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.
• 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’).

Think- Give individual students a chance to work individually and develop their own personal hypothesis. Pair- Students then share their hypothesis with a partner or small group (as deemed best by the teacher). Each group then decides what to share with their classmates. Share- Each group then shares their hypotheses with the entire class. The teacher may decide to collect data on the board and then help guide the whole class to ‘correct’ conclusions using information from as many groups as possible. This is the same basic process that the scientific community carries out in its quest to solve scientific problems. This strategy can be used throughout this set of class activities and appears in many places below.

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.
Note: The geologic timescale was developed based on the fossil and rock record over the past two hundred years or so. Changes in the fossils in various layers found all over the world have been catalogued and are continuously being refined and updated (and argued about by geologists). Mass extinctions are marked in the geologic record by large groups of fossils disappearing forever and those species remaining diversifying and becoming common in subsequent layers above.

**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/](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.
5. Alternatively: As you use Google Earth, notice the *Fly To* search bar. In this search bar enter the following coordinates: 42.83881N,078.60112W and enter. See Waypoint 3 video clip below.

**Explore:**

1. Describe the topography of the area.
   
   The area is hilly and cut with valleys which have been cut by weathering and erosion.

2. Describe the creek’s topography.

   The creek cuts through the bedrock of the area. It has waterfalls, rapids, and deeper pools. It has large slabs of more resistant rocks (lime stones) which have been undermined by the erosion of and subsequent removal of less resistant rock types. The creek also has boulders in places.

3. Explain how the creek may have formed the cliffs on each side of it through time.

   Weathering and erosion over millions of years.

4. Have any other geologic events over the past million years had an effect on the area? Explain.

   Ice ages have covered the entire area with large glaciers multiple times over the past million years or so. These events formed much of the areas hilly topography, formed the great lakes (including Erie into which Buffalo Creek eventually flows), and also left the many boulders seen in the area.
5. Hypothesize about how the area may change in the near and distant future.

Answers may include that the creek will continue to cut deeper into the bedrock and that the cliffs will continue to erode, widening the valley.

Explain:

1. View Waypoint 7 video clip.

Actually videotaped at the culmination of my field trip, this clip shows the Bullis and Girdle Road intersection about 100 feet above the creek and fossil beds.

2. View Waterfall video clip.

Clip shows the Buffalo Creek valley at the base of the Bullis Road bridge and some of the waterfalls common to the topography.

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. Permission for use of these maps was granted by Dr. Ronald Blakey, Professor at Northern Arizona University.

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 Google Earth.

The mountains are the beginning of the modern Appalachians and formed during the Taconic orogeny (mountain building event) during the Ordovician Period (about 440 million years ago) along the east coast of Laurentia, which is part of what, will eventually become North America. Later (380 million years ago) the Acadian orogeny formed the Acadian mountains which were even larger and they drained through a system of rivers to the West into the Catskill Delta.

Explore:

1. Describe the location of North America on your map. How does it compare to modern maps?
1. Answers will vary; note the location of the equator at this time. Have students speculate about how the climate may have been different at this time. Also note, this is well over 100 million years before Pangaea started to form.

2. Where is the Elma, NY area located at this point in geological history?

   The Elma area is under the shallow inland Catskill Sea. It will remain under various depths of water (depending on rising and falling sea levels) throughout the Devonian Period (about 400-360 million years ago).

3. What type of geological events would have been occurring in this area during this period?

   Large amounts of sediment were weathered and eroded from the Taconic and Acadian mountains in the east and were carried south and west by the rivers and deposited in the Catskill delta covering what is currently Western New York.

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

4. How did the topography change during the 25 million years spanning from the Mid- to Late Devonian Period?

   Answers will vary. Sea level rose and fell many times over the course of the mid-late Devonian Period. Review sediment sorting principles with the students if necessary. The understanding of sediment sorting by running water will lead them to answers for question 5. You may also want to point out that the ocean basin steadily sank under the weight of the accumulating sediments throughout this time.

5. Hypothesize about how the changes you discussed in question 4 may have affected the development of the rocks found in the area today.

   Students should understand that different rocks formed depending on the type of sediments being deposited at various times which in turn depended on the proximity of the area to the mouths of the rivers (and later the Catskill Delta) and the velocity and volume of the water flow.

   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.)

      The Devonian is well known as the “age of fishes”, although the fish living at the time were very different from the species we know today. Even more abundant were invertebrate groups including corals (which constructed elaborate reefs), bryozoans, worms, brachiopods, mollusks, trilobites, and echinoderms such as crinoids, which are related to modern starfish and sea lilies.

