Grade 11 Biology

Evolution

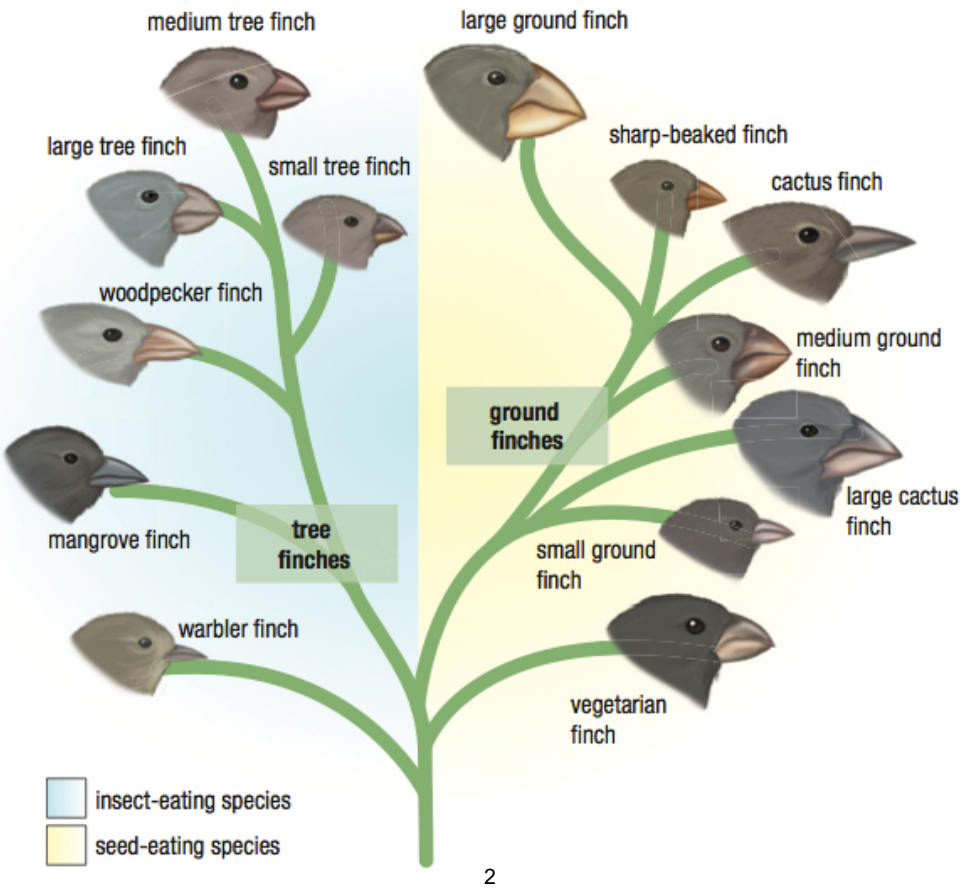
Class 9

Patterns of Evolution

Adaptive Radiation

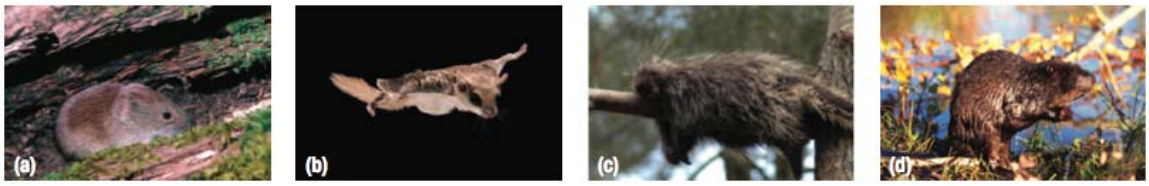
- Rapid evolution of a single species into many new species, filling a variety of formerly empty ecological niches
- Adaptive radiation contributes to biodiversity

- Ex: Darwin's finches on the Galapagos Islands all evolved from a single common ancestor species
- Faced with little competition and a diverse array of food resources, any finches born with a different sized bill or feeding behavior could survive
  - 7 seed-eating species
  - 6 insect-eating species



Divergent Evolution

- Large-scale evolution of a group into many different forms
- Leads to two outcomes:
  - Competition between species is minimized as new species diverge to fill specialized ecological niches
  - New species continue to evolve until most available resources are used
- Divergent evolution increases biodiversity



