in Himachal (Spiti) and
worshipped as “Shalagram shila”



Charles Darwin: proposed a theory about origin of species



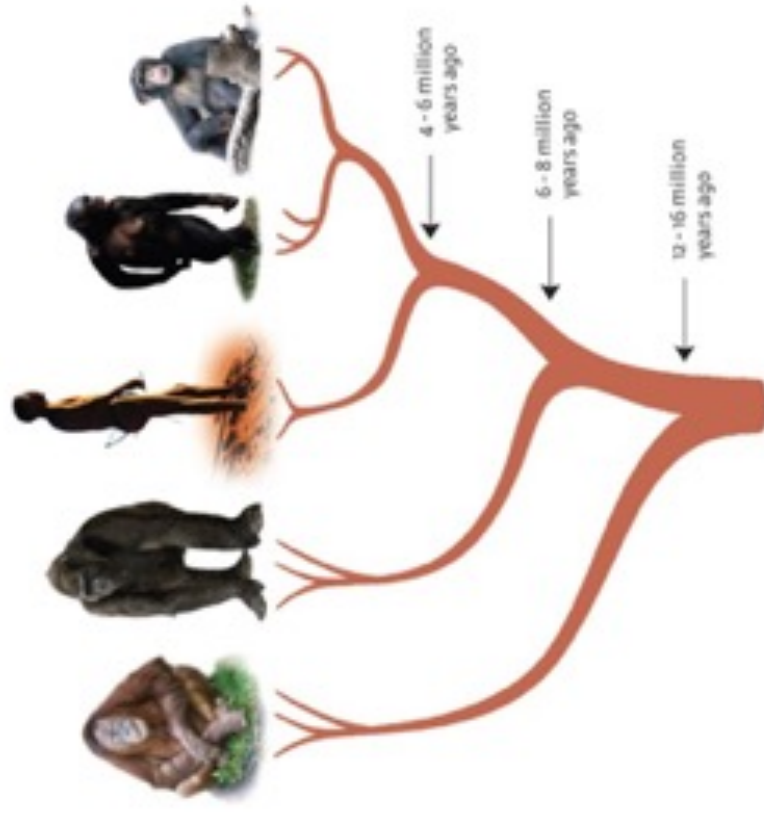
Charles Darwin, 1874



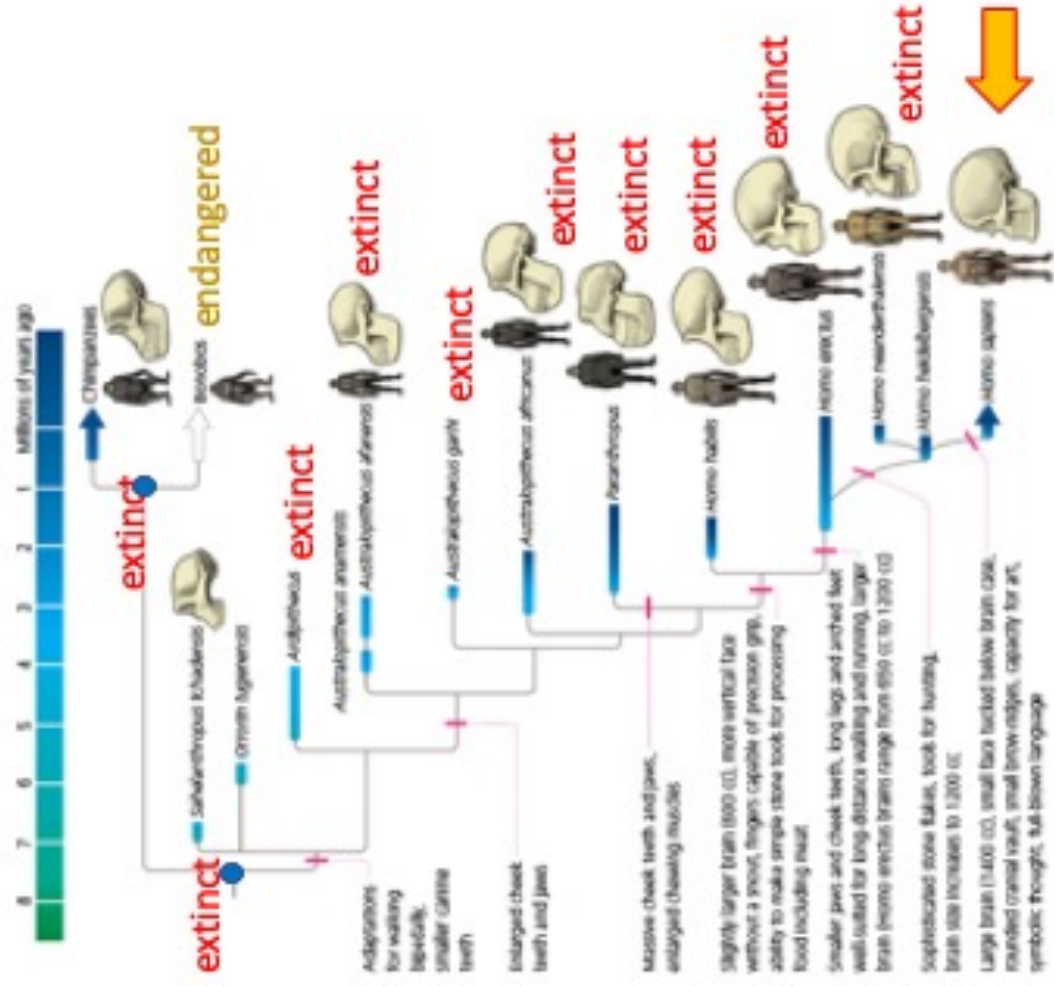
The voyage of the *Beagle*

Darwin's theory of biological evolution

- Modern species have descended from **pre-existing** ancestral species
- During this process lineages have repeatedly split into multiple lineages ("**speciation**")
- The primary force driving speciation is "**natural selection**"



