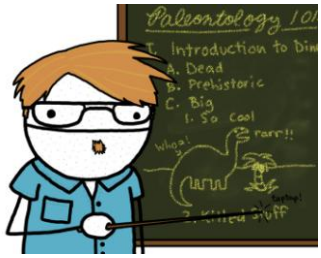
Chapter 19.1

The Fossil Record



19.1 Objectives

- 19.1.1 Explain what information fossils can reveal about ancient life
- 19.1.2 Differentiate between relative dating and radiometric dating.
- 19.1.3 Identify the divisions of geologic time scale.
- 19.1.4 Describe how environmental processes and living things have shaped life on Earth.
- Indiana Standards covered: NoS.6

Fossils

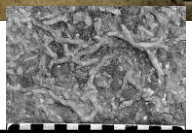
- Most important info on extinct species
  - Ones that have died out
- More than just the giant dinosaur skeletons we are used to seeing in museums.

Natural Casts

- A mold forms when flowing water removes all of the original bones or tissue leaving just an impression
  - When minerals fill in the mold recreating the original shape a cast is made

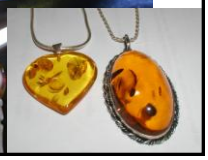
Trace Fossils

- Record the activity of an organism
  - Nests, burrows, imprints of leaves or footprints, feces



Amber-Preserved Fossils

- Organisms that become trapped in tree resin that hardens into amber after the tree gets buried underground



Preserved Remains

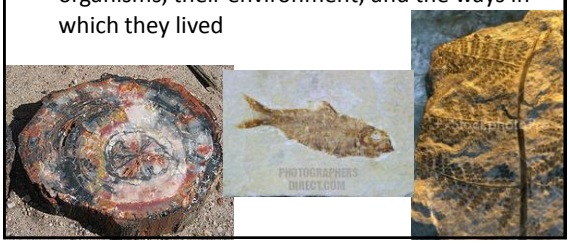
- Form when an entire organism becomes encased in material such as volcanic ash, ice, or immersed in bogs (tar pits)

Fossils

- Most form in sedimentary rock which is made by layers of sediment or small rock particles
- Best environments for fossilizations are wetlands, bogs, and areas where sediment is continuously deposited such as river mouths, lakebeds and floodplains

What Fossils Can Reveal

- From the fossil record, paleontologists can learn about the structure of ancient organisms, their environment, and the ways in which they lived

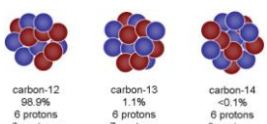


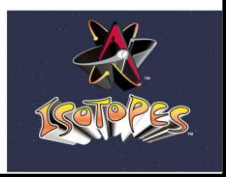
Relative Dating

- Geologists found in the 1700s that rock layers at the bottom of an undisturbed sequence of rocks were deposited before those at the top and therefore were older
  - Relative dating estimates the time during which organisms lived by comparing the placement of fossils

Radiometric Dating

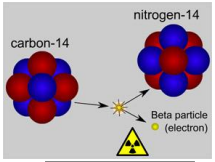
- Used to estimate a fossil's actual or absolute age using the natural decay rate of unstable isotopes found in materials
  - Isotopes of an element have the same number of protons but different numbers of neutrons
    - Ex. Carbon-12, Carbon-13, Carbon-14

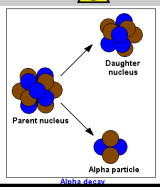




Radiometric Dating

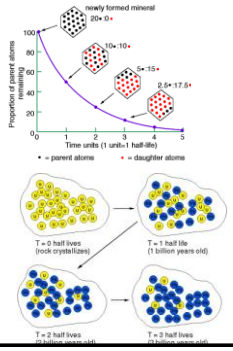
- Some isotopes have unstable nuclei meaning they break down over time
  - This releases radiation in the form of particles and energy
  - As it decays it becomes a different element





Radiometric Dating

- The amount of time it takes for half of the isotope in a sample to decay into a different element or its product is a half-life
  - Half-life is not affected by environmental conditions like temperature or pressure
  - Ex. Carbon-14 decays into Nitrogen-14 with a half-life of about 5700 years

