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| **Title** | **Evolution: Evidences of Evolution or “Get a Clue”** |
| **Introduction** | This lesson provides students an opportunity to study evolution using engaging, relevant, and researched based strategies. Students will uncover the evidences that support the evolutionary path of the modern whale. For the teacher, this lesson plan provides a protocol to teach Clarifying Objective: 3.4.1 from the NC Essential Standards for Science (*“Explain how fossil, biochemical and anatomical evidence support the Theory of Evolution”*)*.* This goal and objective directly correlates with the 1996 National Life Science Content Standard C and to the Framework for K-12 Science Education Life Science Content Standard, LS4.A.  Specifically this lesson will engage students experiencing the evidences of evolution to validate Darwin’s Theory of Evolution as they explore, research, and collaborate to discover the evolutionary path of the modern whale. The content will be discovered through hands-on, inquiry science instruction. The lesson serves as a model for the use of evidence to support any conclusion. In particular the lesson emphasizes how MULTIPLE evidences increase validation of a scientific claim. It also reinforces the cyclical nature of scientific inquiry in which new evidence will justify a modification of current hypotheses. Using evidence to support a conclusion is a skill needed in **all** subject specific areas. |
| **Curriculum Alignment** | **North Carolina Essential Standards for Biology**. Grades 9-12, 2012  **Goal 3.4:** Explain the theory of evolution by natural selection as a mechanism for how species change over time.  **Objective 3.4.1:** Explain how fossil, biochemical, and anatomical evidence support the theory of evolution.   * *NC Essential Standard 3.4 correlates to Content Standard LS4.A: Biological Evolution: Unity and Diversity, Evidence of Common Ancestry and Diversity from* A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. (National Research Council, 2012).* * *NC Essential Standard 3.4 correlates to the 1996 National Science Standards, Content Standard C: Life Sciences, Biological Evolution. (National Research Council, 1996).* |
| **Learning Outcomes** | |  |  | | --- | --- | | Learning Targets | Criteria of Success | | I can analyze how fossil evidence is used to hypothesize an evolutionary path for organisms.  I can use molecular data from DNA sequences or proteins to determine an evolutionary relationship between organisms.  I can analyze anatomical homologies from different organisms to explain common ancestry.  I can interpret vestigial structure/organ evidence to infer how an organism has changed over time due to environmental pressures.  I can use evidences of evolution to support a conclusion of common ancestry and “descent with modification.”  I can communicate a conclusion using evidence to support a claim. | * I will analyze diagrams of whale fossils and predict an evolutionary path of the modern whales. * I will compare DNA sequences of beta casein, a milk protein, from several mammals and determine the ancestral relationship of whales to these other mammals. * I will analyze diagrams of forelimb structures of the human, dog, bat, whale and fish to predict how their similarities and differences show common ancestry. * I will review ankle bone arrangements of modern mammals and that of the ancient *Pakicetus* (whale ancestor) to determine * I will use diagrams of whale fossils to explain how whales have changed over time and predict what environmental changes may have prompted the change. * I will collaborate and compile evidences of evolution (fossil records, biochemical data, embryological data, homologous structure data and vestigial structures) data to explain the current scientific hypothesis as to how modern whales have evolved. * I will summarize the whale evolution evidence by creating a visual presentation to be reviewed by peer “research” teams through a gallery walk. | |
| **Time Required and Location** | **Block Schedule (90 min blocks)**: 4.5 periods = 405 min  Day 1: Introduction model “label” activity (30 min), explanation of “research” and “expert” team/roles, expectations, and outcomes (15 min), begin expert team investigations (45 min).  Day 2: Continue expert investigations (30 min), return to research teams, debrief by experts to research teams (10 min X 5 experts = 50 min), begin to compile evidences (10 min)  Day 3: Continue compiling evidences (20 min) Research teams prepare synopses and mini-presentation boards (75 min), peer evaluations (5 min)  Day 4: Gallery Walk (60 min), group discussion (30 min)  Day 5: Summative Assessment (45 min)  **A/B Schedule (75 min/2X/Week):** 5.5 class periods = 415 min  Day 1: Introduction model “label” activity (30 min), explanation of “research” and “expert” team/roles, expectations, and outcomes (15 min). Begin expert team investigations. (30 min)  Day 2: Continue expert investigations (75 min)  Day 3: Continue expert investigations (10 min), return to research teams, expert debrief to research team (10 min each X 5 experts = 50 min), compile evidences (15 min)  Day 4: Complete compilation of evidences (15 min), prepare synopses and mini-presentation boards (60 min)  Day 5: Gallery Walk (50) and peer evaluations (5 min), group discussion (20 min)  Day 6: Summative Assessment (45 min) |
| **Materials Needed** | * Sticky notes * File folders * Copy Paper * Cardstock * Removable tape * Highlighters * Small letter envelopes * Small Clasp envelopes * Glue sticks * Scissors * Attachments 1-30 * Optional: Laminator for teacher use   **Technology Resources**:   * DVD/Video Player or Computer with LED projector: to show whale clips *(Alternative: Prepare copies of pictures of whales or show books and magazine with pictures)* * Computers(1/pair of students) with Adobe Reader 9; Flash Player, and Microsoft Office 10:   + Analyze tutorial on Whale Evolution   *Alternative: Students may work in groups of 4 with one computer, or students can be provided with print material from the site (Attachment 21: Whale Evolution)*   * Show video lecture from HHMI or show Power Point made from video lecture slides   (*Alternative: Prepare copies of the transcript from this video lecture (Attachment 23; Transcript HHMI Lecture) or prepare a Power Point using the slides from the video lecture.)*   * Flip Cams to record Gallery Walk Presentations   *(Alternative: Use video capability on cell phones, take pictures, and ask IT professional to help)* |