Human Evolution

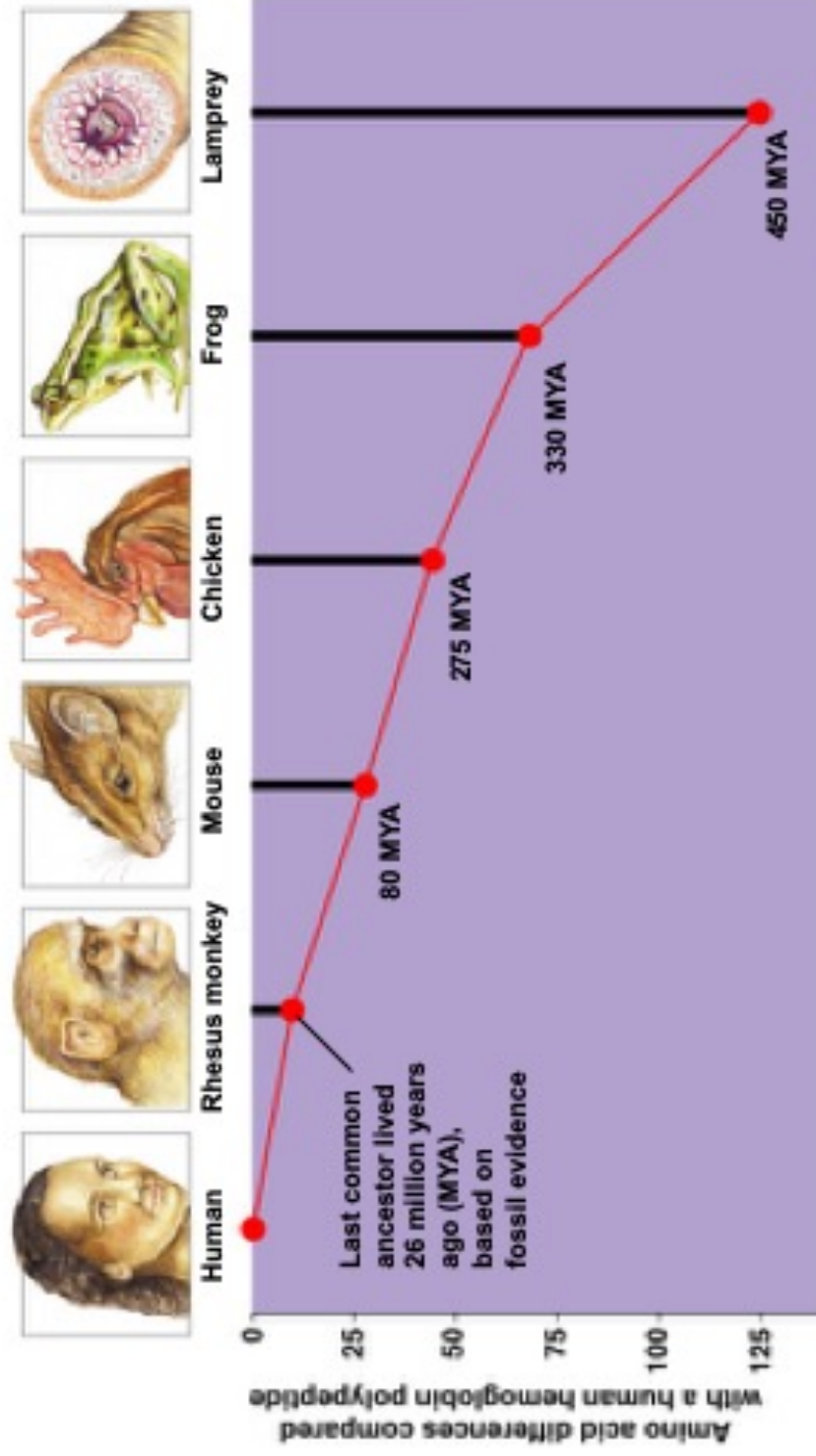


- *Homo erectus* migrated out of Africa throughout Europe & Asia
- Multiple human ancestor species evolved in different geographic regions (*H. sapiens*, *H. neanderthalensis*)
- Neanderthals had large Brains (1600 cc, larger than our 1200 cc brains)
- Overlapped in geography with *H. sapiens* in Europe and Asia
- Extinct ~40,000 yrs ago; WHY?

Misconception: Early humans were chimpanzees

Correction: Humans and chimpanzees shared a common ancestor

Human Evolution



What is NOT evolution

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



Evidence? 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.



Human



Cat



Whale



Bat

Evidence? 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? Comparative anatomy

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

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

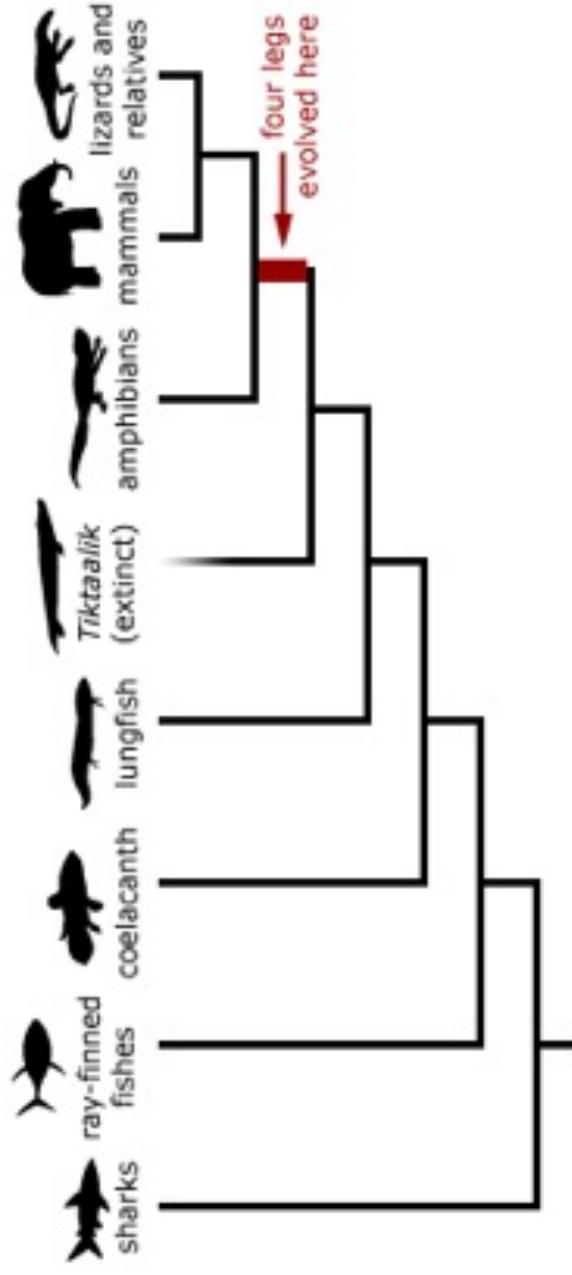


Skeleton of modern dog



Evidence? transitional fossils (missing link)

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



How new species arise? Natural Selection

- In any population, individuals differ from one another in many ways.
- Some of these traits are heritable (passed from parents to offspring)
- Non-heritable characteristics
 - Athletic ability
 - Artistic ability
 - Leadership

Selection pressure: Differential reproduction due to predator & Climate

- Organism producing more offspring than that can survive.
- The available resources cannot support all these individuals
- Competition for the same limited resources creates selection pressure
- Climate change creates selection pressure
- A warmer climate could **remove** a selection pressure for a thick coat, while at the same time **increase** a selection pressure for conserving water more effectively when sweating.

