Kenan Fellowship Earth Science Project

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**Learning Objectives:**

* The learner will be able to explain the geologic time scale and how it was elucidated.
* The learner will be able to describe the evolution of life in the context of the geologic and fossil records.
* The learner will be able to explain the evidences for evolution including fossils, comparative anatomy, comparative embryology, and comparative biochemistry including current molecular techniques.
* The learner will able to explain previous extinction rates and the conditions that may have caused those extinctions.
* The learner will be able to explain how conditions on earth are currently changing and based on their knowledge of the above be able to hypothesize about current and future extinctions.

**North Carolina Standard Course of Study Objectives:**

Earth/Environmental Science (9th Grade):

Competency Goal 3: The learner will build an understanding of the origin and evolution of the earth system.

**Objectives** 3.01 Assess evidence to interpret the order and impact of events in the geologic past:

* Relative and absolute dating techniques.
* Statistical models of radioactive decay.
* Fossil evidence of past life.
* Uniformitarianism.
* Stratigraphic principles.
* Divisions of Geologic Time
* Origin of the earth system.
* Origin of life.

Note: This unit is intended as an enrichment/review supplement to existing Earth/Environmental Science Curriculum. In my twenty+ years experience teaching biology I have always been disappointed in the average students’ lack of background knowledge in geologic history, fossils, and the evolution of life. This unit is intended to get students more interested in these topics and to enrich their background knowledge so when they enter biology they will be ready to tackle the big-picture that Darwinian evolution presents.

**Module 1: Setting the Stage for a Virtual Field Trip to Western New York to Collect Fossils**

**Activity I: The Earth’s Changing Landscapes**

Essential Questions:

* Has the Earth always looked the way it does now?
* If not, how has it changed?
* How do we know about the Earth’s past geology?
* What is the geologic timescale based on?
* Why do scientists not always agree about events in Earth’s past?
* Why do scientists constantly refine the geologic timescale?
* What caused past mass extinctions?
* What may be causing present and future mass extinctions?

Review of Continental Drift

1. Small groups of students are given 11 laminated maps of Earth ranging from the Mid-Cambrian Period (520 Ma) through the Mid-Neogene Period (11.5 Ma) and are to arrange them in order from oldest to most recent. Each map has the Period name on the back to give them clues (and to review the order of geologic history’s major periods). The teacher has an answer key.
2. Students are to work on their own initially attempting to order their maps based on logic and hopefully prior knowledge, this also should be a good review of past and present continental and oceanic geography.
3. The groups will then be asked to share the order that they placed their maps, and to justify why they ordered them the way they did (‘think, pair, share’).
4. Next, students will be given a laminated graph of the mass extinctions that have occurred since the Cambrian. They should be allowed to hypothesize about the causes of the mass extinctions, hopefully linking them, in part, to the Earth’s changing landscape.
5. Again, the groups will be expected to share and to justify their hypotheses with the class.
6. The next step is to give each group a laminated geologic timescale. Students should use the scale to check the order of their original 11 maps of the Earth. They should then hypothesize about why scientists have set up the geologic time scale the way they have within their groups.
7. The groups will then present their conclusions to the class.
8. Lastly, the teacher should debrief the activity with an explanation of the history of the geologic time scale based on geological and fossil record observations. This should reinforce the students’ understanding of the above and clear up any misunderstandings the students may have had which were brought out in the above activities.

**Activity IIA: Western New York Today**

Essential Questions:

* What is the current topography of Buffalo Creek in Elma, NY?
* What geologic processes formed the current topography of Buffalo Creek in Elma, NY?

Engage:

 (Download the free version Google Earth at <http://earth.google.com/>)

1. Find Elma, NY (Zip Code 14059) on *Google earth* (earth.google.com).
2. Find the intersection of Bullis Road and Girdle Road.
3. Find where the bridge on Bullis Road crosses Buffalo Creek (not labeled).
4. Follow the creek north zoom in and move on to the Explore section.

Explore:

1. Describe the topography of the area.
2. Describe the creek’s topography.
3. Explain how the creek may have formed the cliffs on each side of it through time.
4. Have any other geologic events over the past million years had an effect on the area? Explain.
5. Hypothesize about how the area may change in the near and distant future.

Explain:

1. View *Waypoint 7* video clip.
2. View *Waterfall* video clip.

**Activity IIB: Western New York in the Mid and Late Devonian Period**

Essential Questions:

1. What geologic events formed what is now Western NY during the Devonian period and later?
2. Why are the types of fossils found in the area located there?

Engage:

 (Devonian Maps are available at <http://jan.ucc.nau.edu/~rcb7/nam.html>,

1. Find Western New York on the Middle Devonian Map your teacher has provided for you. (Hint: It is located in the light blue area west of the mountains about 2/3 of the way down the map and a little right of the middle-you can see the present map outline of the state borders.) You may need to refer to a map of Western New York or use G*oogle Earth*.

Explore:

1. Describe the location of North America on your map. How does it compare to modern maps?
2. Where is the Elma, NY area located at this point in geological history?
3. What type of geological events would have been occurring in this area during this period?

