Unit 7: Evolution
Content Outline: Geologic Time and Processes (7.3) – Part 1

I. James Hutton (1726 – 1797)
   A. He was a **Geologist**. This is someone who studies rocks and earth's processes.
   B. He proposed the **Theory of Gradualism**. This theory tries to explain that that the earth must be *very, very old* because in order for some processes to occur, such as mountain formation or canyon formation, it would *require enormous amounts of time*.
      1. According to the theory, Earth must be very old. This is *very* important to Darwin's theory of Natural Selection because the theory of gradualism *supports the time frame* needed for Natural Selection to transform species *over generations*.

II. Charles Lyell (1797 – 1875)
   A. He was also a Geologist.
      1. He wrote a book titled *Principles of Geology*. (Darwin took this book on the Beagle voyage.)
      2. In the book, Lyell proposed the **Theory of Uniformitarianism**. ("The key to the past is the present".) The theory tries to explain that the *same* geologic processes that are occurring today, also occurred in the past. These processes helped to create, over millions of years, the geologic formations we see today. For example, erosion, over millions of years and *still* today, led to the formation of the Grand Canyon.
      3. For this theory, Earth must be hundreds of millions of years old. (This also supports Darwin's theory… it provides enough *time to pass* so that we get the millions of different species to evolve.)

Please review Georges Cuvier and his Theory of Catastrophism at this point. Then please tie the three people together by the work that they all did and relate it back to Darwin's Theory of Natural Selection as time is important to the theory.

III. Dating Fossils to create a geologic "time line":
   A. Two ways this can be achieved:
      1. Absolute "Radiometric" dating
         a. Uses the *half-life* of radioactive elements that accumulate in an organism over time.
         b. C-14 (Used for thousands.); U-238 (Used for millions billions.)
      2. Relative Dating
         a. Uses the *different strata of rock* and **index fossils** to establish a time line. **Index Fossils** are fossils that we know a specific time period they existed. They are compared to the location or strata where we found an "unknown" dated fossil. If the "unknown" is found above the index, the "unknown" is younger. If the "unknown" is found below the index, the "unknown" is older. *Positions* are *relative* to *time*.
   B. Plate tectonics
      1. Refers to the *moving* of the continental plates.
      2. The continents moving are a direct cause of the biogeography of species.
      3. Collisions? (Mountains form.)
      4. Separation? (Sea floor spreading… see the "world's Zipper" in the Atlantic Ocean floor.)
      5. Subduction and slipping? (Plates being pushed under the other, such as by Japan; Plates sliding past one another, as in California.)
      6. "Ring of Fire" (Refers to all the volcanoes around the Pacific Plate.)

Geologic Time and Processes (7.3) – Part 2

I. Macroevolution (Evolution/Change on a *large* scale.)

A. This term refers to the evolution of a *new taxon* from a *pre-existing taxon*. (Basically, the evolution of a new species or higher on the classification scale.)

B. **Punctuated Equilibrium**

1. This way of speciation was proposed in 1976 by Stephen Jay Gould, a famous Harvard professor.
2. In this method, *long periods of stability(this is the equilibrium)* are interrupted *suddenly(this is the punctuated)* by a major disruption(such as an asteroid hitting the earth) that causes a mass extinction of existing species to occur. Once all disruption has calmed down(usually after several years), a mass evolution of new species will occur to occupy all the new open niches that were created due to the mass extinction. (These punctuations usually mark/cause the end of an era.)
3. Snowball Earth caused the end of the Pre-Cambrian era. 7/8 of the earth was covered by ice. It took millions of years to thaw out. Most organisms died. Those that survived were around deep sea thermal vents, where it was warm enough to support life. Once the ice melted, the Cambrian explosion of species occurred to start the beginning of the Paleozoic Era (called the Age of Fish).
4. Pangea, the super continent, caused the end of the Paleozoic era. This coming together of all the continents caused the earth's water to be dramatically displaced. The interior swamps and oceans disappeared and over time became vast deserts. Most aquatic and terrestrial animal and plant species went extinct due to loss of water. Those that survived were around the edge of the supercontinent or in the one big ocean. This mass extinction allowed for the mass explosion of new reptile species and desert plants. This began the Mesozoic Era(called the Age of Reptiles).
5. The Asteroid that hit the earth 65 million years ago caused the end of the Mesozoic Era and the extinction of the dinosaurs and many plant species. It caused the sun to be blocked out by soot and ash for years. The planet became very cold. The organisms that survived were mainly Mammals, because of their warm fur. Some reptiles, amphibians, and fish survived too. Also some plants. Once the sun returned to the entire earth, we see the mass explosion of mammals and the beginning of the Cenozoic Era (called the Age of Mammals).