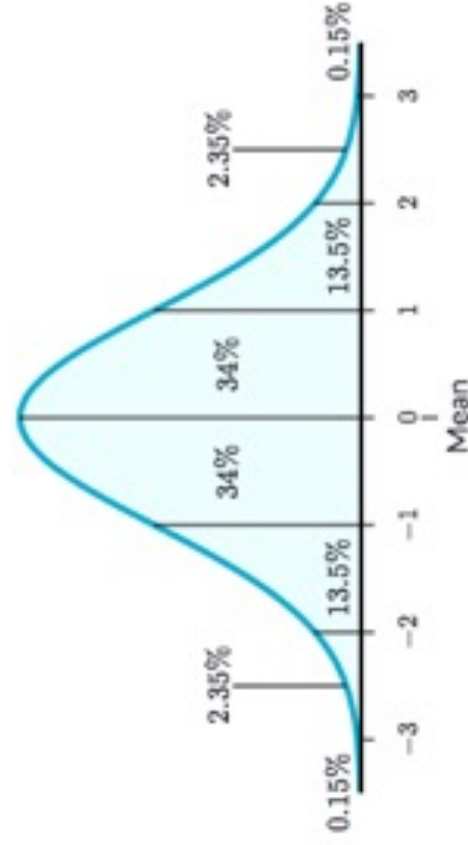
Selection pressure: Differential reproduction due to predator & Environment

- Selection pressures can be imposed by other animals. If a new type of predator arrives then this will introduce a new selection pressure.
- When **killer whales** evolved (~ 10 million years ago) many whale and seal species were driven to extinction as a result.
- Birds evolved without the pressure of many hunting predators (snakes, for example), and as a result many of the birds 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 1

