

Evolution

- 1) Introduction to evolution
 - a) **Biology**- Greek; Bios (life) + logos (study of)
 - b) **Zoology** – Greek; zoon (animal) + Logos (study of)
 - c) Life on earth is constantly changing, countless numbers of animals and plants have flourished and gone extinct in earth's **4.6 billion years** of existence.
 - d) On a short timescale (a human lifetime) we see changes in frequencies of different traits within a **population**- a reproductively interactive group of animals of a single species.
 - i) Dark or light colored peppered moths in England
 - ii) Diseases
 - e) Formation of a new species and dramatic changes in organismal appearance require longer time scales. (10,000's – 10's of millions of years)
 - i) Birds
 - ii) Dinosaurs
 - f) **Evolution** is simply the changes in characteristics and diversity of life in Earth's history.
 - i) evolution has produced great diversity of species in the animal kingdom. Over 1.5 million species of animal have been named and thousands are described every year.
 - ii) Many scientist believe that so far we have only managed to name 20% of all existing species and only 1% of all that has ever existed.
- 2) History of evolutionary thought and major contributors to zoology
 - a) The idea that life has changed over Earth's history was first proposed by early **Greek philosophers** (Xenophanes, Empedocles, and Aristotle).
 - i) They recognized fossils as evidence for former life which was destroyed by a natural catastrophe.
 - b) However with the rise of the Catholic Church this evolutionary thought declined among scholars who largely accepted the biblical account of earth's creation which required no mechanistic explanation.
 - i) In the early 1600's A.D. Archbishop James Ussher calculated based on the bible that the earth was formed on Sunday, October 23rd 4004 B.C.
 - ii) This became widely accepted amongst church officials and further declined evolutionary thought labeling it as heretical (which at the time carried a death sentence if found guilty).
 - c) By the 1700's the churches influence had declined enough that naturalist could again speculate on the evolution of animals.
 - d) **Jean Babtiste de Lamarck** (1744-1829) came up with the first hypothesis for how evolution worked.
 - i) He successfully explained that fossils were remains of extinct animals and proposed evolution works by **inheritance of acquired characteristic**
 - ii) This hypothesis states that organisms would acquire adaptations based on their environment and then pass the newly acquired trait to their offspring
(1) Giraffes necks

- (2) **Transformational**- individuals transform their characteristics through uses and disuse of body parts and these traits can be passed on
- (3) Rat tails
- e) **Charles Lyell** (1797-1875)- established **uniformitarianism**- (1) laws of physics and chemistry have not changed throughout earth's history (2) past geological events occurred by natural processes similar to those that we observe today.
 - i) His work went on to show that the earth was more likely millions of years old not thousands and that these changes in earth have no inherent directionality.
 - ii) **Teleology** is the mistaken notion that evolution of living organisms is guided by purpose toward an optimal design.
- f) **Charles Darwin** (1809-1882)- A great naturalist who proposed (along with **Alfred Wallace**) the mechanism for how evolution works (**Natural selection**).
 - i) This is widely accepted amongst the scientific community as the main mechanism for evolutionary change on earth.
 - ii) Modern **Darwinism** actually encompasses many theories of scientific thought.
 - (1) **Perpetual change**: the living world has a long history of ongoing change, with hereditary continuity from past to present life. This is supported by the fossil record and overwhelming numbers of observations and is considered scientific fact.
 - (2) **Common descent**: all forms of life propagated from a common ancestor through a branching lineage. This is supported by studies of organism form, cell structure, and genetics. Again the overwhelming evidence in support of this has placed it into scientific fact.
 - (3) **Multiplication of species**: evolution produces new species by splitting and transforming older ones. This is seen in the fossil record and is supported by modern genetics. Though scientists have great support for this theory, the details of how this process works and what exactly a "species" is is still debated.
 - (4) **Gradualism**: large differences in anatomical traits among species originate by accumulation of many small changes of large periods of time. This theory is an active area of study for evolutionary biologists, because it suggests only small scale changes over time can happen. However, we know examples of sudden genetic changes that have been beneficial for populations. Therefore, we know gradual evolution occurs but it may not explain the origins of all structural differences among species.
 - (5) **Natural selection**: organisms within a population whose traits increase their ability to produce viable offspring will pass on their traits more than those who don't share these traits. This ultimately leads to evolution as the environment changes and favors certain traits.
 - (a) It is important to understand that evolution by natural selection works on existing characteristics.
 - (i) For example, wings evolved from existing forelimbs; however they did not evolve for the "purpose" of flying. Evolution has no foresight.
- g) **Henry Huxley** (1825-1895) "Darwin's Bulldog", one of England's greatest Zoologist and probably the best comparative zoologist to ever live. He had little to no schooling, worked on clarifying

invertebrate relationships, then went on to be the for front of the relationship of humans to apes, and he also first proclaimed that birds came from small dinosaur lineages (which is widely accepted today).