   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.

   See Above. The primary purpose of this Engage and the Explore question that follows is to review what students have learned thus far, especially if done over the course of several days.

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.

   See above.

Explain A:

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

   The instructor may want to review the rock cycle and especially focus on the processes of weathering and erosion before moving on.

Explain B:


   This video clip reviews the sedimentation process and the law of superposition using the layers of the cliffs along the creek.

   *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?
A mass of steep, vertical, overhanging rock that has been exposed by various means of weathering.

2. What type of rocks make up the cliffs you viewed in the video clip?
   Various types of sedimentary rocks including limestones, sandstones, mudstones and shales.

3. What is the Principle of Superposition?
   The principle states that in undisturbed sedimentary rocks the oldest layers lie below the younger layers above them.

4. What is relative dating?
   The process of inferring the age of rock layers or the sequence of events in a particular area using the principle of superposition for example.

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?
   The oldest layers and fossils are on the bottom, and they get younger as we move up the cliff. Note: There are actually several unconformities in these cliffs, for specific details see Maletz, 2006.

6. What types of fossil organisms are in the rocks?
   Mostly invertebrate groups including corals, bryozoans, brachiopods, mollusks, trilobites, and the stems of crinoids, which are related to sea lilies.

7. How do you think they were fossilized?
   They were buried and preserved in the sediments as they were deposited. All of these organisms had skeletons made of various minerals and these hard parts are what we are seeing in the rocks.

8. Hypothesize about why one of the slabs is red in color. Think, pair, share.
   They contain some form of iron.

**Explain C:**

   Video clip discusses how weathering, erosion, and sedimentation formed the rocks of the area in the past and how erosion and weathering are presently at work exposing the layers we now see.

**Elaborate C:**
1. Describe the different types of sediment that make up the rock layers in the video clip:

- **Sand**: small grains of weathered rock
- **Silt**: finer grains of weathered rock than sand
- **Clay**: even finer grains of weathered rock
- **Sandstone**: sedimentary rocks composed of sand sized grains
- **Limestone**: sedimentary rock formed of the skeletons of fossilized organisms
- **Shale**: sedimentary rock composed of very tiny particles

2. Do all of these layers contain fossils?

   Yes, for the most part they do.

3. Which type of rock layer probably formed in a beach-type environment? Explain.

   The sandstones and limestones would’ve formed close to the shore of the inland sea because the heavier grains ‘fall out’ closer to the mouths of the rivers as the current that carries the sediment slows. Review sediment sorting if necessary.


   The shales because the finest sediments are carried further out into the ocean than the sand and larger sediments.

5. What does **anoxic** mean?

   No oxygen is present.

6. What effect may an anoxic environment have on the color of the sediment layer formed in that condition? Explain your answer.

   The layers are darker in color due to large amounts of carbon in the sediments because there is less decay in anoxic conditions than in aerobic environments.

7. Where are these anoxic environments likely to be found?

   In the deeper offshore areas.
Explain D:

1. View *Crinoid Slab* video clip.

   Video clip shows a large slab below the waterfall which contains many crinoid stems. Crinoids are echinoderms that attach themselves to the bottom of the ocean by long stalks or stems which fossilize readily. As stated above they resemble modern sea lilies.

Elaborate D:

1. What is the shape in the middle of the crinoid stem in the video?

   It is a star (radial symmetry).

2. What modern animals have the same shape?

   Echinoderms such as starfish.

3. Hypothesize about how the waterfall created the large slab shown in the video clip? Think, pair, share.

   As the water fall erodes the weaker rocks below it, the more resistant rocks (like the crinoid slab) break off and remain at the site of the ‘old’ waterfalls as they recede upstream over time.

Evaluate:

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?

   When sea level was relatively high, the Western NY area was further out from the shoreline and thus shales formed in the area. When sea level was lower, the same area was closer to the shoreline and thus limestones and sandstones formed then.

2. What types of organisms inhabited the area at that time? How do you know?

   Mostly invertebrate groups including corals, bryozoans, brachiopods, mollusks, trilobites, and crinoids.
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?

Obviously, answers will vary for all three of the above.

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.

The instructor may choose to review fossil formation and the types of fossils before moving on.

Explain B:

1. View Fossil Formation video clip.

The video clip discusses fossil formation using some actual living and dead organisms in the creek and discusses trace fossils using some footprints in the creek bed.

Elaborate:

1. List some organisms that people find fossils of.

Answers will vary, the teacher may want to point out some of the less common or popular examples such as worm burrows, amber, and frozen remains of mastodons.