- 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

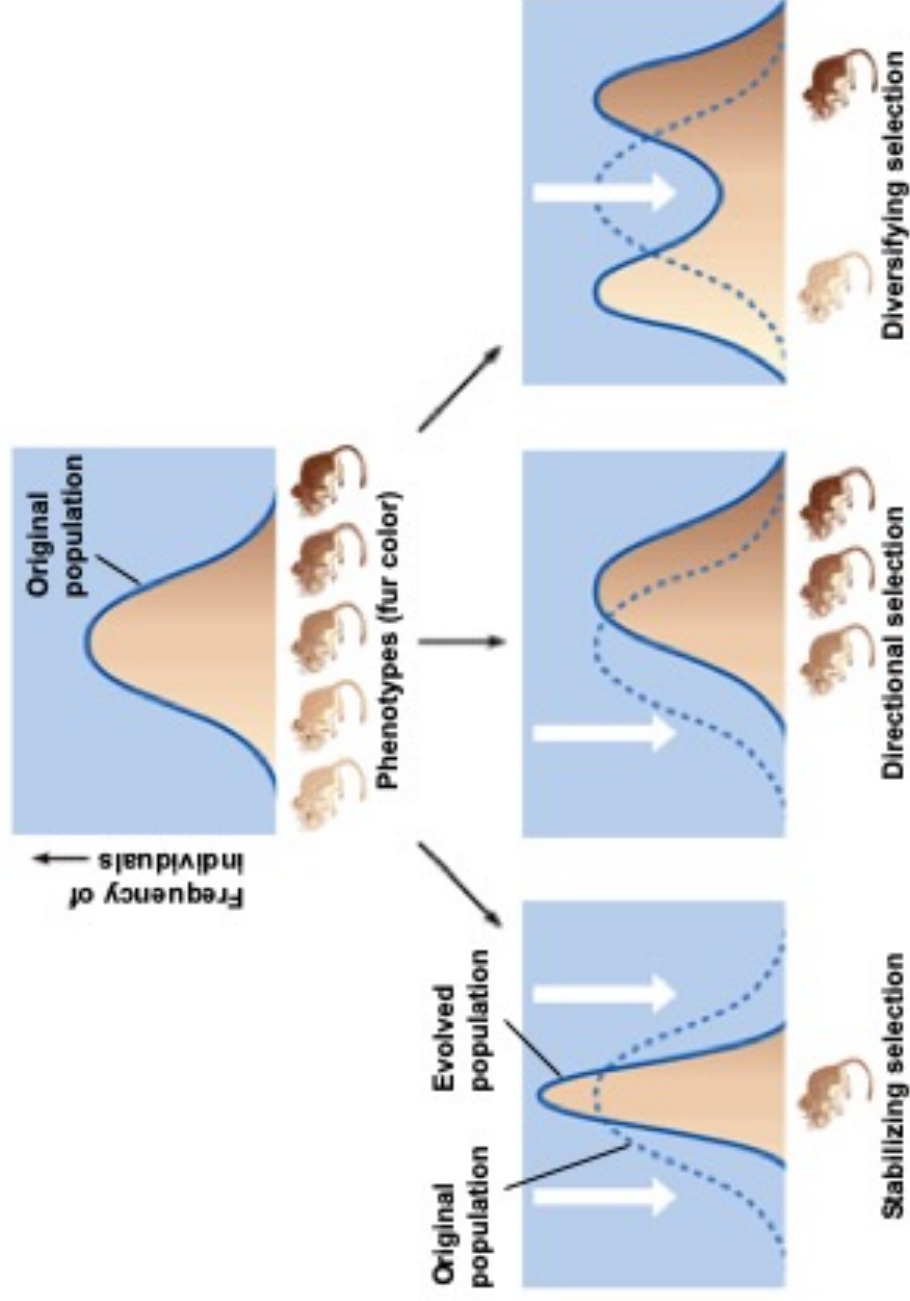
Natural selection: conditions apply*

- Natural selection can only work on existing variation: **Variation cannot be created on demand.**
- Some species lack range of variation to support evolution
- **THEY WILL BE EXTINCT**
- **Organisms with traits best suited to the environment will survive & reproduce**