| **Participant Prior Knowledge** | Teachers should become familiar with strategies used throughout this lesson. In particular:   * KWL (*Attachment 8)* * Gallery Walk (*Attachment 31*) * Collaborative grouping (Supplemental Resources) * Interactive Notebooks (Supplemental Resources) * It is recommended that the teacher go to <http://www.indiana.edu/~ensiweb/teach.fs.html> to view strategies, background information, misconceptions, controversial issues, resources, tips, etc. on teaching evolution. This website has a wealth of information for anyone who teaches this subject.   Students:   * Students should have covered and mastered the goals and objectives 3.1-3.3 (genetics and environmental influences of gene expression) and 3.5 (molecular genetics). * Students should be introduced to the diversity of living organisms through visual media. This could be done via the internet, videos, books, magazines, etc. The idea is for students to begin to see how all organisms are controlled by their genes and the influence of their environment on those genes.   + A good series of videos are the Life Series by Discovery Channel. This site provides a wide variety of video clips that will increase understanding of the large diversity of life on planet Earth. (<http://animal.discovery.com/videos/life-on-animal-planet/> this website gives you video clips of the series at no charge),   + Diversity of plants can be viewed at this site. <http://video.nationalgeographic.com/video/player/kids/green-kids/plants-kids.html>,   + Another plant video source with time lapse photography is <http://www.naturefootage.com/stock_footage/plant_footage.htm>. These clips provide videography of the unique adaptations of plants which lead to their wide diversity.   + This site is an image source that shows the amazing fluorescent creatures from the deep oceans. <http://www.livescience.com/15131-gallery-glowing-sea-creatures.html>   Students should be asked questions, such as “why do you think this animal or plant looks, acts, survives, eats, moves, grows, like it does?” The point is to get students to think about the many different organisms on Earth. As the entire unit unfolds, they will see that the adaptations of these animals are due to selective pressures of the environment and the genetic variation that they and their ancestors have possessed. |
| **Facilitator Preparations** | * Read and review suggested resources on evolution and strategies listed in Supplemental Information * Review the entire lesson plan to determine pacing for your particular circumstances * Teachers should become familiar with Interactive Notebooks (See Supplemental Resources: Teaching Strategies). Students should write all responses in their interactive science notebook/journal. In order to assess specific targets prior to the lesson notebook assessment, students should be instructed to complete assignments on notebook paper or handouts. Once returned the assignment should be glued in the notebook. In order to facilitate organization and to provide evidence of the entire course, students should place everything in the notebook. Multipage papers, lab reports, and summative tests may be stored in an in-class folder for each student.   This lesson includes several steps. As a result teacher preparation has been divided to align with these steps: Exploration/Model, Activity, Content Wrap-up, Guided Practice, and Assessment.  **Exploration/Model**   * Prepare Food labels (*Attachments 2 through 7*) by copying, cutting out, gluing to cardstock (can be copied on cardstock) and laminating. *Optional*: labels may be reduced so that individual students have a set for their notebooks. Removable tape is needed if using mini-labels. * Prepare envelopes, with one set of labels for each group. Small clasp envelopes are ideal for this purpose. The envelopes should be labeled E-1through E-6 (do **not** identify type of evidence on the front of the envelope, this will discovered later) * Collect other supplies: sticky notes * Prepare questions for classroom discussion (examples are included in step 2 & 4)   **Activity**   * Prepare heterogeneous groups of 4 students if necessary. * Read KWL Strategy; (*Attachment 8: KWL Strategy)* * Prepare video clips of whales <http://www.inthewildproductions.com/Free_Nature_Video_Clips.html> or locate pictures of whales * Prepare DNA Strips, (*Attachment 9: DNA Strips)*.Teachers should make copies of DNA strips, glue on cardstock and laminate (or copy directly on cardstock) * Make copies of DNA comparison charts, (*Attachment 10: DNA Comparison Chart)* * Prepare fossil strips (*Attachment 12: Large Fossil Strips; Attachment 13: small fossil strips.* Teachers should make copies of whale fossil strips, glue on cardstock and laminate (or copy directly on cardstock) * Prepare ankle bone evidence (*Attachment 14: Ankle Bones*): Teachers should make copies of ankle bone evidence, cut out each picture with letters, glue on cardstock and laminate (or copy directly on cardstock), identification labels used in Content Wrap-Up   **Content Wrap-Up**   * Review questions located in activity,(*Attachment 16: Answer key, Disc questions 1-6, Content Wrap-Up)* * Review “script” located in activity * Prepare copies of Whale Primer; (*Attachment 17: Whale Primer*) * Prepare whale names and identification strips (*Attachment 18, Whale Fossil names, lg and sm versions)*:Teachers should make copies of whale names and identification, glue on cardstock and laminate (or copy directly on cardstock) * Make copies of Whale ankle bone identification (*Attachment 14: Ankle Bones)* and explanation, *(Attachment 15: Whale Ancestry)* * Review vocabulary words, (*Attachment 19: Vocabulary Content Wrap-Up)* * Review suggested questions found in lesson,(*Attachment 20: Assessment: Discussion Q and A, Content Wrap-Up*), use as needed, either for discussion or make copies for students to place in notebook   **Guided Practice**   * Prepare link to Whale Evolution, <http://evolution.berkeley.edu/evolibrary/article/0_0_0/evograms_03> * Optional, prepare printed information from the Berkeley site (*Attachment 21: Whale Evolution)* * Review vocabulary, (*Attachment 22: Vocabulary Guided Practice*) * Prepare video lecture from HHMI, http://media.hhmi.org/hl/05Lect3.html * Optional, prepare copies of transcript or prepare a power point using slides from the above video lecture, *(Attachment 23: Transcript HHMI Lecture*) from <http://media.hhmi.org/hl/05Lect3.html> * Prepare a sample of a mini-presentation board to show students. Cut the tab off two file folders (not hanging type). Overlap the left side of one over the right side of the other to form 3 sections. Glue, tape or staple overlapping sections. Stand it up just like a trifold board. * Review explanation of Gallery Walk (Supplemental Resources) * Prepare presentation rubrics for Gallery Walk (*Attachment 30: Whale Evolution Gallery Walk Rubric)*   **Assessment**   * Make copies of Summative Assessment *(Attachment 27: Summative Assessment, Attachment 28: Key to Summative Assessment)* * Prepare instructions for Alternative Summative Assessment: Essay on “How Does New Evidence Change or Confirm the Accepted Theory of Whale Evolution?” * Optional Assessment: Make copies of *Attachment 24: New Evidence Whale Evolution, and Attachment 26: “missing link”* to be used in the Essay assessment. |
| **Activities** | **Note:**  The teacher acts as a facilitator throughout this activity. Within reason, students should be allowed to move at the pace of their group. Assigning roles should help the group stay on task. Teachers should be prepared to provide the next set of instructions when needed.  **Biochemical, Fossil and Homologous Structure Evidence**  **Exploration/Model**  ***This portion of the lesson is crucial in understanding the process that is being used throughout the remainder of the lesson. The Exploration section has been divided into steps to make this easier and to help see the connection in the Activity section more clearly.***   * Students are grouped into “research teams” of 4. Each group of students will be given one set of food labels featuring only one type of “evidence.” (*Attachments 2 through 7*). * Teacher may choose any combination of 6 labels or all 8 of the Food labels provided. It is suggested that students get at least 6 labels from different food groups always including the “Tuna” label. The labels are from the following sources:   L-1. Cereal (sweetened, crunchy cinnamon type)  L-2. Wheat cereal (shredded type, no added sugar)  L-3. Woven wheat crackers  L-4. Candy, fruit chews  L-5. Creamy peanut butter  L-6. Tuna  L-7. Spaghetti noodles  L-8. Nutrition bars, caramel-nut  **Step 1**: Teacher explains that the job of the “research team” is to determine what food is represented by the label or at least to categorize foods into similar groups based on the evidence they have been provided. Students should be told they are in “different countries” therefore they may not share information between groups until they “publish” their results. **They should NOT share the type of evidence they are using among groups**.  