Obtain a Late Devonian Period map from your teacher and find the same area on it.

1. How did the topography change during the 25 million years spanning from the Mid to Late Devonian Period?
2. Hypothesize about how the changes you discussed in question 4 may have affected the development of the rocks found in the area today.

Elaborate:

1. In general, what types of organisms would you expect to be living in the area during the Middle and Late Devonian Period? Think, pair, share. (Hint: you may need to consult your textbook or other resources at this time for assistance.)
2. Is there any way for sure to know whether your answers for question one are correct? Explain.

**Activity III: Sedimentary Rock Formation**

Essential Questions:

1. How do sedimentary rocks form?
2. How do sedimentary rocks record the geologic and evolutionary history of an area?

Engage:

1. How did the area which is currently Western New York form during the Middle to Late Devonian Period? Think, pair, share.

Explore:

1. Review the geological processes that were occurring during the Middle to Late Devonian Period in the area that is now Western New York using your maps.

Explain A:

1. Use your textbook or other resources to review the rock cycle and sedimentary rock formation as instructed by your teacher.

Explain B.

1. View *Law of Superposition-Sedimentary Rock Formation* video clip.

\*NOTE: These rocks were formed during the Devonian Period from approximately 400 to 370 million years ago-not 500 million (half a billion) years ago (Cambrian Period) as stated in the video .

Elaborate B:

1. What is a cliff?
2. What type of rocks make up the cliffs you viewed in the video clip?
3. What is the Law of Superposition?
4. What is relative dating?
5. What can we infer about the age of the rock layers (and the fossils they contain) as we move from the bottom of the cliffs and go up?
6. What types of fossil organisms are in the rocks?
7. How do you think they were fossilized?
8. Hypothesize about why one of the slabs is red in color. Think, pair, share.

Explain C:

1. View *Sedimentary Rock Layers: Erosion* video clip.

Elaborate C:

1. Describe the different types of sediment that make up the rock layers in the video clip:
* sand
* silt
* clay
* sandstone
* shale
1. Do all of these layers contain fossils?
2. Which type of rock layer probably formed in a beach-type environment? Explain.
3. Which type of rock layer probably formed in a deeper ocean environment? Explain.
4. What does *anoxic* mean?
5. What effect may an anoxic environment have on the color of the sediment layer formed in that condition? Explain your answer.
6. Where are these anoxic environments likely to be found?

Explain D:

1. View *Crinoid Slab* video clip.

Elaborate D:

1. What is the shape in the middle of the crinoid stem in the video?
2. What modern animals have the same shape?
3. Hypothesize about how the waterfall created the large slab shown in the video clip? Think, pair, share.

Elaborate:

1. How can the rise and fall of sea level account for alternating sand, silt, and clay layers forming in the same area that you saw in the video clips?
2. What types of organisms inhabited the area at that time? How do you know?

**Activity IV: Fossil Formation**

Essential Questions:

1. How, when and where do fossils form?
2. How are fossils discovered and interpreted by humans?

Engage:

1. Have you ever seen any fossils?
2. Where did you see them?
3. What organisms were they from?

Explore:

1. Think, pair, share with your class on answers to the above questions before moving on.

Explain A:

1. Use your textbook or other resources to review the types of fossils and how they form as instructed by your teacher.

Explain B:

1. View *Fossil Formation* video clip.

Elaborate:

1. List some organisms that people find fossils of.
2. Are there any differences in the way various organisms fossilize? Explain your answers. Think, pair, and share.

Evaluation:

1. Do all organisms fossilize?
2. How common or rare is the fossilization of any organism?
3. What conditions are necessary for fossilization to occur?
4. How do humans eventually find fossils?

**Activity V: Weathering and Erosion Forces Expose Ancient Rocks and the Fossils They Hold**

Essential Questions:

1. What is weathering?
2. What is erosion?
3. How do the above processes expose ancient rock layers and fossils?

Engage:

1. What happens to rocks and rock formations over time?
2. What causes this to occur?

Explore:

1. Hypothesize about what has happened to the sediments laid down in the Elma, NY area during the Mid-Late Devonian Period leading up to the conditions found in the area today. Think, pair, share.

Explain A:

1. View *GPS Waypoint 3* video clip.

Elaborate A:

1. Why are we finding sea organisms (approximately) 700 feet above sea level?

Explain B:

1. View *Outcrop* video clip.

Elaborate B:

1. Describe the outcrop’s structure.
2. How does its structure relate to its formation?
3. Define weathering.
4. What are the types of weathering
5. How do trees and other organisms cause weathering?

Explain C:

1. View *Weathering #1* video clip.

Elaborate C:

1. Describe the creek’s role in the cliff formation.
2. Describe gravity’s role in the cliff formation.
3. What are revealed as the cliffs erode?
4. What is a coral reef?
5. What are some organisms that live in coral reefs?
6. What effect do the mosses and liverworts have on the roots?