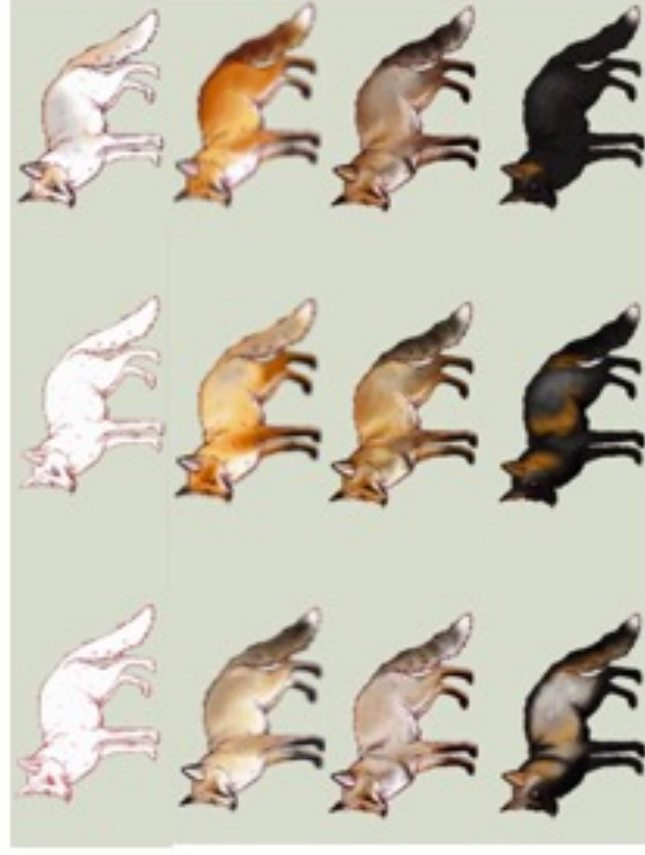
Types of Natural Selection

- 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



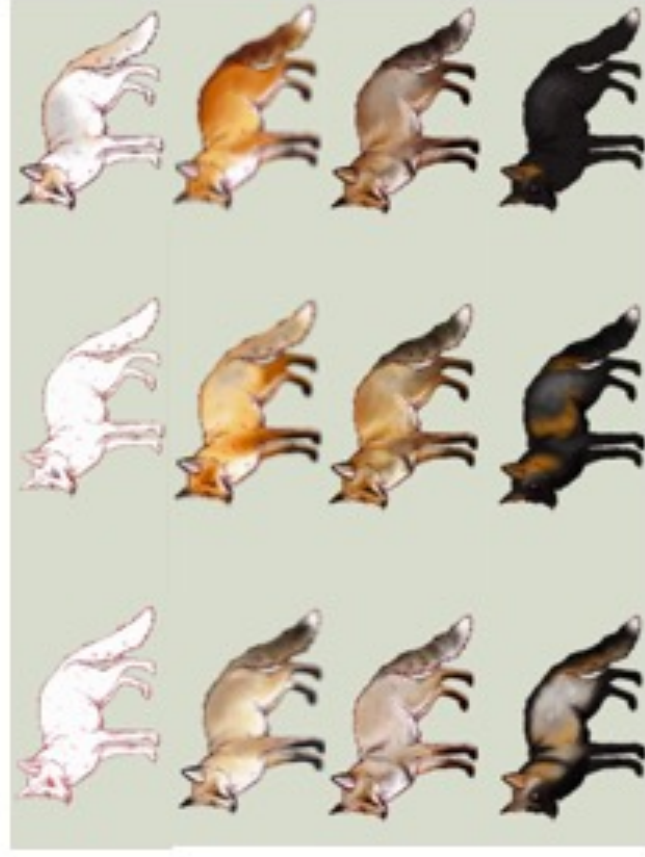
Early fox
population



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



Types of Natural Selection



Early fox
population