Each group of students is asked to group the labels based on one of the following sets of criteria (evidence).   |  | | --- | | Evidences Attachments | | E-1. Shape of labels (2) | | E-2. Total Calories (3) | | E-3. Ingredient list (4) | | E-4. Fat content (5) | | E-5. Total carbohydrates (6) | | E-6. Total Protein (7) |   Students will arrange their set of labels into groups. Students can use only the “evidence” (E-1 through E-6) provided in their particular set of labels to determine how to group them. For example, students who have the “Total Carbohydrates” evidence (E-5) may group the labels into 3 groups: “high carbs,” “med carbs” and “low carbs.”  Students will cluster their labels on the table. At this point, it is not necessary to draw or write these conclusions in their notebooks. Although some students may want to do so, it should not be required. This is an oral activity.  Example, E- 5: Carbohydrate Content  36g  **L2**  40g  L4  “HIGH  41g  CARBS”  **L7**  **NOTE**: If there are enough students to make additional groups of 4, teachers may copy the “master label” (*Attachment 1: Master labels all evidence*) and delete information to create another set of “evidence.” For example, a set of labels may be created that shows only “grams of fiber” or “grams of sugar.” By saving the “master labels” to your PAINT program, you can “erase” or “cover up” information that is not needed.  Students will work together to develop a statement as to how and why they grouped the labels, and to ultimately come up with the relationship between all of their labels. In other words, which ones are more closely alike and why. For example, “*The “high carb” group has over 30 g of carbohydrates per serving, while the “med carb” group has 20-30 g per serving,” and the “low carb” group has less than 20g.* All “data” should eventually be in number ranges (ex. 0-20, 20-30 or 30-130).  NOTE: the group of students who have the ingredient list should actually predict what they think the food item is that is represented by the label. For example, the ingredient list for L6 says “tuna.” Therefore they can infer/predict/state that it is “tuna.” In addition, this group should be assisted in reading through some of the ingredient lists so that they will not get too focused on non-essential ingredients, like preservatives. The group should note the first 2 or 3 ingredients, any spices, flavorings, or dyes that are used. Usually this group can identify L1 as some type of sweet cereal, L4 is difficult to identify with the ingredients, and L5 is usually narrowed down to a peanut containing food. The other labels can basically be narrowed down into like groups such as, “*contains wheat*” or *“contains high sugar*”, etc.  **Assessment**: Students will create a simple statement that justifies their reasoning for grouping the labels or predicting the food type. Teacher visits each table to listen for logical conclusions based on the evidence. For example, the group who has the Carb evidence may say, *“We grouped L2, L4 and L7 in the high carb category because that was the highest carb count in any of our labels.* There is no right or wrong answer as long as their conclusions are justified by the data.  **Step 2**  The teacher will give all groups sticky notes with numbers L1-L6 on them, representing the 6 labels. If you choose to use all 8 labels, then give them 8 sticky notes and label them L1-L8. Using a different color of sticky note is ideal, but the labels, L1-L6 can be written in different colors with markers. If this is the procedure chosen, the teacher should provide a color code so that everyone’s “L1” is the same color, “L2” the same color, and so on.  The teacher will divide the board into 5 sections with **headings E-1 through E-5** (**not** the actual names of the evidence like “fat grams”). If more than 5 types of evidence are used, add sections, one for each type of evidence.  On the Board, a student from each research team will “publish” their group’s findings by placing sticky notes in clusters to visualize which labels were more closely related. They should write the type of evidence under the “evidence heading” above their cluster of sticky notes.  For example: *Students who have the “Total Carb” content evidence may possibly cluster their labels in the following manner depending on how they justify their evidence. There is no right or wrong answers at this point as long as the groups can provide a reason for their groupings*.  TOTAL CARBs (g)  L3  L1    L6  L2  L4  L 8    L53  L7    Once all groups have placed their label groupings on the board, students will observe the data provided by all groups. The “speaker” for the group should be called on at their tables or to come to the board to explain the justification for making the conclusions that they did. This could be an elaboration of the statement made during the Assessment part of Step 1.  The whole class is given a few minutes to observe and discuss the data once these statements have been made. They will determine if all the evidence points to the same conclusion. The teacher may help facilitate the discussion by asking “D*o you find label 6 grouped with the same labels in all cases?”*  **Step 3**:  The teacher leads a discussion to discover if the data supports the predictions made.   * 1. The L6 sticky note is identified and the teacher emphasizes that the “research” team predicted that the food is “tuna” because that is what the ingredient list stated.   2. The teacher points out that if indeed the food is tuna, the other evidence should support that conclusion.   3. The L6 sticky note is pulled to the side away from all the other data. The teacher says, *“Let’s review the other evidence about L6*.” As the teacher identifies each piece of L6 evidence, the students are asked, *“Does this evidence support the prediction that this is tuna?”* As each label is discussed, if the group agrees that the evidence supports the prediction of the food, the teacher moves the sticky note to join the first one. This proceeds until each piece of L6 evidence is reviewed. The students can easily see that the other evidence supports this prediction. At this point, all L6 sticky notes should be grouped together. The teacher may ask, *“Based on the evidence you have reviewed, how confident are you that indeed this is tuna?”* The teacher should lead the students to basically agree that if all pieces of data support the prediction then the validity of their conclusion is close to 100%.   4. This process is repeated with other labels. It is suggested that the teacher choose, L1, L4 and if time permits, L5. Using L1, students may only see 4 out of 6 pieces of evidence support the prediction that L1 is some type of cereal. The class should be led to a validity statement such as, *“We are 80% sure this is a cinnamon flavored, sweetened cereal.”* As previously stated, L4 is difficult to identify, but the teacher should move through the procedure in the same way, allowing students to make incorrect predictions. If time permits, L5 should be reviewed.   5. After this process, the teacher asks, “*It is now time to see if your predictions and supporting evidence is accurate*.”   