- Northern Ontario forests house many rodents which evolved from a single common ancestor
- Deer mice prefer small seeds and insects
- Flying squirrel are active during the night while red squirrels are active during the day
- Porcupine feed on twigs and thin bars of conifers
- Beaver feed on twigs and bark of angiosperms

Convergent Evolution

- The evolution of similar traits in distantly related species
- Leads to two outcomes:
  - Natural selection favours evolution of similar traits in similar environments
  - Species will retain other features that provide evidence of their distinct evolutionary past

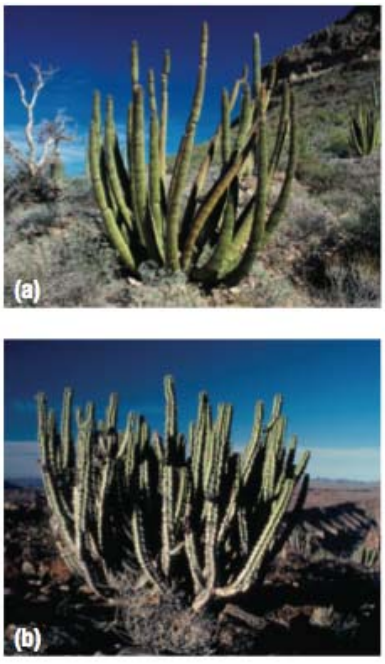
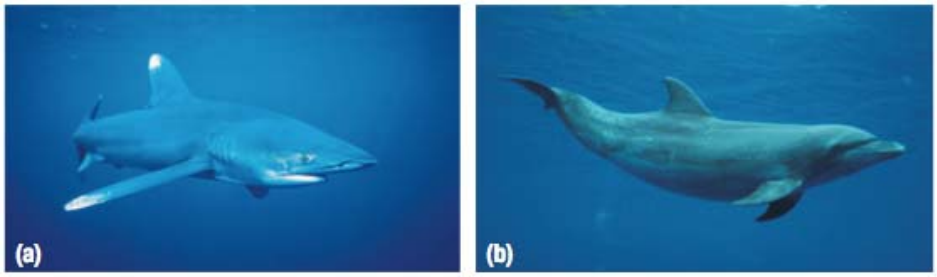


Figure 4 (a) Cacti and (b) euphorbia have evolved similar features in response to their hot dry environments.

- Ex: Cacti evolved in the deserts of South America and are native only to Americas
- Euphorbia look similar to cacti but evolved in the deserts of South Africa
- Both have sharp spines and thick green stems for photosynthesis
- Spines of cacti evolved form leaves
- Spines of euphorbes evolved form the outward growth of stem tissues

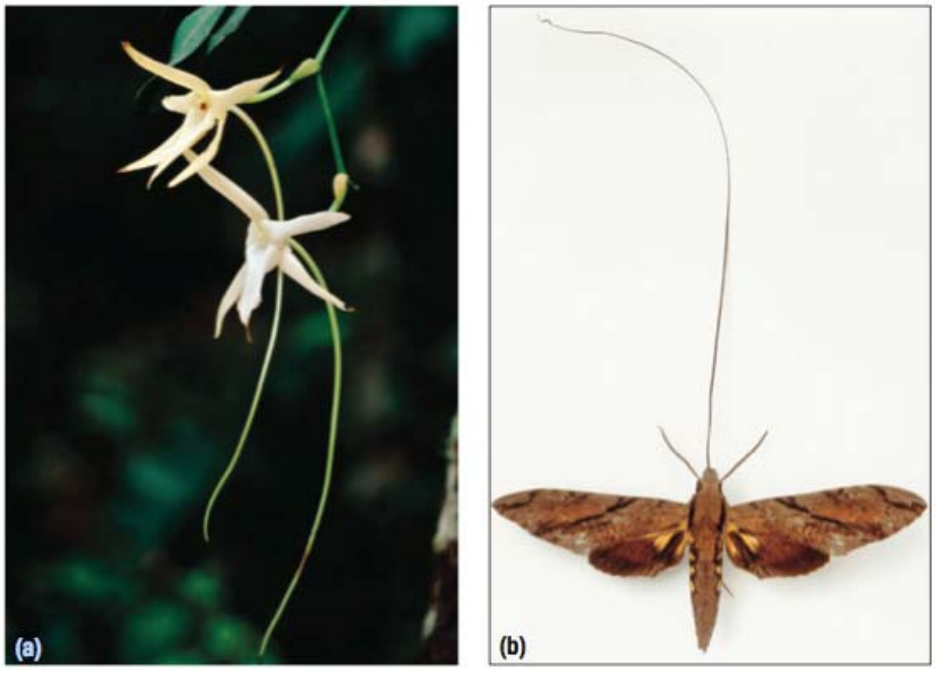


- Ex: Sharks and dolphins both evolved streamlined bodies for their high-speed hunting behavior
- Sharks evolved from a primitive fish with a cartilaginous skeleton and a side-to-side body motion
- Dolphins evolved from warm-blooded marine mammals with a bony skeleton and a up-and-down motion