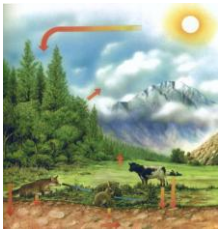


1. Assuming we start with only parent isotopes (no daughter), after one half-life has passed, there should be 1⁄2 parent remaining and 1⁄2 daughter newly formed. The ratio of P:D is 1⁄2 : 1⁄2 or 1:1. Complete the rest of this table, as in the first example:

# Half-lives	Fraction of Parent material	Fraction of daughter material	Parent: Daughter Ratio (P:D)
1	½	½	1:1
2			
3			
4			
5			
6			

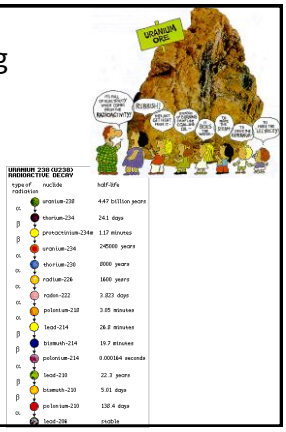
Radiocarbon Dating

- Carbon-14 is commonly used for radiometric dating of recent remains
  - Organisms absorb carbon through eating and breathing so it is constantly being resupplied, when it dies the intake stops, but the decay continues
  - Depending on the ratio of parent to daughter material the age can be determined.



Radiometric Dating

- For older stones and fossils, different isotopes are used.
  - Ex. Uranium-238 that breaks down into lead-206 has a half life of 4.5 Billion years
  - Ex. Chlorine-36 that breaks down into argon-36 has a half life of 300,000 years

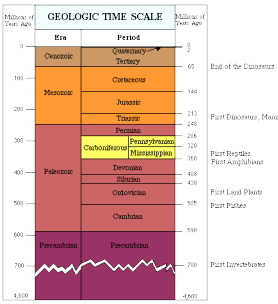


Determining the Earth's Age

- Scientists have used radiometric dating to determine the age of the Earth
  - Due to erosion and the rock cycle rocks do not remain in their original state
  - Meteorites however do not get recycled
    - They are thought to be formed at similar times so we used uranium – to – lead isotope ratios to determine it is about 4.5 Billion years old

Geologic Time Scale

- A representation of the history of Earth
  - Organizes history by major changes or events that have occurred using evidence from the fossil and geologic records
  - Has three basic units of time: era, period, and epoch



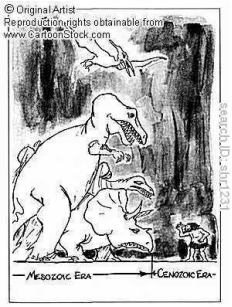
Geologic Time

- Eons-four total
- Era-lasts tens to hundreds of millions of years
  - Consist of 2+ periods
- Periods-most commonly used unit of time, last tens of millions of years
  - Each is associated with a particular rock system
- Epoch-smaller units of geologic time that last several millions of years

Cenozoic Era	Quaternary Period	Holocene Epoch
		Pleistocene Epoch
	Tertiary Period	Pliocene Epoch
		Miocene Epoch
		Oligocene Epoch
		Eocene Epoch
		Paleocene Epoch

Geologic Time

- Eras came from ideas about life forms preserved as fossils
  - Ex. Paleozoic means "ancient life"
  - Ex. Mesozoic means "middle life"
  - Ex. Cenozoic means "recent life"
- Periods are defined by mass extinction events

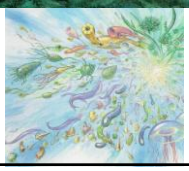


Paleozoic Era

- Time frame when multicellular organisms first appeared around 542 million years ago
  - Members from every major animal group evolved within only a few million years
  - Ended in 251 million years ago with a mass extinction
    - 90% of marine animal species and 70% of land animal species became extinct