Explain D:

1. View *Weathering #2* video clip.

Elaborate D:

1. What effects does water have on rock formations?
2. Relate the above effects to the video clip.
3. Does weather/erosion occur at a constant rate?
4. What factors affect the rate of weathering and erosion of a particular rock formation?
5. Why has the creek bed’s erosion ‘slowed down’ in its present state

Evaluation:

1. How did weathering and erosion form the rocks were finding these fossils in approximately 370 million years ago?
2. How has weathering and erosion enabled us to find the fossils we will be studying nest?

**Activity VI: Finding the Fossils**

Essential Questions:

1. What types of fossils are commonly found in Western NY?
2. What geologic events were instrumental in forming Western New York’s topography over the past few million years?

Engage:

1. Have you ever found a fossil?
2. If so: where?
3. If not: where would you look for fossils?

Explore:

1. Are fossils found everywhere? Think, pair, share with your group and class about where you’d look for fossils and what type of organism you’d expect to find there.

Explain A:

1. View *Fossil Extraction #1* video clip.

Elaborate B:

1. What foes ubiquitous mean?
2. What are ubiquitous in the rocks?
3. Why do you think the nicest fossils are “right at the top” or on the surfaces of the exposed faces of the rock slabs?

Explain B:

1. View *Fossil Extraction #2* video clip.

Elaborate B:

1. What tools would’ve been useful in extraction some of the fossils you’ve seen in the video clips?
2. What is a paleontologist?
3. What do “they argue about”?
4. What may have happened to these organisms to preserve them in these rocks where were finding them?

Explain C:

1. View *Trilobite* video clip

Elaborate C:

1. What is the organism?
2. Why are they significant?

Evaluation:

1. Why are the fossils in the video clips where they are?
2. Do you think Western New York is the only place you’d find similar fossils? (Refer to your Devonian Maps)
3. Hypothesize about where else you would find fossils of similar species formed during the Devonian period. Think, pair, share.

**Extension Activity:**

Explain:

1. View *The Boulder* video clip.

Elaborate:

1. What is a boulder?
2. Hypothesis about the origin and current placement of the boulder.
3. What events (things) have affected Western NY (and the Northern United States in general) over the past million years or so, lasting between 15-20 thousand years?
4. Besides dropping boulders, what other effects did those events have on the topography of the area?

**Module 2: Investigating the Fossils:**

**Note:** There will be two options available at this point:

* Local students will have access to the actual fossils which I have collected, and will continue to collect in subsequent trips to the WNY area.
* Other students/teachers will have access to photos of my fossil collection and photos we took while filming the ‘virtual field trip’.
1. Local students will be given samples will be given rock samples to examine and identify and extract fossils from. **Note:** This could also be videotaped and used to produce a segment for others to view who will not have access to the actual fossils. Also, teachers who have their own fossil collections, or who live in areas with access to local fossils, could incorporate theirs at this point of the unit.
2. Students will produce dichotomous keys to classify and group the fossils in my collection. (One or more preliminary activities involving producing dichotomous keys will be necessary; I have several good examples to choose from).

**Module 3: Investigating Devonian Organisms:**

1. Student(s) are to choose one of the organisms we’ve identified in the previous module and research the following:
* How is the organism classified (Kingdom, phylum, class, order, family and genus)?
* What is the organism’s phylogenic history (from what did it evolve)?
* When did the organism live (appearance and disappearance in the fossil record)?
* Where did the organism live (habitat)?
* What was the organism’s means of making a living (niche)?
* Why is the organism extinct?
* What modern organisms (if any) is it most closely related to?
1. Students should choose and produce one or more of the following products using the information from their research in part 1.
* Power Point presentation
* Brochure
* Newspaper Article
* Other appropriate product
1. Students will present what they’ve done in step 2 to their class or another selected audience as a summative assessment (graded at the individual teachers’ discretion using appropriate rubric.)

**Module 4: Studying Mass Extinctions:**

1. Students will research the causes of mass extinctions including, but not limited to:
* Climate change (global warming/glaciation)
* Tectonic activity
* Changes in Sea level/chemistry
* Changes in atmospheric chemistry
* Bolide impact (iridium anomalies as evidence along with craters)
* Others: including extinction of food species, competition, parasites, epidemics, etc.
1. Groups of students will choose one of the Earth’s mass extinction events and research the proposed cause(s) of that event. \* Students will then produce a presentation to share their finding with the rest of the class or another appropriate audience in the form of a power point presentation, news report video, newspaper article, or other acceptable form. May be used as a summative assessment at the teacher’s discretion.

\*One or more groups of students may be assigned research on the current extinction rate, its causes, and how this extinction event compares to those in the past.

1. In conclusion: the class may want to discuss what lies in the near and distant future for Earth’s living creatures, including humans.

I have also purchased the DVD *Walking with Prehistoric Beasts* from *The Discovery Channel*. This is an excellent video that could be used as a review of the entire unit and to stimulate interest in further discussion and to prepare the students for biology and inquiry into Charles Dawin’s theory of Natural Selection.