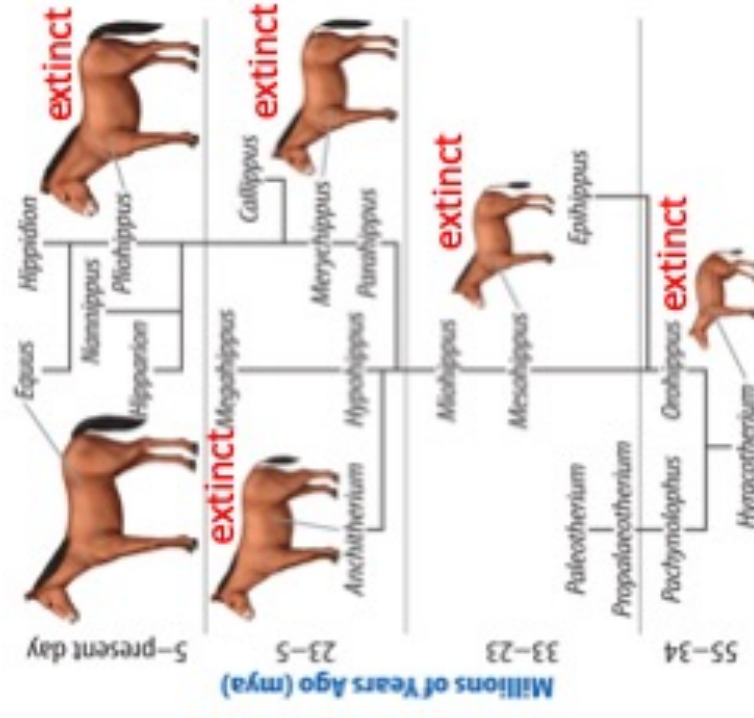


Environmental condition
of snow gave
advantage to white fur
color advantage of
camouflage



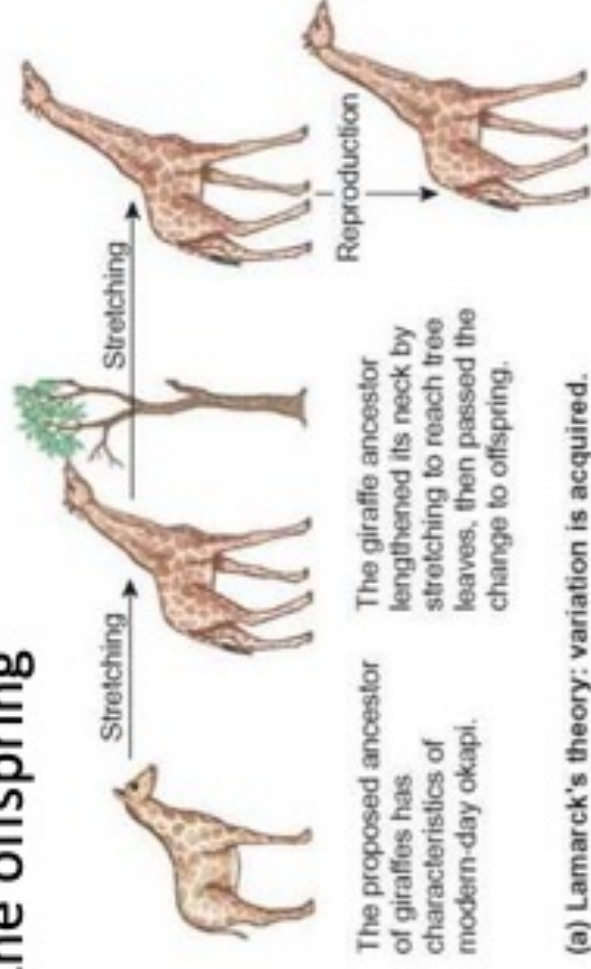
Types of Natural Selection

- **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
- Horses adapted 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