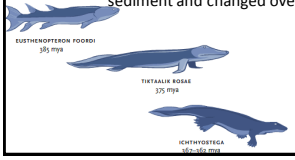
Paleozoic Era

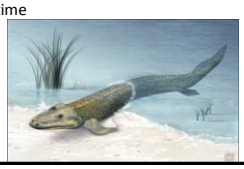
- After the mass extinction multicellular organisms radiated (first vertebrates, land plants)
  - Cambrian explosion-huge diversity of animal species evolved
    - In the beginning all organisms were in the ocean
      - First vertebrates were jawless fishes, lots of trilobites
      - Many arthropods, but most died in the mass extinction



Paleozoic Era

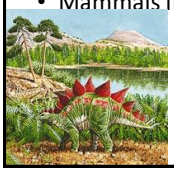
- Life moved onto land during the middle of this era
  - Number and variety of plants increased
  - Four legged vertebrates became common including amphibians
  - Most of the coal in the US formed during the Carboniferous period for the remains of millions of organisms buried in the sediment and changed over time





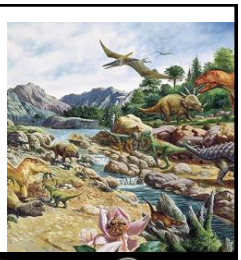
Mesozoic Era

- From 251-65 million years ago
- Called the age of reptiles because the dinosaurs roamed during this era
- Birds and flowering plants were prominent
- Mammals first appeared including marsupials



Mesozoic Era

- Divided into three periods
  1. **Triassic**-crocodiles and dinosaurs arose, first mammals, extinction near the end of this period destroyed many animal families
  2. **Jurassic**-LOTS of dinosaurs and abundant underwater life like sharks, bony fishes, ichthyosaurs
  3. **Cretaceous**-rise in marsupials and other mammals, ended with mass extinction caused by meteorite strike that killed the dinosaurs

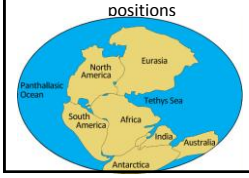


Cenozoic Era

- Began 65 million years ago and continues today
- Made up of two periods
  1. Tertiary- (65-1.8 mill. Years ago)
     - Placental mammals and monotermes (mammals that lay eggs) evolved, lots of birds and flowering plants, and first human ancestors appeared near the end
  2. Quaternary- (1.8 mill. Years ago till today)
     - Homo sapiens appeared about 100,000 years ago

Plate Tectonics

- Explains how the Earth's plates move slowly over the Earth's mantle
  - Earth started with the super continent Pangaea around 225 million years ago
    - Slowly moved over millions of years to their current positions



19.1 Assessment: What can paleontologists learn from fossils?

- Structure of organisms, about their environment, and the way they lived

19.1 Assessment: Why do so few organisms become fossilized?

- Need rapid burial and hard parts like teeth or bones
- Even if one is made could be destroyed by earthquakes or other forces

Chapter 19.2

Patterns in Evolution

19.2 Objectives

- 19.2.1 Identify the processes that influence survival or extinction of a species or clade.
- 19.2.2 Contrast gradualism and punctuated equilibrium.
- 19.2.3 Name two important evolutionary characteristics of coevolving organisms.
- Indiana Standards covered: NoS.3 & B.8.5

Species can Become Extinct

- Elimination of an entire species is extinction
  - Occurs when a species as a whole is unable to adapt to a change in its environment
  - Two types
    1. Background extinctions
    2. Mass extinctions

1. Background Extinctions

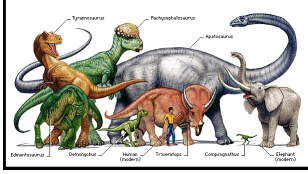
- Extinctions that occur continuously but at a very low rate
  - Occur at roughly the same rate as speciation
  - Usually only affect one or a few species in a small area like a rain forest or mountain range
  - Caused by changes in environment like new predators or a decrease in food

2. Mass Extinctions

- These are fairly rare, but much more intense
  - Usually happen on a global level
  - Destroy many species
  - Occur due to catastrophic events like ice ages or asteroid
  - Have had at least 5 in the last 600 mill. years

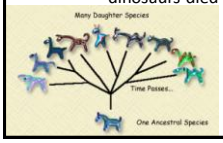
Result of Mass Extinction

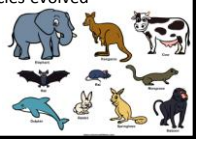
- Encourages rapid evolution of the surviving species by making new environments and resources available to them.