6. The teacher reads the “key” to the labels. The teacher should point out evidence that they chose that supports the predictions, and explain that some evidence was just too general and could not truly support the prediction.   **Assessment:** The teacher asks the students to answer the following questions. The teacher may choose to have students answer the questions as a reflection, an “exit ticket” or as a summary to be recorded in their notebooks. If the latter is chosen, students should describe the overall procedure before answering the questions. Teacher may also assess understanding by simply leading another discussion using the questions. (See “Questioning Strategies” in the Supplemental Resources).   1. Did all the data point to the same conclusion? (no) 2. Which set of data seemed to be the least beneficial? Why? (the shape of the labels, because it doesn’t really tell what is inside the container) 3. Which, if any, data point to the same or similar conclusions? (the amount of calories, fat content and carb content gave similar conclusions) Why? (These parameters must be measuring similar things.) 4. Which set of data was the most beneficial and why? (ingredient list because it gave an exact list of what the item was made of) 5. What is your overall conclusion about using evidence to group items in terms of their relationship to each other? 6. How could your conclusion be affected by using only one piece of data? 7. How would you summarize how the validity of a conclusion is measured and evaluated? *(For example a student might say, “Conclusions need to have a lot of evidence to support it,” “Conclusions that only have one or two pieces of evidence are not as valid as a conclusion that has many evidences to support it.” “It might be hard to put a number on how “true” a prediction/conclusion is, but the more data that supports it the better.”)*   NOTES for assessing activity and content: In analyzing ALL the evidence, there is no definitive evidence that proves the identity of each food or exactly how closely related the foods are to one another. However, the ingredient list is the most valid because it gives you specific components of the foods. The idea is to explain to students that there are **several** pieces of evidence to support the conclusion:   * *that the cereals, crackers and pasta are most closely related due to their high calories, relatively low fat, high carb content and the fact they all contain wheat. Semolina is defined as: “the purified middlings of hard wheat (as durum) used especially for pasta (as macaroni or spaghetti”,* [*http://www.merriam-webster.com/dictionary/semolina*](http://www.merriam-webster.com/dictionary/semolina)*)* * *somewhat closely related are the peanut butter and caramel-nut bars due to the fact they both contain peanuts, and similar protein contents* * The L6 is “tuna” because the first ingredient is listed as tuna. The other evidences support that it is tuna as well.   Students may state alternate theories, and as long as they have reasonable evidence to support them, they may be valid. The main idea is to introduce them to predictions based on “single” bits of evidence are not as valid as predictions supported by many evidences. Be sure to note that if using **only** the “physical” evidence, *the shape* of the label, they could have easily come to erroneous conclusions.  **Activity**  **Note:** This section of the lesson is again divided into steps to help guide and frame the activity. Students are still in groups of 4. If student conflicts or collaborative grouping was not efficient during Exploration, groups should be rearranged keeping in mind that heterogeneous grouping is still recommended.  **Step 1:**  Teacher should tell students that they will be using the model they just experienced a bit later in the lesson. To switch gears, ask them to construct a KWL chart in their notebooks. KWL strategies are useful in all disciplines to help activate prior knowledge (*Attachment 8: KWL Strategies*). Their topic is “whales.”  The teacher may decide to help activate student’s prior knowledge by showing a video clip of whales. There are many clips available on the internet. Any video that shows the whales in motion and/or their body shape would be sufficient. At this point, the video is simply to stimulate thinking about whales. Please do not include information about whale fossils or evolutionary path since these topics will be discovered throughout the lesson. The following is an example of a site that provides free nature video clips, including whale video clips: <http://www.inthewildproductions.com/Free_Nature_Video_Clips.html> *Optional*: Pictures of whales may be substituted to activate prior knowledge.  Each student will construct a KWL chart in their notebooks. They will start the chart with what they already know (“K”) about whales. Afterward, each student will complete the “W” (“Want” to know) portion of the KWL. The final column “L” will be completed at the end of the activity.  When students have finished the KWL, ask student groups to discuss and predict what they think the ancestors of whales would have looked like.  Students discuss and predict what they think the ancestors of whales may have looked like. Groups will describe these ancestors including appearance and habitat (where they might have lived and ate).  **Assessment**: Make a drawing of the “whale ancestor” created by the group. Write a statement as to why you described it as you did include the reasoning for your description. At this point, the teacher is getting an idea of student’s prior knowledge. The statement should include a logical explanation. For example: *“Our whale came from*  *a dinosaur that swam in the oceans. It was gargantuan and had very sharp teeth to protect itself from meat-eaters like T-Rex.” “Our whale ancestor was very small, like a small fish. Over time the fish had so much to eat, that it got bigger and bigger.” “Our whale ancestor could fly because the modern day whale flipper looks sort of like wings.”* Although the desire is to “correct” the misconceptions do not do so at this point. It will become evident to the student by the end of the lesson why their description might be incorrect. They will revisit this step later in the lesson to re-evaluate their prediction.  **Step 2:**  The teacher will tell students that they are evolutionary biologists who are studying the evolutionary descent of whales. They will be arranged in research teams whose job is to sort through the evidence and come up with an explanation for the evolutionary past of the modern whale. They will have 3 sets of data to analyze: DNA data, fossil data, and specific ankle bone data.  Students will assume roles for research team collaboration:   1. Timekeeper-insures team is on task, communicates time requirement for activities   (For example: Explains to group how many minutes to discuss or create, or that an assignment is due next class period, etc.)   1. Materials manager—insures team has all needed materials when necessary, returns materials when completed, helps team members organize notebooks/journals and place assignments in the order requested 2. Recorder—responsible for keeping group documentation. The teacher may ask students to complete individual documentation at certain points. The recorder should assist team in understanding her role and when they must document. They are also responsible for keeping all documentation accessible to group when needed. 3. Group manager—insures that the team is carrying out the roles as detailed above, insures that communication between the teacher and group members is clear, helps to alleviate conflicts within team, insures that all members have equal value to group, communicates to teacher if team is functioning well, and reports specific problems within the team if they cannot be resolved by the members.   **Step 3:**  **EVIDENCE 1: DNA Teacher tells group:**  **“This evidence has been collected from a reputable laboratory and requires analysis by your team.”**  Students will be given the DNA sequences (*Attachment 9: Whale DNA Strips*) of a segment of beta-casein from various animals, and a chart to record the comparison, that is, the number of DNA bases that are different between animals (*Attachment 10: DNA Whale Comparison chart*). The key to the chart is found in *Attachment 11: DNA Char*t *Key*. Teacher may make copies for each student or ask students to redraw the graph in their notebooks. If the teacher chooses, the recorder in the group can keep all data, notes, etc. and submit one notebook for group. Teacher should either model the method to determine differences or let groups discover how to determine them from the DNA sequences. With either method, the teacher should monitor groups closely for accurate collection of evidence.  Students will identify the differences between the segments of DNA and complete the comparison chart. They will use comparison data from charts as evidence to make a conclusion about the relationships of the whale to the other animals and record in notebook.  **Assessment**: Teachers should be assessing for student ability to use the data to show relationships between the organisms. Unless specifically asked, students may write a statement using the data to support a conclusion. For example, a group might say *“The Right Whale, Sperm Whale, Porpoise and the Hippo are the most closely related because that’s where the fewest differences were found.”* Other students may draw a phylogenetic tree to show relationship. For example,  Porpoise  Rt. Whale    S. Whale  Hippo  **Step 4**  **EVIDENCE 2: Fossil The teacher says: “This fossil data was collected by people all around the world and must be analyzed.”**  Students will be given diagrams of whale fossils *(attachment 12: Whale Fossil Strips Large and Attachment 13: Small Whale Fossil Strips*); they are NOT in any order). There are no names, dates or explanations given to students at this point.  It suggested that you supply students with a sketch or diagram of the modern whale with which to compare the fossils. (*Attachment 34: Modern Whale sketch*)  Students will compare/contrast pictures of whale fossils and put them in order of evolutionary progression. In other words, which fossil is oldest? What is the sequence of fossil age? Teams will make a statement as to their reasoning using the fossil evidence provided. (Many students will erroneously predict that the whale ancestors begin with the most “whale-like” fossil.  It is important in working with fossils that students realize the fossil record is found in layers upon layers of rock. Therefore, the oldest fossil would be in the deepest layer of rock. This is the basis of relative dating. Teachers should lead their students to this understanding by questioning. Possible questions are:  Assessment: Teacher should assess for understanding and using evidence to make a claim. Teacher will ask, *“Which fossil is the oldest in your sequence?”*  Teacher should work with each group to make assessment through this oral questioning.   * If they answer correctly, ask them why they think this is the case. Students might say “this fossil looks more like the whale so it’s the closest one to the top.” * If they say that the “4-legged” fossil is at the top ask the following questions.   + If I am a paleontologist, and I started digging for fossils, which one of these would I come to first?     - They should answer the “whale-like” fossil. However if they do not, then ask them to remember what the modern whale looked like from the videos or pictures presented early in Step 1 of the Activity.     - Then ask, “Which one of the fossils looks more like the whale?” The students will immediately pick the correct fossil (one of the most “whale-like”). They still may not realize that it should go at the top.   + Some of the confusion lies in the fact that they have a misconception that all life started in the ocean and went to land. However, in the case of the whale, the pattern was water-land-water.   + Students need to be somewhat accurate at this point. The teacher should lead them to narrow down which fossil is oldest (one of the four-legged fossils) and narrow down which fossil is most recent (one of the “whale-like” fossils). See the key to fossil order (*Attachment 33: Key Whale Fossil Name and Date)*, but **do not correct** students at this point.   The teacher may want students to record the sequence in their notebooks by using the numbers on the diagrams. If removable tape is available students could cut the strips and place them in their notebooks. Most likely as they work through the steps of the lesson, they will have to reorder the fossil strips as new information is discovered. If removable tape is not available students can keep their fossil strips in a small envelope paper-clipped in their notebooks.  **Step 5:**  **EVIDENCE 3: Ankle Bone Teacher says: “This data has just recently come to light. It is interesting, but the impact is not quite known. Your group needs to analyze this data by grouping the bones in similar groups.”**  Students will be given pictures of different animal ankle bones (*Attachment 14: Ankle Bone and Name Cut Outs*). The teacher should identify Ankle Bone “B” as a known whale ankle bone fossil. However, the others are unknown at this time. Students can only group ankle bones in similar like groups. They will record groupings in notebook. Again, the teacher can decide how to do this, either by numbering the ankle bones or placing them in the notebook with removable tape.  **Teacher says: “Once you have analyzed this ankle bone data, look back over all the evidence you have received. Compare the evidences and make a conclusion about the evolutionary path of the whale and it’s relatedness to other animals. ”**  Students will compile all evidences and come to a general conclusion and predict how the whale has changed through time and how they relate to other animals. The conclusion should include the analysis of the evidence. Groups should record all conclusions in their notebooks.  **Assessment:** Teacher should assess these conclusions specifically to see that students are able to use the data to support their claims. It is equally important that if students add data to their research based on prior knowledge, then they should state this. For example, students might say, “*We know that the Rt. Whale, S Whale and the porpoise should be most alike because they are aquatic mammals”* Although this is correct. They need to consider how they know the fact and use it. However, they must use the data in the lesson to support their claims.  **Content Wrap-Up**  **Step 1:**  Teacher will give students questions on a handout that can be glued into their notebooks. Each group discusses and then records answers. Ask these questions for groups to discuss at their tables.   * 1. Why is DNA of beta-casein used?   2. What is the overall conclusion about the relationships of these animals using this DNA data?   3. Does this seem logical? Explain.   4. Was anything surprising about the results of this evidence?   5. Using all the evidence in this activity, how is the whale related to other animals? Which animal is most closely related to the whale? Explain by summarizing the evidence.   