Coevolution

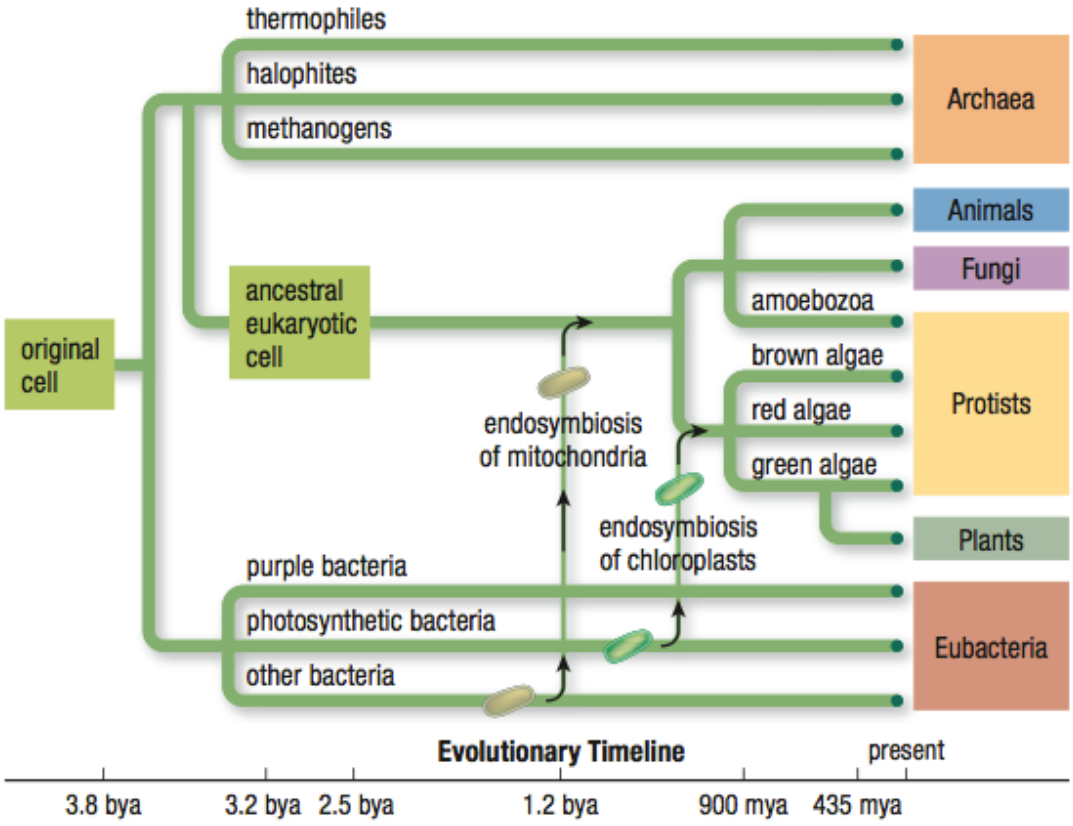
- Process in which one species evolves in response to the evolution of another species
- Also known as an “evolutionary arms race”
- Most pronounced in symbiotic relationships
- Their dependency on each other may cause the extinction of both species if one species is threatened

- Ex: Madagascar long-spurred orchid can only be pollinated by the hawk moth
- Longer spurs was naturally selected for because moths need to spend more time and effort making them more likely to pick up pollen
- Moths with slightly longer tongues could reach the nectar at the bottom of the spurs