Speciation Occurs in Patterns

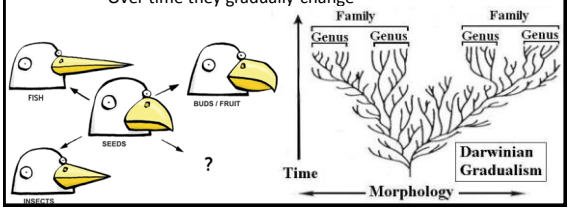
- The diversification of one ancestral species into many descendents is called adaptive radiation
  - Usually adapted to a wide range of environments
  - Ex. Mammals after the Cretaceous mass extinction
    - Early mammals were small insect eaters, but after the dinosaurs died 4000 mammal species evolved





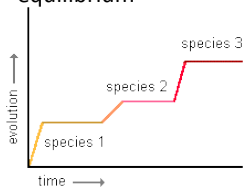
Gradual Evolution

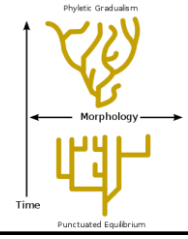
- Gradualism
  - Darwin's idea that by slow, stead pace of geologic time that evolution also needed to be slow and steady
    - Over time they gradually change



Speciation Occurs in Patterns

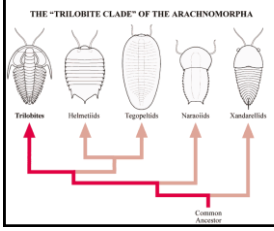
- In the fossil record, there are bursts of evolutionary activity followed by long periods of stability, this pattern is punctuated equilibrium





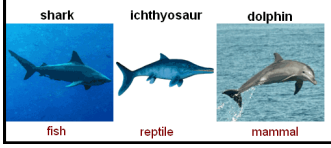
Clade Survival

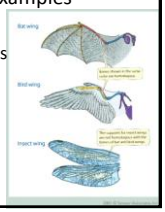
- In order for a clade of organisms to survive the rate of speciation must be equal to or greater than the rate or extinction.



Convergent Evolution

- Evolution toward similar characteristics in unrelated species due to similar environmental pressures
  - Analogous structures are common examples
    - Ex. Wings on birds and insects
    - Ex. Tail fins of fish and marine mammals





Beneficial Relationships Through Coevolution

- Bull-thorn acacia plant has hollow thorns that stinging ants live in
  - The ants get nectar from the plant, and the ants protect the plant from animals that want to eat it
  - This relationship developed from coevolution meaning that two or more species evolved in response to changes in each other

Evolutionary Arms Races

- Coevolution can occur in competitive relationships and an evolutionary arms race
  - Each species responds to pressure from the other through better adaptations over many generations
    - Ex. Plants create chemicals to discourage herbivores from eating them, the herbivores have a resistance, plants with stronger chemicals are favored, etc.

19.2 Assessment: How does variation within a clade affect the clade's chance of surviving environmental change?

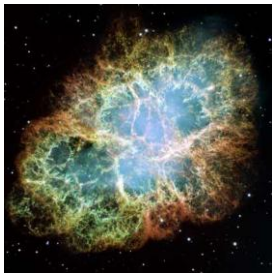
- If there is variation, it increases the chance of the surviving environmental changes.

19.2 Assessment: Explain how punctuated equilibrium is different from gradualism.

- Punctuated equilibrium consists of brief periods of rapid change that interrupt periods of little change. Gradualism is a slow, steady pace of change in species.