6. As a scientist do you think this is enough evidence to positively make the claim of evolutionary relationships between the animals? If so, why and if not why?   (*Attachment 16: Discussion Q and A, Step 1*) **However, do not expect** them to come to accurate decisions until the next step in the activity. At this point they are trying to evaluate the evidence.  **Step 2:**  **Teacher says: NEW EVIDENCE IS AVAILABLE! You have even more evidence to help you conclude the evolutionary path of the whale. With this new evidence you will need to re-evaluate your previous conclusions.”**  Student groups will be given a copy of the Whale Primer (*Attachment 17: Whale Primer*) on the discoveries of whale origins. Students will be given strips of paper with whale fossil names and identifying information (*Attachment 18: Labels for Fossils*) to match to their fossil pictures. The groups use the Whale Primer to confirm or re-evaluate their fossil evidence conclusion, and correct if necessary. Once adjusted, students will label the fossil diagrams in their notebooks with name and age. This is why the removable tape is optimal.  **Step 3**  **Teacher says: “More information about the Ankle Bone Evidence has come to light. Each group should re-evaluate their original analysis.”**  Students will be given the ankle bone animal origins and a description of the type of ankle bones in each picture (*Attachment 15: Ankle Bone and Explanation*). Students will re-evaluate their ankle bone groupings and change if necessary. Animal origins should be included in their groupings.  **Step 4:**  Through discussion or brief lecture, the teacher should provide the vocabulary words for this activity (*Attachment 19: Vocabulary for Content Wrap UP*).  Students should re-evaluate all data and prior conclusions to reflect this new information. Students will write a new conclusion using the re-evaluated evidence and using the vocabulary introduced by the teacher. This conclusion will be written in the notebook.  **Assessment:** Teacher will give each group different questions to discuss, summarize and make a two-minute presentation to the class. The questions might be the exact ones used in the food label activity or similar ones. Further options include use of the questions for whole group discussion or the teacher may print them and assign for homework. (Suggested questions with answers, *Attachment 20: Assessment Discussion Q and A*)  **Guided Practice**  **Step 1:**  Teacher will provide thelink to “Whale Evolution” on the Berkeley site. <http://evolution.berkeley.edu/evolibrary/article/0_0_0/evograms_03>  Students should work in pairs to go over the data. They may do this online if computers are available or teacher can print this information out prior to class. See printed material from this site in (*Attachment 21: Whale Evolution*) and permission email (*Attachment 31: Permission to reprint from UC Berkeley site*).  As students go over this information, they will list other evidence of whale evolution.  Once the students have completed their research on this site, through a mini-lecture, the teacher will review the additional vocabulary to distinguish the different types of evidence that was found on the site. *(Attachment 22: Vocabulary Guided Practice*).  Students write a new statement to add to their previous conclusion about whale evolution. They will use the new evidences to support their conclusions from the prior activities, and they will use the new vocabulary in this new statement. Teacher should explain that science is ever-changing and therefore, as new evidences, technologies and discoveries are made, theories and hypotheses must be re-evaluated similarly to the method they used in this lesson.  **Step 2:**  Teacher will show the following video from the Holiday Lecture Series at the Howard Hughes Medical Institute: Evolution: Constant Change and Common Threads Lecture 3 – Fossils, Genes, and Embryos by David M. Kingsley, Ph.D. <http://media.hhmi.org/hl/05Lect3.html> the video is a lecture and provides hyperlinks to each slide. If time is an issue, the teacher can choose which slides to highlight. If the website and video are unavailable, make copies of the transcript. (*Attachment 23: Transcript HHMI Lecture*). The teacher can read parts of the transcript or create a power point to use in place of the video.  Students will watch the video and make notes about different evidences that have been mentioned in the examples used by the presenter. They will highlight any information that was new to them or that confirmed something they had learned in this lesson. Two different colors of highlighters may be used. |
| **Assessment** | 1. Students will complete the “L” portion of the KWL from the previous activity.    1. Teacher should be assessing for major points of new information gained.    2. Since this is bulleted information, deeper connections will not be obvious. 2. Students will create an abstract and mini-presentation board to summarize all the data to predict the evolutionary path of the whale. All “new” evidence should be included. Teacher will be assessing for:    1. the correct use of evidence to support a claim    2. The accuracy and complete use of all the data    3. Using logical sequencing of data to summarize 3. Students will participate in a gallery walk to view each group’s final conclusions about whale evolution*.(Attachment 35: Gallery Walk Review Guide)* Teacher will be assessing (*Attachment 30: Whale Evolution Gallery Walk Rubric*):    1. Accurate knowledge through questioning    2. Discussion of similarities and differences between presentations 4. Students will write a reflection about this lesson: Evidences of Evolution: “Get a Clue” using teacher-directed questions.    1. How would you rate this lesson in terms of “interest?”    2. Do you think the lesson made “sense?” Did it flow? Did you get frustrated at any time because directions were unclear? (This is different from being frustrated because new evidence made you retrace your steps.)    3. What was the most surprising thing you learned during this lesson?    4. Write a sentence or two that would connect these words in a meaningful statement.   Evidence Conclusion Research Ever-changing Valid or Validity Evolution   1. Teacher will ask specific questions regarding evidence of biochemical data, fossil evidence and homologous structure data through a summative assessment. The assessment is a combination of short answer and multiple choice questions. See Summative Assessment (*Attachment 27: Summative Assessment, Attachment 28, and Key to Summative assessment*). 2. Optional Assessment: Student will be given another set of “new evidence” (*Attachments 24: New evidence in Whale Evolution and Attachment 26: Missing link*). They will write a one page explanation of how this evidence may change or confirm the accepted path of whale evolution. |