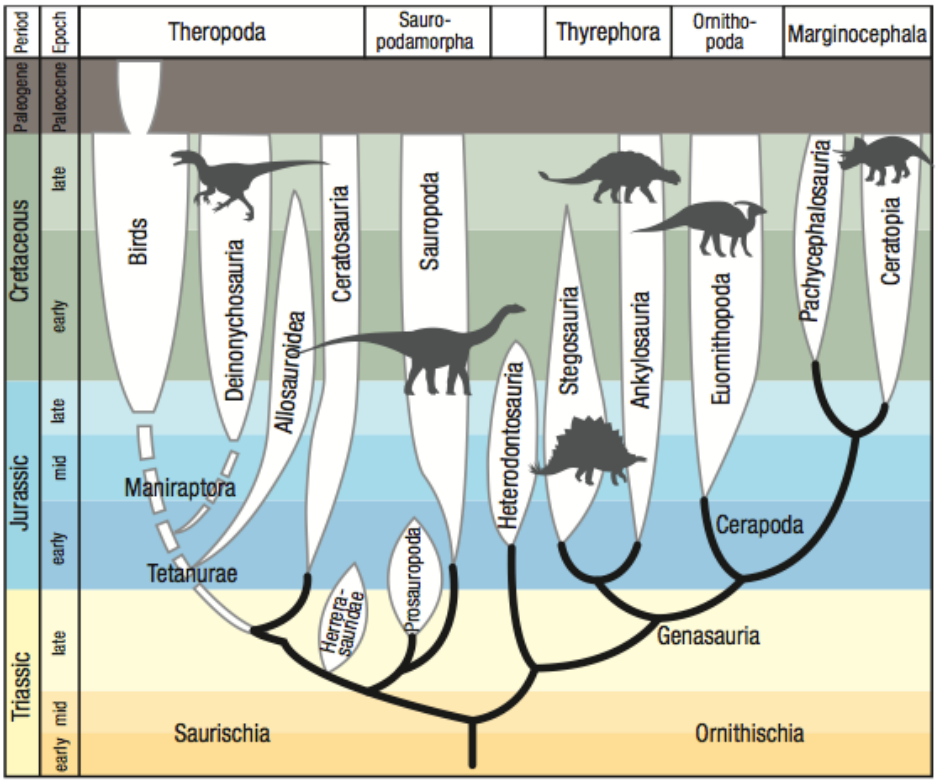
The Tree of Life

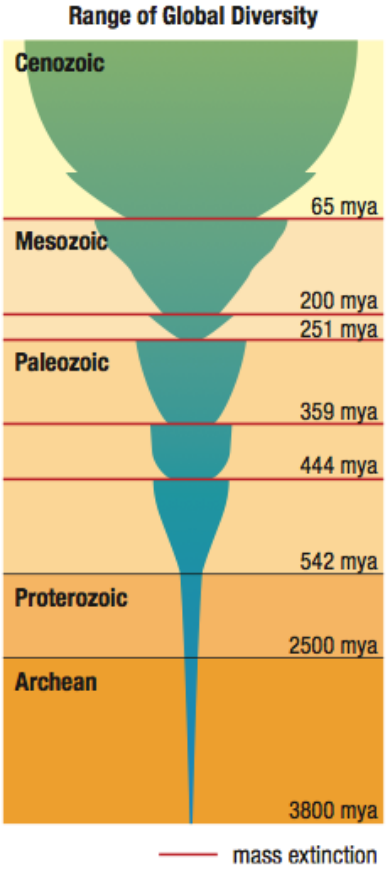
- How did life begin?
- Abiogenesis – the formation of life from non-living matter
  - Many molecules found in life such as amino acids, hydrocarbons, and other simple organic molecules can form under natural conditions
  - Some RNA molecules can self-replicate
- Life existed on Earth for more than 3.5 billion years



Diversification and Mass Extinction

- Dinosaurs underwent a mass extinction 65 millions years ago due to an asteroid crater
- Energy released by the impact of the asteroid released a wave of super-heated air capable of killing all life on land
- Smoke and dust blocked sunlight
- Only surviving descendants of the dinosaurs are birds





History of Life on Earth

- Earth's history is divided into five eras
- Cambrian explosion – time when most animals evolved and underwent rapid diversification
- Movement of tectonic plates, volcanoes and rapid climate change played a role in extinction events

Cladistics and Phylogeny

- Cladistics – the method of determining evolutionary relationships based on the presence of absence of recently evolved traits
- Two groups that share a recently evolved trait (synapomorphy) are thought to be more closely related to each other
- Biologists use software programs and genetic information to determine phylogenetic relationships

Creating a Cladogram

Animal	Characteristics			
	Digits	Skin surface	Forelimbs	Tail
lemur	five digits	hair	grasping hands	present
deer	two digits	hair	non-grasping	present
cow	two digits	hair	non-grasping	present
chimpanzee	five digits	hair	grasping hands	absent
human	five digits	hair	grasping hands	absent
lizard*	five digits	scales	non-grasping	present