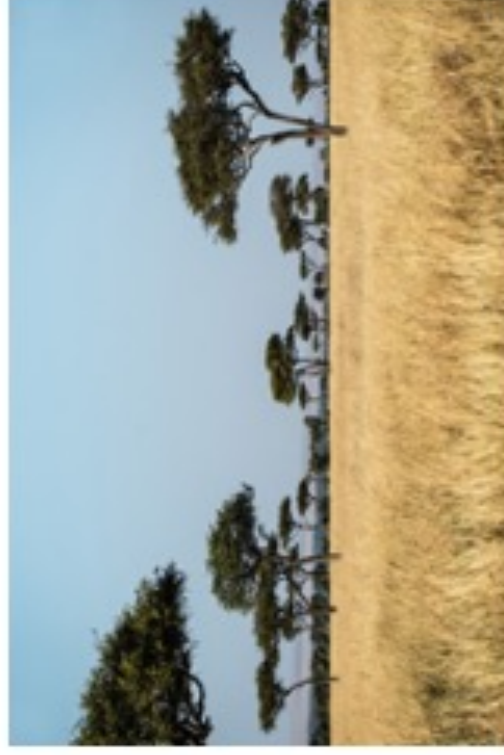
Bizarre theory of Lamarck

- Theory of inheritance of acquired characteristics was proposed by Jean-Baptiste Lamarck (1809)
- By repeated use organism become better at a trait
- These changes could be passed to the offspring



How giraffes got long necks ?

Savanna (mixed woodland-grassland ecosystem



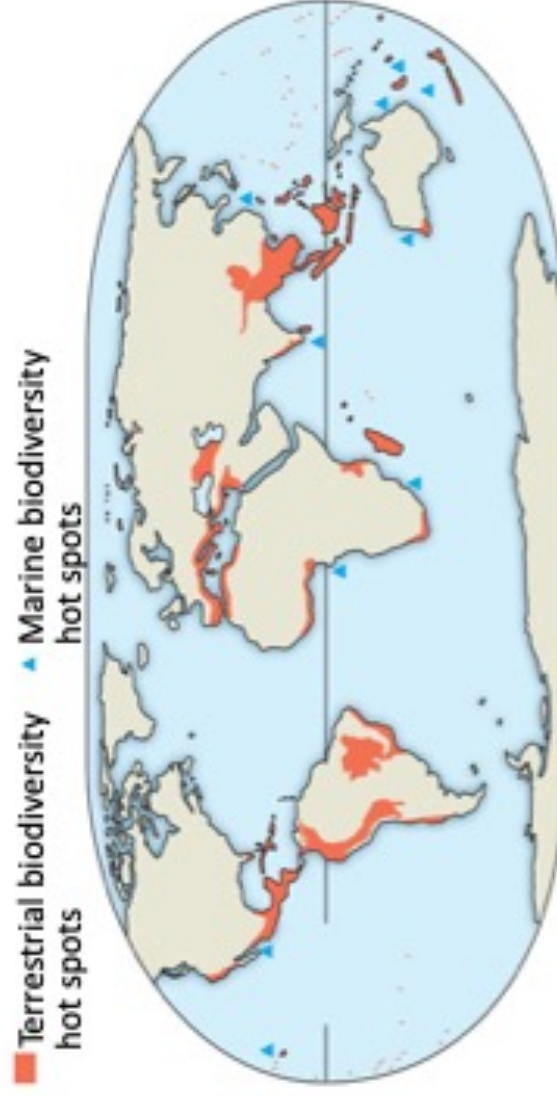
Evolution has longer neck variants of giraffe. Short and medium neck giraffes couldn't reach leaves from the tree
Neither

Extinction

- Extinction is the process through which a species ceases to exist because of death of every individual.
- Extinction may be regarded as the **result of failing to adapt** to environmental changes due to lack of diversity.
- **Extinction is a natural process.**
- **Extinction could be man-made.**

Causes of Extinction

- Loss of Biodiversity
- Habitat Degradation
 - Change in habitat (Rainforest to agricultural lands)
 - Can be caused by natural processes e.g., volcanoes, floods, drought, etc...
- Human activity



Human genetic variations



Only 35% of the human has **LACTASE enzyme** who can digest lactose beyond the age of about 7-8 years

Most people who retain the ability to digest milk **as adult** can trace their ancestry to Europe