| **Critical Vocabulary** | Definitions of words 10-13, can be found in the “evolibrary” at the Berkeley website: <http://evolution.berkeley.edu/evolibrary/article/0_0_0/lines_08>   1. **Evidences of Evolution**   Evidence that gives the Theory of Evolution the scientific data that life has existed for billions of years and has changed over time. There are many types of evidences:   1. **Fossil evidence**: The fossil record provides snapshots of the past that, when assembled, illustrate a panorama of evolutionary change over the past four billion years. The picture may be smudged in places and may have bits missing, but fossil evidence clearly shows that 2. **Homologous structures/Homologies**: Similar characteristics due to relatedness are known as homologies. Homologies can be revealed by comparing the anatomies of different living things, looking at cellular similarities and differences, studying embryological development, and studying vestigial structures within individual organisms. 3. **Biochemical/molecular evidence:** Different species share genetic homologies as well as anatomical ones. Roundworms, for example, share 25% of their genes with humans. These genes are slightly different in each species, but their striking similarities nevertheless reveal their common ancestry. In fact, the DNA code itself is a homology that links all life on Earth to a common ancestor. DNA and RNA possess a simple four-base code that provides the recipe for all living things. In some cases, if we were to transfer genetic material from the cell of one living thing to the cell of another, the recipient would follow the new instructions as if they were its own.   The explanations of words 14 and 15, can be found at this Berkeley site <http://evolution.berkeley.edu/evolibrary/article/lines_07>   1. **Embryological evidence:** Studying the embryological development of living things provides clues to the evolution of present-day organisms. During some stages of development, organisms exhibit ancestral features in whole or incomplete form. 2. **Vestigial structure:** A feature that an organism inherited from its ancestor but that is now less elaborate and functional than in the ancestor. Usually, vestigial structures are formed when a lineage experiences a different set of selective pressures than its ancestors, and selection to maintain the elaboration and function of the feature ends or is greatly reduced. , and geographical evidences |
| **Modifications** | Because collaborative groups are used throughout this lesson, modifications can be handled in a more informal way by allowing students to choose roles within their own group. Students with LD may choose to be the time keeper, materials manager or another role that will not be intimidating to them. Usually students choose to their strengths which often eliminate the need for more formal modifications. However, below is a list of additional modification suggestions.   |  |  |  |  | | --- | --- | --- | --- | | Activity | EC | AG | ELL | | Exploration/Model | **Reading**: A student in food ingredient group can be assigned to read aloud | Students can identify food ingredients as a source of protein, carbohydrate, lipid, vitamin, mineral or preservative | Instead of giving food labels, give pie charts for fat content or carb content showing % of the whole. Ex. | | Exploration/Model | Strips can be magnified for easier use. Highlighters can be used to mark directly on strips. Rulers are helpful to keep place. | Students can research the technique for obtaining these DNA sequences through genome mapping. | 15% fat | | Guided  Practice | Someone in group can read sentence strips to group members.  From Whale Evolution website, students can draw the evidence they find. | Students can research relative dating and absolute (radio dating). They can tell the importance, reliability, use and difference of the types. Students may choose to construct a model of relative dating using diff types of soil in a beaker. They can make a short presentation to the class.  Students can study the process of determining osmoregulation using oxygen isotopes and how it is used as evidence in evolutionary explanations. <http://www.colorado.edu/anthropology/faculty/sponheimer/pdfs/SponheimerandLee-Thorp1999c.pdf> | Students can be given small pictures of fossil data and ankle bone data to put in notebooks. Also, names and dates can be printed to glue in books | |
| **Alternative Assessments** | The process of Formative assessment is very important in modifying instruction for ALL groups of students. However, in this lesson formative assessment is crucial so as to monitor understanding in special groups. This lesson is inquiry and discovery based, therefore traditional assessment (tests, quizzes, labs, etc.) are minimal. The assessment of understanding is constant and necessary in order to modify instruction as needed. In addition to the many formative assessment opportunities throughout this lesson, the following suggestions are but a few more that may be of specific help in understanding depth of knowledge to those in special groups.  EC: Students might be asked to simply look at the numbers on the labels and identify which are more alike. They may be asked to explain how important the “amount” of information is in making decisions. Students could use blocks or Unifix cubes to show similarities of different organisms. Block organism could be made with different colors and the more colors that are alike the more closely related the organisms are. Summative Assessment could be given orally as well.  ELL: Same as above. Also pie charts could be used instead of labels. Students could then group like charts together to demonstrate understanding of similar organisms. Using the Unifix cubes, students might be given a key to the colors that refer to different traits of animals. Red=feather, blue = flippers, etc.  AG: Students can create organisms made from blocks or unifex cubes and provide a key showing how the organisms are more closely related. These creatures could be used in assessing EC and ELL students (see above, ELL). Students can make a special presentation on osmoregulation and the fossil records that shows how the blow hole in a whale has “moved” through time. They could also research embryological development of Cetaceans and demonstrate how the “blow hole” moves during this development as well. Research the phrase “Ontogeny Recapitulate Phylogeny” and report to the class. |
| **References** | **The following websites and resources are specifically used in this lesson.**   1. <http://evolution.berkeley.edu/evolibrary/article/lines_07> 2. <http://evolution.berkeley.edu/evolibrary/article/0_0_0/evograms_03>See Attachment 31: Permission to reprint material UCBerkeley 3. Holiday Lecture Series at the Howard Hughes Medical Institute: Evolution: Constant Change and Common Threads Lecture 3 – Fossils, Genes, and Embryos by David M. Kingsley, Ph.D. <http://media.hhmi.org/hl/05Lect3.html> 4. <http://www.inthewildproductions.com/Free_Nature_Video_Clips.html> 5. [www.indiana.edu/~ensiweb](http://www.indiana.edu/~ensiweb) “Whale Ankles and DNA” and “Becoming Whales”   This site is used extensively in this lesson. It should be stated that this site has a vast amount of information. It cannot be stressed enough how important this site is to those who want to know more about evolution and how to teach it. The information is updated regularly. ENSI Webmaster Larry Flammer with his amazing credentials is a friend to all science teachers. In creating this website, he has and continues to add lesson plans, tips for teachers, related articles, new research, etc. The site offers a listserv that insures that you receive the latest and greatest from this valuable website.  <http://media.hhmi.org>: Additional Holiday Lecture series by Dr. Philip Kingsley available at this site. This would be a great resource for advanced students or students who might be unable to attend traditional classes, for example a student who may not be able to attend class due to health reasons.  <http://www.colorado.edu/anthropology/faculty/sponheimer/pdfs/SponheimerandLee-Thorp1999c.pdf> Journal article on how fossil teeth are analyzed. |