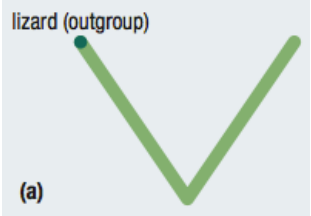
***Outgroup** – a group that is not closely related to the groups of interest and are unlikely to share any recent traits with other groups

- Consider each characteristic and infer which is the most recently derived trait by comparing traits with the outgroup

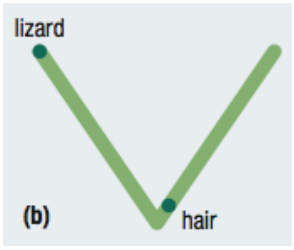
- Create a table of synapomorphies

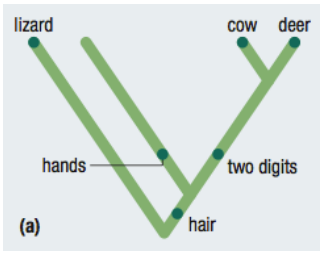
Animal	Synapomorphies—shared derived traits			
	Two digits	Hair	Hands	No tail
lemur	–	+	+	–
deer	+	+	–	–
cow	+	+	–	–
chimpanzee	–	+	+	+
human	–	+	+	+
lizard	–	–	–	–

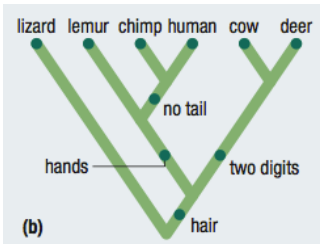
- Draw a V with the outgroup at the upper left. The base represents the common ancestor

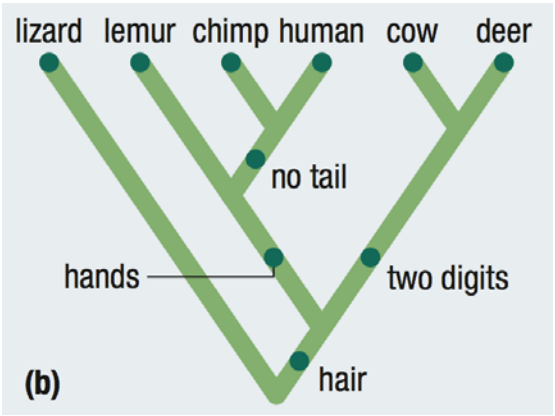


- All the animals except the lizard share the feature of having hair. Indicate the evolution of hair on the right branch
- Remaining animals could either have two digits or grasping hands
- The lack of a tail can be represented by the last branch









- We can infer:
  - Cow and deer are more closely related
  - Humans and chimpanzees are more closely related
  - Lemurs are more closely related to chimps and humans than to cows and deer

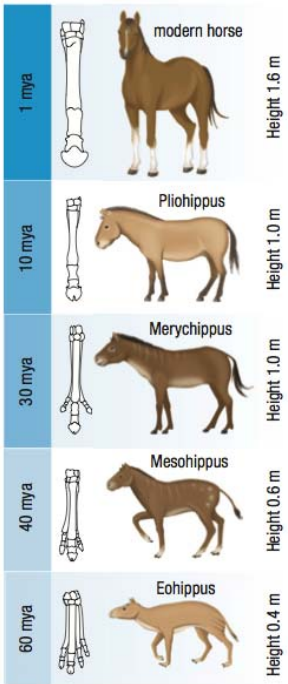
Checkpoint

- Use the data below to construct a cladogram and describe the phylogeny of the organisms.

Animal	Characteristics			
	Mouth opening	Skin surface	Respiratory organ	Bony limbs
lungfish	jaw	scales	lungs	absent
turtle	jaw	scales	lungs	present
robin	jaw	feathers	lungs	present
pike	jaw	scales	gills	absent
lamprey*	no jaw	scales	gills	absent