2. Are there any differences in the way various organisms fossilize? Explain your answers. Think, pair, and share.

Again, answers will vary. As above, the teacher may want to point out some of the less common or popular forms such as preservation in tar pits and peat bogs, petrification, and amber.
Evaluate:

1. Do all organisms fossilize?
   No, must do not. Especially those that do not possess hard body parts or tissues. The teacher may want to remind students to think about groups other than animals including bacteria, protists, plants and fungi.

2. How common or rare is the fossilization of any organism?
   Fossilization is a fairly rare occurrence that only takes place in very specific conditions (such as sedimentation in anoxic conditions).

3. What conditions are necessary for fossilization to occur?
   Obviously conditions are different for each type of fossil. The instructor may wish to be sure that each type of fossil’s specific conditions are covered.

4. How do humans eventually find fossils?
   The layers of rock that contain the fossils must be exposed by weathering and erosion. In the case of many, the ancient rock layers may be thrust upward during orogenies, and then subsequently weathered. Finally, there may an element of luck, see many stories of fossil discovery in the literature such as Charles Walcott’s discovery of the Burgess Shale or Donald Johanson’s discovery of Lucy.
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?

   They weather.

2. What causes this to occur?

   Answers will vary. The instructor may want to be sure that all the types of weathering are covered.

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.

   They were buried and turned into solid rock. Later they were thrust up during the formation of Pangaea and the Appalachian orogeny. They have weathered for millions of years and cut away by Buffalo Creek.

Explain A:

1. View GPS Waypoint 3 video clip.

   The video clip discusses the relative elevation of the area (see note in video about the accuracy) which is over 700 feet above sea level and poses the question of finding sea organisms at that elevation. The coordinates of the area are also given.

Elaborate A:

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

   See the answer to Explore above.
Explain B:

1. View Outcrop video clip.

The video clip shows one of the main outcrops where we find fossils and discusses its structure. It is composed of layers of weathered shales (mudstones) that are very fragile and limestones (which are erroneously called sandstones in the video). For a detailed description of the actual geology, please refer to the literature sited at the end of this guide.

Elaborate B:

1. Describe the outcrop’s structure.

Answers will vary. It is obviously composed of many layers of sedimentary rock. It is up to the instructor to decide how much detail is discussed.

2. How does its structure relate to its formation?

See descriptions above.

3. Define weathering.

Any process that leads to the breakdown of rock.

4. What are the types of weathering?

Mechanical and chemical, it is up to the teacher to decide how much detail is necessary.

5. How do trees and other plants cause weathering?

Their roots mechanically break up the rocks by growing into them and expanding. Their roots may also exude acids that chemically weather the rocks.
Explain C:

1. View *Weathering #1* video clip.

   The video clip discusses how the creek and gravity have formed the cliffs and exposed the fossils. It also shows what must have been a Devonian coral reef, and ends with mosses and liverworts growing on the rocks.

Elaborate C:

1. Describe the creek’s role in the cliff formation.

   The creek has cut downward into the bedrock over millions of years.

2. Describe gravity’s role in the cliff formation.

   Gravity pulls broken rocks downward.

3. What are revealed as the cliffs erode?

   The fossils.

4. What is a coral reef?

   A large mass of corral skeletons formed by multiple generations of corral animals growing on the remains of their ancestors.

5. What are some organisms that live in coral reefs?

   Fish and a multitude of invertebrates, see above.

6. What effect do the mosses and liverworts have on the rocks?

   They exude acids that chemically weather the rocks.
Explain D:

1. View *Weathering #2* video clip.

   The video clip shows some cliffs further down and on the opposite side of the creek. It shows water running through the rocks and water’s effects on rocks. It also deals with the structure of the present creek bed.

Elaborate D:

1. What effects does water have on rock formations?

   Water physically washes rock fragments away and also causes chemical weathering. This area also freezes and thaws for several months of the years. The teacher may want to discuss the effect that ice has on rock structures and may even want to discuss ‘potholes’ if appropriate.

2. Relate the above effects to the video clip.

   *Answers will vary.*

3. Does weathering/erosion occur at a constant rate?

   *No, absolutely not.*

4. What factors affect the rate of weathering and erosion of a particular rock formation?

   *Answers will vary.* The teacher may decide to pool answers to be sure the multiple factors are covered including, but not limited to: the type of rock, topography, climate, precipitation and organisms present.

5. Why has the creek bed’s erosion ‘slowed down’ in its present state?

   *The creek bed appears to be a thick layer of rock relatively resistant to weathering.*

Evaluate:

1. How did weathering and erosion form the rocks we’re finding these fossils in approximately 370 million years ago?

   *Review of what has already been discussed above.*

2. How has weathering and erosion enabled us to find the fossils we will be studying next?

   *It has exposed them.*
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?