Chapter 19.3

Earth's Early History

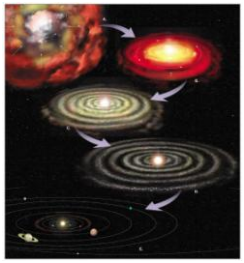


19.3 Objectives

- 19.3.1 Identify some of the hypotheses about early Earth and the origin of life.
- 19.3.2 Explain the endosymbiotic theory.
- 19.3.3 Explain the significance of sexual reproduction in evolution.
- Indiana standards covered: NoS.3, B.6.5, B.8.1, B.8.6, & B.8.7

Earth's Beginning

- Solar system was formed from a condensing nebula, a cloud of gas and dust in space.
  - Supported by computer models and observations from the Hubble Space Telescope
  - About 4.6 billion years ago the Sun formed from the nebula
  - Over time, the material pulled together due to gravity and repeated collisions creating the planets

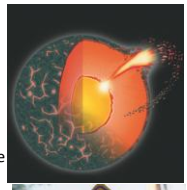


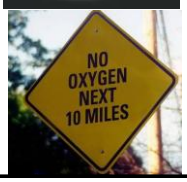
Earth's Beginning

- Earth was most likely violent and very hot for its first 700 million years (now called the Hadean era)
  - Many asteroids, meteorites, and comets struck the planet releasing lots of heat
  - Radioactive decay of elements inside the Earth released heat as well

Earth's Beginning

- The heat kept the Earth in a molten state, but eventually it cooled and formed layers
  - Hydrogen, carbon monoxide, and nitrogen gas were released from the interior creating an atmosphere containing compounds like ammonia, water vapor, methane, and carbon dioxide
  - Most scientists agree that free oxygen was not abundant until 2 billion years ago after the first life forms evolved



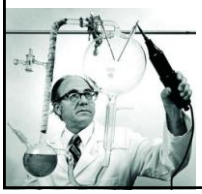


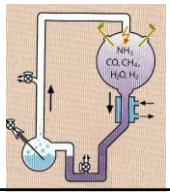
Earth's Beginning

- With the cooling of the Earth the continents began to form
- Water vapor in the air condensed and fell as rain creating pools and large bodies of water
  - Once liquid was present organic compounds could be formed

Organic Molecule Hypothesis

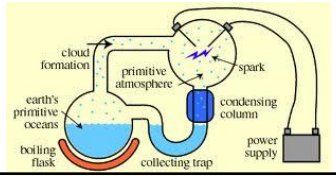
- Miller-Urey experiment
  - In 1953 Miller and Urey designed an experiment to test earlier scientists idea that energy from lightning led to the formation of organic molecules from inorganic molecules present in the atmosphere





Organic Molecule Hypotheses

- Miller-Urey experiment
  - They built a system to model conditions they thought existed on early Earth
  - They demonstrated that organic compounds could be made by passing an electrical current (simulates lightning) through the mixture of gases

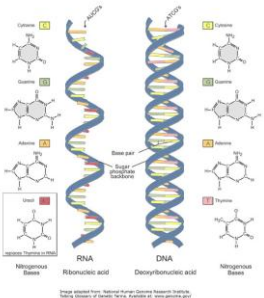


Organic Molecule Hypotheses

- Miller-Urey experiment
  - They produced a variety of organic compounds including amino acids needed to build proteins
    - They used an atmosphere of methane, ammonia, hydrogen, nitrogen, and water vapor
      - Later scientists said that different compounds were found in the atmosphere but similar tests still created organic molecules

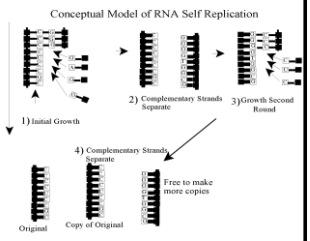
RNA as Early Genetic Material

- RNA is proposed as the genetic material for early living things on Earth instead of DNA
- In the 1980s, Cech and Altman independently discovered that RNA can catalyze reactions
  - Ribozymes are RNA molecules that can catalyze their own replication and synthesis



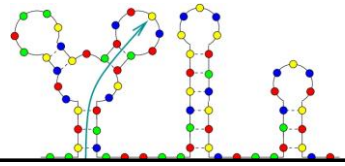
RNA as Early Genetic Material

- RNA can copy itself, chop itself into pieces, and then make more of itself
  - DNA however needs other enzymes to replicate itself
- Short chains of RNA will form from inorganic materials in a test tube
  - If zinc is added as a catalyst even longer chains will grow



RNA as Early Genetic Material

- RNA can fold into different shapes depending on the sequence of nucleotides
  - This allows it to perform more functions than DNA
  - However it does not catalyze reactions as well as proteins, nor store genetic info as well as DNA so it eventually became less important