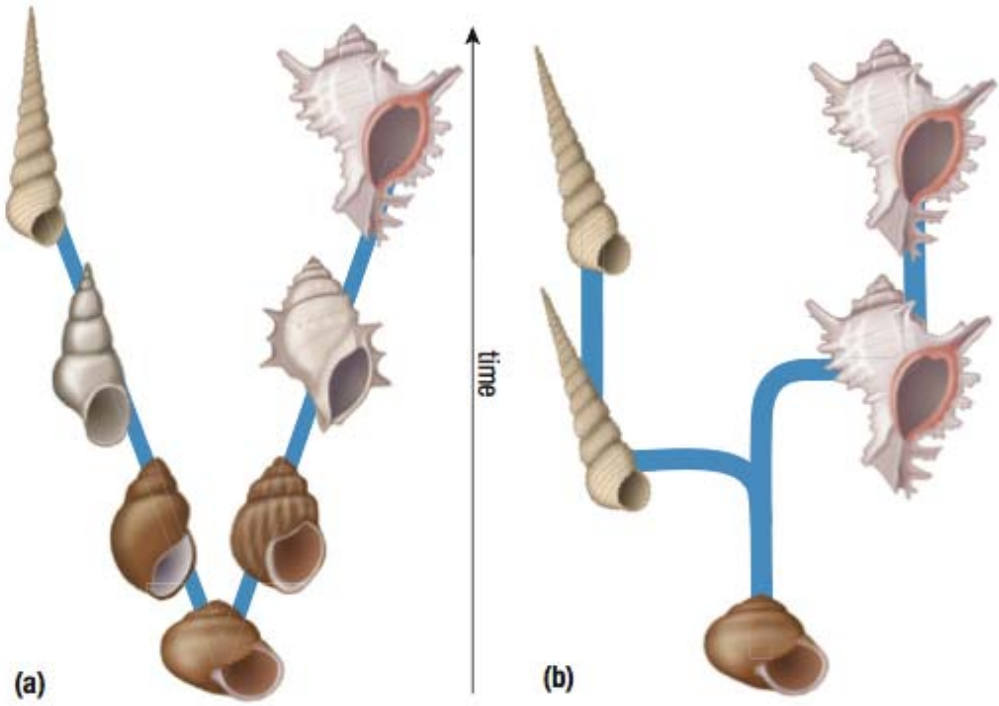
*The lamprey has been chosen as the outgroup.

Gradualism and Punctuated Equilibrium



- How quickly do new species evolve?
- **Theory of Gradualism** – Large evolutionary changes are the accumulation of many small and ongoing changes and processes

- **Theory of Punctuated Equilibrium** – Evolutionary changes come from relatively rapid spurts of change followed by long periods of little or no change
- Assertions:
  - New species evolve rapidly in evolutionary time
  - Speciation usually occurs in small isolated populations and leaves behind few transitional fossils
  - After initial burst of evolution, additional changes are slow
- Both gradualism and punctuated equilibrium play a significant role in evolution



Gradualism **Punctuated Equilibrium**

Figure 10 The fossil of *Archaeopteryx* shows features that are clearly transitional between those of a reptile and a bird.

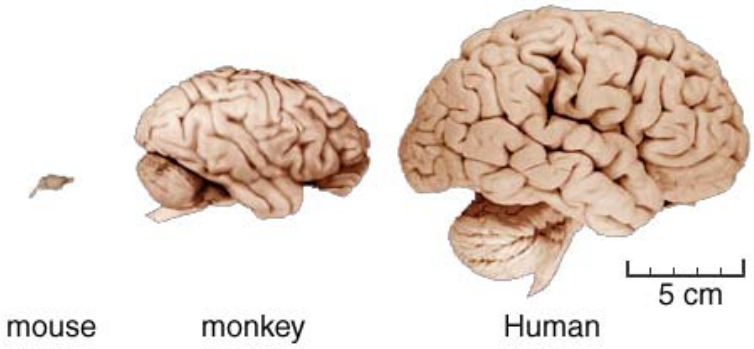
- Transitional forms – a fossil or species intermediate in form between two other species in a direct line of descent
- *Archaeopteryx* is a transitional species that has a bony jaw with teeth and a long, bony tail but also feathered wings

- *Aetiocetus* have nostrils in the middle of the skull which is a transition between early ancestor whales with nostrils front of the skull and modern whales with nostrils on the top of their head

Figure 11 *Aetiocetus* is the transitional form between modern whales and their ancesters.