This ability is 10000 years old

Before that milk was essentially a toxin to adults

Human genetic variations

Sickle Hb HOTPOTS



Malaria HOTPOTS



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

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



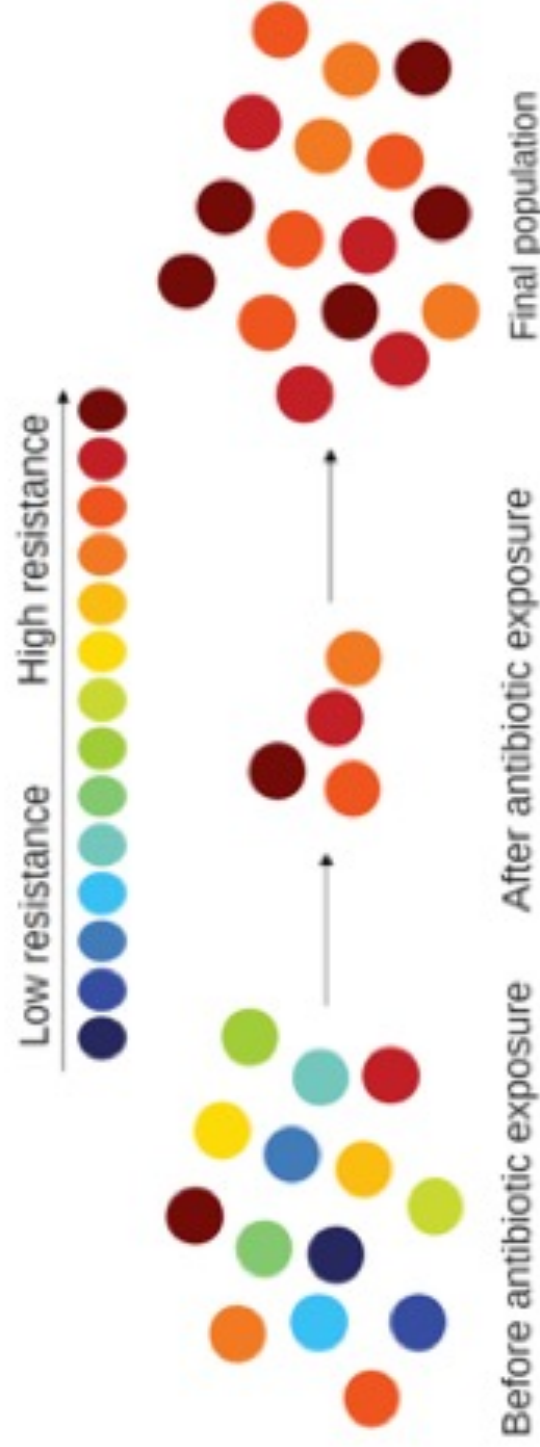
Normal red blood cell

Sickled red blood cell

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

Examples of Darwinian Evolution: Antibiotic resistance in bacteria

- Antibiotic resistant bacteria *Staphylococcus* is commonly found on people
- *All Staphylococcus* became resistant to penicillin in 1945, two years after it was first widely used



Examples of Darwinian Evolution: 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

Evolution MCQ

- **The force that initiates evolution is _____**
 - Variation
 - Mutation
 - Extinction
 - Adaptation
- _____ **is a human vestigial organ**
 - Intestinal villi
 - Papillae
 - Tail bone
 - None of the above
- **The earliest geological time period among the following is _____**
 - Cambrian
 - Permian
 - Jurassic
 - Quaternary

Evolution MCQ

- **Which condition can be explained by Lamarckism?**
 - How giraffes got their long neck
 - How humans lost their tail
 - How humans became bipedal
 - none of the above
- _____ **was a missing link between amphibians and mammals.**
 - Archaeopteryx
 - Tiktaalik
 - Avimimus
 - Caudipteryx
- **True/False?**
 - Human lack genetic variation
 - Human and Fish share common ancestor
 - Antibiotic resistant bacteria existed before antibiotics were discovered

Evolution MCQ

- **Example of a homologous organ**
 - The arm of a human, wing of a bird
 - Wing of an insect, wing of a bird
 - Leg of a dog, leg of a spider
 - None of the above
- **When did dinosaurs die off?**
 - 105.1 million years ago
 - 65.5 million years ago
 - 75.5 million years ago.
 - None of the above
- **The last common ancestor of humans is**
 - Pan troglodytes
 - Homo neanderthalensis
 - Homo erectus
 - Dromaeosaurus

Evolution MCQ

- **Which of the following statements is INCORRECT regarding inheritance of traits?**

- A. The muscular strength gained by a weight lifter during his lifetime is inherited by his children.
- B. A flower with tasty nectar that is eaten by a butterfly is more likely to pass on its delicious genes through the pollen spread by the butterfly than one that is not tasty.
- C. A green-feathered bird that survived all of the predators in the forest will pass on the green feather genes to its offspring.

- **Which of the following statements is FALSE based on Darwin's theory of evolution?**

- A. Natural selection is the driving force of evolution.
- B. Favourable genetic variations become more and more common in individuals throughout their lives
- C. Natural selection drives organisms to live in groups and ultimately become distinct species.

- **As the climate got colder during the Ice Age, a particular species of mammal evolved a thicker layer of fur. This is an example of what kind of selection?**
 - A. Stabilizing selection
 - B. Directional selection
 - C. Disruptive selection
 - D. Speciation"
 -
- **Which of the following was NOT a belief of Darwin's?**
 - A. Evolution of species gradually generates more intelligent species.
 - B. There is a struggle for survival among organisms.
 - C. Those individuals with fitter variants will survive and reproduce.