Power of Microbes

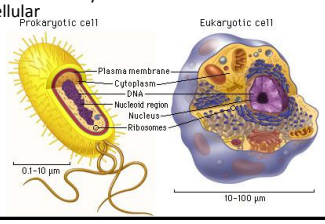
- Single-celled organisms deposited minerals changing the atmosphere by giving off oxygen by photosynthesis
  - Before that the first ones were anaerobic and lived without oxygen

Power of Microbes

- Scientists have found evidence of photosynthetic life more than 3.5 bill. Years ago
  - They were marine cyanobacteria which are bacteria that can carry out photosynthesis
  - Some live in colonies and form stromatolites which are domed, rocky structures
  - Gave off oxygen and allowed aerobic organisms to live

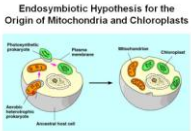
How Eukaryotic Cells Evolved

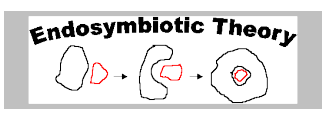
- Fossil record shows that eukaryotic organisms evolved by 1.5 billion years ago
  - Unlike prokaryotes, eukaryotes have a nucleus and membrane-bound organelles
  - First ones were only one cell but later ones became multicellular



How Eukaryotic Cells Evolved

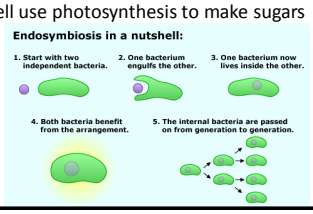
- In the 1970s the hypothesis of endosymbiosis gained popularity
  - It is the relationship in which one organism lives within the body of another and both benefit
  - It suggests that early mitochondria and chloroplasts were once simple prokaryotic cells that were taken up by larger prokaryotes around 1.5 bill. Years ago





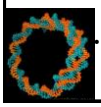
How Eukaryotic Cells Evolved

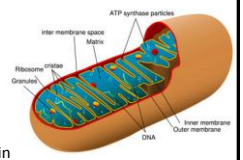
- Instead of being digested some of the smaller prokaryotic cells survived inside the larger ones
  - Advantages: larger cell gets energy in the form of ATP from the mitochondria and the chloroplast let the larger cell use photosynthesis to make sugars

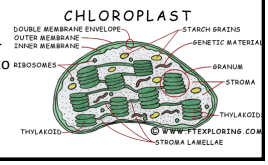


How Eukaryotic Cells Evolved

- Lynn Margulis found evidence to support the endosymbiotic hypothesis
  - Mitochondria and chloroplasts have their own DNA and ribosomes
  - They can copy themselves within the cell they are a part of
  - About the same size as prokaryotes
  - DNA forms a circle and their gene structures are similar to prokaryotes
  - Similar membranes to prokaryotes

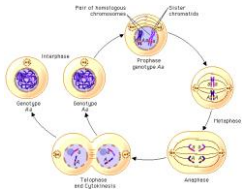


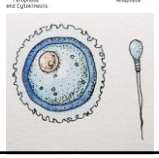




Evolution of Sexual Reproduction

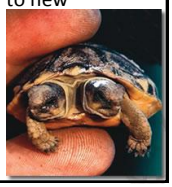
- The first prokaryotes and eukaryotes produced asexually.
  - Asexual reproduction creates identical offspring and is quicker
  - Sexual on the other hand needs two parents and by combining their genes it creates genetic diversity, but requires more energy





Evolution of Sexual Reproduction

- The evolution of sexual reproduction is still being researched
  - It was used to help mask harmful mutations and increase survival through natural selection
  - It allows organisms to adapt quickly to new conditions



19.3 Assessment: What was Earth's early atmosphere like?

- Made up of mainly carbon dioxide, water vapor, and nitrogen. Little to no oxygen.

19.3 Assessment: What evidence supports the endosymbiotic theory?

- Have DNA and ribosomes
- Can reproduce on their own
- Circular DNA
- Same size as prokaryotes
- Membrane similar to prokaryote