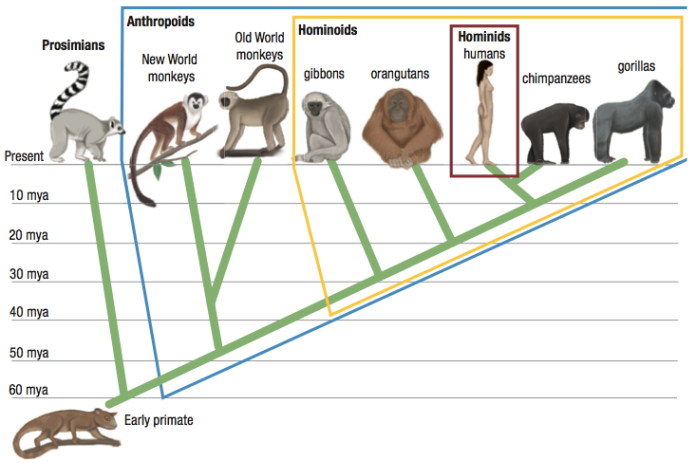
Human Evolution

- Humans have three distinct characteristics:
  - Large brain relative to body size
  - Hands are able to manipulate and coordinate
  - Bipedal allows us to walk upright



Human Phylogeny

- Primates – group of relatively large-brained, forward-directed eyes, flexible hands and feet and arms that rotate fully



- Chimpanzees are the closest living relatives to humans sharing about 98.8% of DNA
- Humans belong in the hominid clade
- 6 millions years ago, hominids could walk upright and use stone axes and large cutting tools
- Tools allowed hominids to increase the amount of meat in their diet providing a rich source of protein and fats
- Use of hearths for cooking allows reduction of disease and allows more food to be consumed

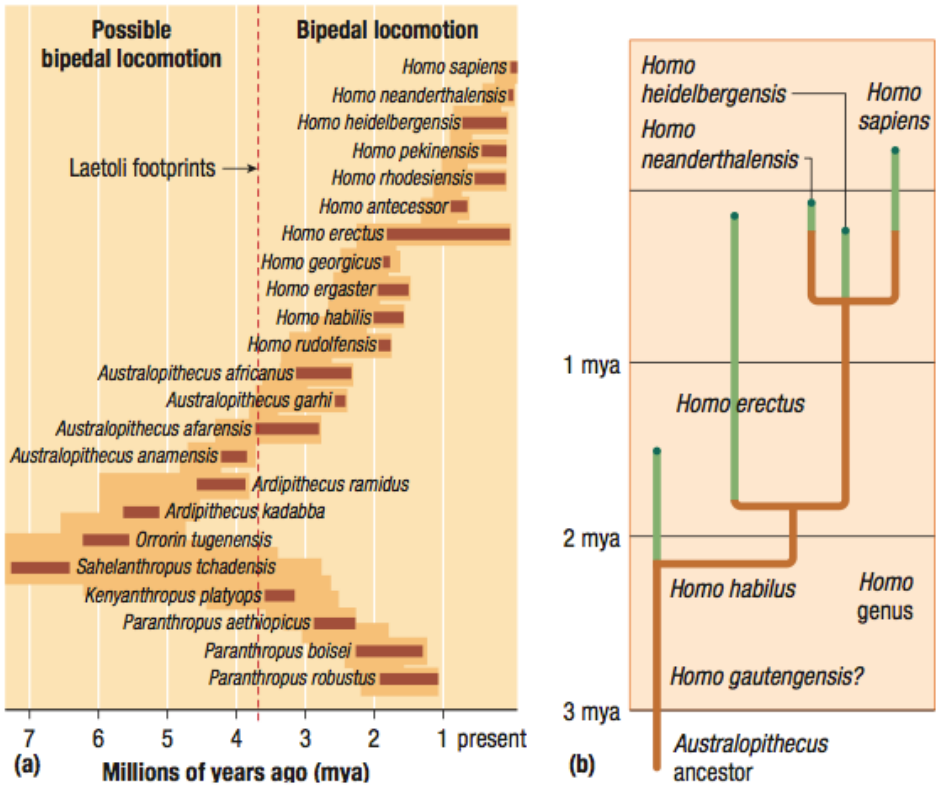
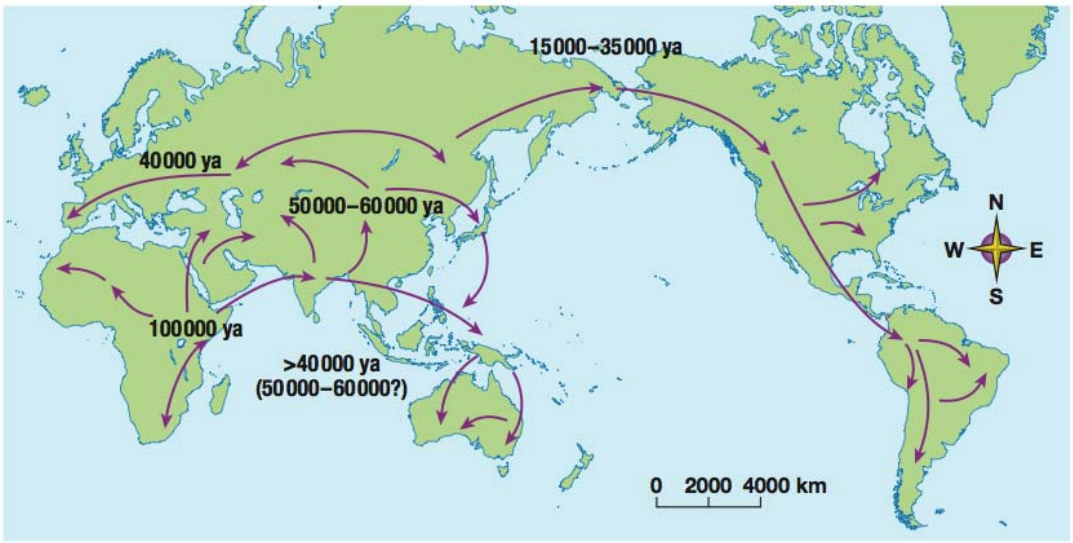