C. Microevolution *can cause* Macroevolution to occur *with enough time and enough changes in the DNA*.

Students will see these again in the next section. It is important that students understand that the equilibrium is referring to the long periods of stability and that little species changes on a large scale occurs there. There are occasional Punctuations of trauma that cause mass extinctions. The mass extinctions are always followed by large scale explosion of new species trying to fill the open niches. So most new species and traits appear at the beginning of a new time period.

Geologic Time and Processes (7.3) – Part 3

I. Geologic Time Scale, Plate Tectonics, and Major Geologic events

A. Eras – These are the *largest* periods of time.

1. Separated by *catastrophic global* event. (See below)
2. Eras are broken into smaller time frames called **Periods.**
   a. Periods are broken into smaller time frames called **Epochs.**
3. These time frames are based on strata fossil evidence of primary plants and animals found.

B. Pangaea (**Punctuated Equilibrium** occurred.)

1. The *super-continent* formed 250 mya and then separated 180 mya.
   a. MYA = Million Years Ago
2. Separates the Paleozoic Era from the Mesozoic Era.
3. Global effects? Most land is desert, except for along the coast of the one ocean.
4. Life affected? All life forms.
5. This is supported through fossil and geologic evidence.

Students need to understand life still existed in the water. It was just that there was only one large ocean. Aquatic organisms could get caught inbetween land masses and eventually that water would dry up or be displaced. The land was plush around the edge where water existed, but the majority of the center was dessert like.

C. **Impact Theory** (around 65 mya) (**Punctuated Equilibrium** occurred here too.)

1. Separates the Mesozoic Era from the Cenozoic Era.
2. Walter & Luis Alvarez came up with the theory.
3. Global Effects? Sunlight was absent from most of the earth. Dinosaurs go extinct.
4. Iridium, element found in asteroids, is found at the K/T boundary only in soil samples.
5. The impact point was around the modern day town of Chixalub, Mexico. (On the Yucatan Peninsula.)

Students need to be able to relate the presence of sunlight to photosynthesis and warmth. No light means little photosynthesis and cold. Also students should remember from 7th grade life science that reptiles are Ectothermic ("cold blooded") and birds and mammals are endothermic ("warm blooded"). This internal heating comes from digesting our food in cellular respiration. So the heat would help survival as well as fat and feathers/fur.

D. **Snowball Earth** (**Punctuated Equilibrium** occurred here too.)

1. Formed 750 mya lasted til 570 mya
2. Separates the Pre-Cambrian Era from the Paleozoic Era.
3. Global Effects? Most life dies, except around deep-sea vents.

E. Eukaryotic Life forms evolve about 2.7 billion years ago (Remember the Endosymbiant Hypothesis?) Please review the Endosymbiant Hypothesis with students.

G. Oxygen Catastrophe or Oxygen Revolution

1. The rapid rise in atmospheric free oxygen occurred about 2.7 Billion years ago by the evolution of Cyanobacteria in the Earth's water bodies. ("cyano" means "blue-green")

Please point out to students that since the bacteria are blue-green they can perform photosynthesis. This creates food but also Oxygen gas as the waste product. Oxygen gas is corrosive and can breakdown other molecules. This is why we use it to help breakdown our food and get energy.

2. This caused a mass extinction of *anaerobic* (lacking oxygen) organisms. Oxygen was deadly to them.

Please go over anaerobic and aerobic with students.

H. Prokaryotic Life forms evolve about 3.5 Billion years ago.

H. Geologic Time and Processes (7.3) – Part 4

I. **Homologous** structure vs. **Analogous** structures
   A. Remember, Homologous structures indicate common ancestry.
   B. Remember, Analogous do not indicate common ancestry (*Just* similar function.)
      1. Fly wing vs. Bird wing
   C. **Convergent Evolution** –Remember, only *appear* to be related due to *similar* environments and pressures.

II. **Cladogram** or **Phylogenic Tree**
   A. It is an "Either – or" evolutionary tree based on *shared characteristics*.
   B. *Common ancestor*s are indicated at the "Y"
   C. Each branch called a **clade.**
      1. *Must* be common ancestor and *all* of its descendants.
   D. Construction of one:
      1. **Ingroup** (common structure) vs. **outgroup** (outcast)
         a. Ingroup organisms get a 1; outgroup organism gets a 0.
      2. Shared Primitive Character
         a. Trait that is *common to many taxons* or clades. (For example, a Backbone.)
      3. Shared Derived Character
         a. Trait that is *common to one clade* only. (For example. Hair on mammals.)

Please use the Cladogram exercise to have students work at constructing and explain a cladogram.