Answers will vary for the 3 questions above. The teacher may want to allow students to share their individual experiences with the classmates in order to survey their prior, knowledge, experiences and maintain their interest.

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.

No. The teacher may assist students to understand that fossils are only found in sedimentary rocks that had living organisms’ remains in them before they became rocks. Also, the rocks must not have been destroyed and must have subsequently been exposed. Lastly, fossils of specific organisms can only be found in areas where those organisms lived and where the conditions necessary for preservation and fossilization processes to occur were able to take place.

Explain A:

1. View Fossil Extraction #1 video clip.

The video clip shows many fossils in two large slabs of limestone that have fallen from the cliffs above.

Elaborate A:

1. What does ubiquitous mean?

   Everywhere.

2. What are ubiquitous in the rocks?

   Various types of fossils.
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?

The large slabs tend to fracture along the bedding planes where they weaken due to the presence of the fossils.

Explain B:

1. View Fossil Extraction #2 video clip.

The video clip shows a trilobite fragment being extracted (crudely) from a slab of rock. It also shows many other fossils in the slab.

Elaborate B:

1. What tools would’ve been useful in extraction some of the fossils you’ve seen in the video clips?

A geologist’s hammer, chisels, picks, etc.

2. What is a paleontologist?

A scientist that studies the geologic past and fossils.

3. What do “they argue about”?

Specific details of the geologic past, and how to interpret the fossils they find.

4. What may have happened to these organisms to preserve them in these rocks where we’re finding them?

Answers will vary. They obviously died, but how, and under what circumstances? The teacher may want to allow the students to speculate on the conditions in the area 370 million years ago. There was mountain building going on east of the area, thus there would’ve been frequent earthquakes and underwater landslides that would’ve killed and buried large numbers of organisms. There would’ve also been long, stable periods where deceased organisms would be buried and preserved where they died. Many other scenarios are plausible and this is what paleontologists argue about. See number 3 above.
Explain C:

1. View *Trilobite* video clip.

   This short clip shows an excellent Phacops trilobite found on our trip.

Elaborate C:

1. What is the organism?

   See above.

2. Why are they significant?

   They are an index fossil. The teacher may want to explain the significance of index fossils with a few other examples. The teacher may also want to describe the trilobites in general (although, the students may be researching them later in Module 3).

Evaluate:

1. Why are the fossils in the video clips where they are?

   They died and were buried in the sediments being laid down in the shallow sea where they lived during the Devonian Period. The sediments were buried and formed into rock. Later those rocks were thrust up into mountains as Pangaea formed. Since then those mountains have been weathered and eroded into the hilly landscape present today which includes the creek that cut through those rocks and exposed the fossils you’re going to work with in the next module.

2. Do you think Western New York is the only place you’d find similar fossils? (Refer to your Devonian Maps)

   No, fossils like this are found in most of the areas that were under shallow seas or near the large land masses present during the Devonian both in North America and sites around the world. The teacher may want to allow students to observe their maps and specifically name places that would possibly have similar fossils. This would also be a good geography review.

3. Hypothesize about where else you would find fossils of similar species formed during the Devonian period. Think, pair, share.

   See above. The teacher may want to have students view Dr. Blakey’s other maps at http://jan.ucc.nau.edu/~rcb7/nam.html.
Extension Activity:

Explain:

1. View *The Boulder* video clip.

   The video clip shows a large boulder in the middle of the creek.

Elaborate:

1. What is a boulder?

   *A large rock that has been rounded by weathering.*

2. Hypothesize about the origin and current placement of the boulder.

   *Answers will vary. Remind the students that the area was covered by large glaciers several times over the past million years, and that the last ice age’s glaciers receded from the area around 10,000 years ago. The boulder was carried there in a glacier and was ‘dropped’ in that site when the glacier melted. These boulders are very common in the northeastern part of North America.*

3. What events (things) have affected Western NY (and the Northern United States in general) over the past million years or so, lasting until about ten thousand years ago?

   *See above.*

4. Besides dropping boulders, what other effects did those events have on the topography of the area?

   *The teacher may choose to review the affects that glaciers have on the topography of an area and the resulting features left after the glaciers retreat. Further discussion might even include global warming’s affect on modern glaciers all over the world and how humans are causing this phenomenon (if we are) and how we are and will be affected by this in the future.*
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?

2. 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

3. 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.

2. 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.

3. 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 Darwin’s theory of Natural Selection.