Figure 5 The Laetoli footprint fossils are clear evidence of upright walking dating to about 3.6 million years ago.

- Hominid fossil record shows a set of 69 footprints dates to 3.6 millions years ago
- Footprints show that humans ancestors evolved the ability to walk upright

- All early hominids evolved and lived in Africa
- *H. erectus* population spread to Eurasia
- *H. neanderthalensis* populated parts of Europe



Cultural Evolution

- Ancestors lived as hunter-gatherers for more than 300 000 generations
- In the last 1000 generations, humans have domesticated plants and animals, developed agricultural systems and begun to live in large population centres
- FoxP2 gene codes for a protein that regulates a number of genes vital for human speech

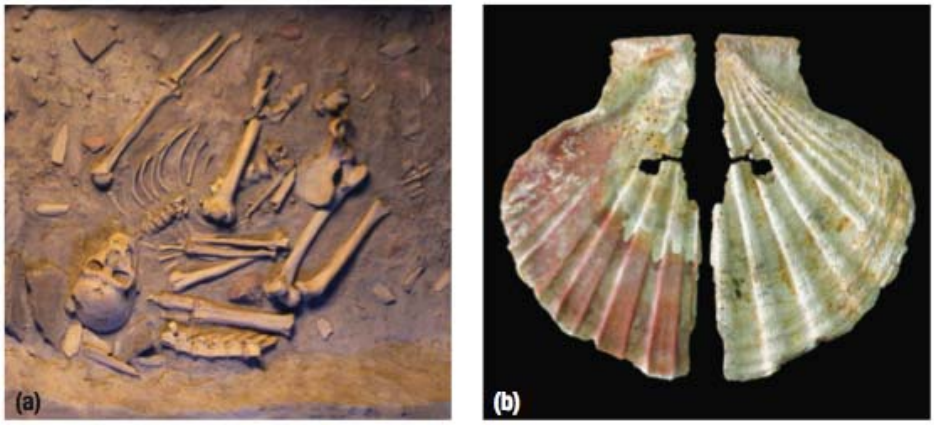


Figure 8 (a) Neanderthals performed burial rituals. (b) Perforated shells made into a neck pendant along with pigments that might have been used as cosmetics—from a Neanderthal site

- Both *H. sapiens* and *H. neanderthalensis* both performed burial rituals and body ornaments
- Some interbreeding may have occurred between the two species

- Cultural evolution influences biological evolution
  - Evolution of lactose tolerance
  - Evolution of domesticated species
  - Evolution of sense of taste

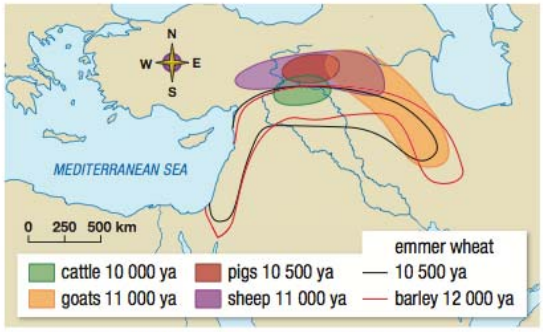


Figure 10 Humans have directly influenced the evolution of many species, including species we have domesticated through artificial selection. "ya" means years ago.