- h) **David Starr Jordan** (1851-1931) an American Ichthyologist (study of fishes) who dominated the field during his career naming and classifying fish from all over the united states and thus producing the first survey of fishes for North America.
- i) **Constantine Samuel Rafinesque** (1783-1784) one of the greatest taxonomist of all time. When reviewing his work it took a full 178 pages to list all the species he had named and classified.
- j) **John James Audubon** (1785-1851) was a great American Ornithologist (study of birds). He named and described over 25 species of birds, and the Audubon society is named after him.
- k) **Edward Drinker Cope** (1840-1897) an American paleontologist, ichthyologist, and herpetologist (study of amphibians and reptiles). He described and named over 1000 species of vertebrates and was the main character behind the bestselling book *Bone Wars*.

3) The fossil record

- a) A **fossil** is a remnant from past life uncovered from the earth.
- b) The **fossil record** is the sequence in which fossils appear in rock strata.
 - i) Based on this sequence and the ages of rocks and fossils geologists have established a **geologic record**.
- c) Ages of rocks or fossils can be determined using radiometric dating. This is a technique that looks at the ratio of an element's stable form (ex. carbon-12) with its radioactive form (ex. carbon-14).
- d) The geologic record is divided into groups based on the dominant life forms present in the fossil record.
 - i) 4 eons
 - (1) Haden- molten earth no life (~1/2 billion years)
 - (2) Archaean- first life forms formed and began to oxygenate our atmosphere (~1.5 billion years)
 - (3) Proterozoic- first eukaryotes formed. (~2 billion years)
 - (4) Phanerozoic- beginning of animals to present (~1/2 billion years)
 - ii) Phanerozoic eon divided into 3 era's
 - (1) Paleozoic- "ancient animals"
 - (2) Mesozoic- "middle animals"
 - (3) Cenozoic –"recent animals"
 - iii) Paleozoic had 6 periods
 - (1) Cambrian- "Cambrian explosion"; rapid proliferation of animal diversity. All life was aquatic and invertebrate
 - (2) Ordovician- colonization of land by fungi, plants, and invertebrates. First vertebrates evolved in the ocean. Ended with a mass extinction of 60% of all life caused by glaciation and sudden sea level dropping.
 - (3) Silurian- proliferation of jawless fishes and first freshwater fish and jawed fish.

- (4) Devonian- “the age of fishes”; diversification of bony fishes, first tetrapods, and insects appear. This period ended in a mass extinction of 75% of all life most likely caused by a series of small extinctions.
 - (5) Carboniferous (sometime divided into Mississippian and Pennsylvanian)- amniotic egg evolves allowing for vertebrates to colonize land further. Origins of reptiles but amphibians still dominate vertebrates. Plant life was so prominent oxygen levels became so high that the air would catch on fire!
 - (6) Permian- radiation of many reptiles that ended with the largest mass extinction in earth’s history (96% loss). The likely cause was a rapid greenhouse effect caused by volcanos and methane released from the sea floor.
- iv) Mesozoic
- (1) Triassic- dinosaurs evolved; origin of mammals. Rapid climate change from increased plate tectonics and possible asteroid impact ended ~50% of known life most notable affecting terrestrial life allowing for dinosaurs to fill in and become the dominant animal group.
 - (2) Jurassic- plant eating dinosaurs dominate the landscape, flight evolves in vertebrates and the first birds evolve.
 - (3) Cretaceous- the breakup of **Pangea** led to diversification of organisms. Ends with asteroid impact off of modern day Mexico’s Yucatan peninsula forming the **KT boundary** killing 75% of life. This ends life for almost all dinosaurs opening up space for the mammals to take over.
- v) Cenozoic is divided into two periods tertiary (before *Homo*) and Quaternary (after the formation of genus *Homo*)