| **Supplemental Information** | Background reading:  General Evolution   * <http://www.aaas.org/news/press_room/evolution/> Science News resource * <http://evolution.berkeley.edu/> background info, resources, used in this lesson plan and much more. There are several great tutorials at this site for teachers and students. * <http://www.faseb.org/Policy-and-Government-Affairs/Science-Policy-Issues/Evolution-Education-Resources.aspx> background information and arguments for teaching evolution * <http://mcb.harvard.edu/biolinks/evolution.html> many evolution resources: articles, museums, practical uses, research, etc. * <http://www.indiana.edu/~ensiweb/> one of the largest, most comprehensive websites on all things evolution. Some activities in this lesson were modified from this site. * <http://www.millerandlevine.com/km/evol/> resources on controversy and how to handle it * <http://www.nabt.org/websites/institution/index.php?p=110> a clearinghouse of resources * http://www.nationalacademies.org/evolution/ Provides background information and teaching resources * <http://www.nsta.org/publications/evolution.aspx#resources> resources, free and for purchase * <http://www.pbs.org/wgbh/evolution/library/index.html> information with high quality, videos, photos, etc. * <http://www.sigmaxi.org/resources/evolution/index.shtml> uses of evolution * <http://www.wellcome.ac.uk/Education-resources/Teaching-and-education/Big-Picture/All-issues/Evolution/Articles/WTD026060.htm> applying evolution   **Teaching Strategies:**   * **Questioning**: “Questioning challenges students and teachers to use good questions as a way to open conversations and further intellectual inquiry. Effective questioning (by the teacher and by students) deepens classroom conversations and the level of discourse students apply to their work. Teachers use this strategy to create opportunities for students to investigate and analyze their thinking as well as the thinking of their peers and the authors that they read in each of their classes.” <http://newschoolsproject.org/uploads/resources/resource-common-instructional-framework.pdf>   Question Toolkit: This website assists teachers in asking different types of questions to gain specific insight into student’s thoughts, ideas and knowledge. <http://www.questioning.org/Q7/toolkit.html>   * Inquiry Based Learning: * Basic explanation <http://www.thirteen.org/edonline/concept2class/inquiry/index.html> * How to’s: <http://www.neiu.edu/~middle/Modules/science%20mods/amazon%20components/AmazonComponents2.html> * Interactive Notebooks: * <http://www.gushwalogy.org/interactive_notebook.htm> good practical use of notebooks, easy to follow directions * shows directions to set up and use notebooks, also provides rubric <http://srchapnick.tripod.com/interactive_journals.htm> directions and rubric * Gallery Walk Presentations: * <http://serc.carleton.edu/introgeo/gallerywalk/index.html> this is a great site to understand the use of gallery walks, rubrics, and examples. |
| **Comments** | The main reason I started experimenting with teaching the evidences of evolution through an inquiry approach was because I felt that most lessons I had found were heavy on “front-loading” students with information. Since inquiry and discovery is the actual method by which scientists study science, I wanted my students to use these processes to discover evidences of whale evolution to make an evolutionary biology claim/prediction. I chose whale evolution because there is quite a bit known about this topic (as you can see from the list of supplemental resources). Earlier in this unit I taught a lesson where students must find all the influences and evidence that Darwin used to mold his ideas on natural selection and evolution. At that point, it was obvious to students that the idea of evolution was not “one man’s dream having traveled to some weird islands.” All the evidence supports his claims. This lesson provides another example of how multiple evidences support predictions and the more evidence that support it, the more valid it is.I was fairly pleased with the outcome of the lesson, but it was not perfect. Therefore, I have some more tweaking to do. I believe another approach to this inquiry would be to teach the lesson using “Research Groups” and “Experts Groups” Each member of the research group is also an expert on a specific type of evidence that they research and study with their “expert” team and then the expert reports back to the Research Team. I believe this might actually allow the students to use even more inquiry without me directing each step. This would also maximize collaborative group roles to insure that all members are contributing members of the team.Students have enjoyed this lesson. I have often seen “light bulb” moments and many connections made to the “model” system (the label activity). Some students were frustrated at times. Of course, this is a good thing if you are there to help them work through the frustration. This means they have engaged enough to realize they do not understand a concept. By being there as a facilitator, all I have to do is ask questions to lead them to their own conclusions. This reality is amazing to see. It confirms that indeed this type of teaching and learning is powerful. I often heard students conversing with each other where some team members would explain concepts or clear up misunderstandings. As a teacher, being aware that these things are happening in your classroom is the difference between good inquiry and an inquiry lesson where only a few are doing the work. Students resent this and expect you as the teacher to handle it. By actively participating and monitoring throughout the learning process, teachers are able to do this. I also noticed that some groups would be ready to move on when other groups had not. It is a good idea to have a few questions waiting “in the wings” to be pulled out for these more fast-moving groups. See some of the suggestions in the AG Modifications in this lesson. Additionally, another whole set of evidence could be created using embryological data that might be utilized in these situations. |
| **Author Info** | My name is Sharon Carpenter Green, and I am an 11th grade Honors Biology Teacher at Caldwell Early College High School located in the town of Hudson in Caldwell County, NC.  I have taught for 14 years having entered the teaching profession through lateral entry while living in SC. I am certified in General Science and Health. I received my BS in Biology from Western Carolina University in Cullowhee, NC and my Master of Science in Biochemistry from the University of Tennessee-Knoxville. I started my career in pharmaceutical research with a young R and D company in Princeton, NJ. Moving back to the South was a family decision. I taught college labs at the University of SC-Spartanburg for several years until I learned about the opportunity to become a secondary high school biology teacher. This was accomplished and in 2005 I moved back to NC. I began teaching in North Carolina at West Caldwell High School in Lenoir, NC, and I remained there for 3 years. Four years ago, I was offered a position to teach honors biology at Caldwell Early College High School, an innovative high school using the methodology of research based practices outlined through their parent agency, The NC New Schools Project. This has been an amazing professional opportunity. Since teaching at the Early College, I have been a presenter at the NCSTA Annual meeting each year since 2009. I received my National Board Certification in 2010 and was named District 7 NCSTA Science Teacher of the Year for 2011. One of my highest honors was being chosen as Caldwell Early College High School “2011 Teacher of the Year” by my peers. Having been chosen as a Kenan Fellow for 2012 has been a wonderful opportunity. Networking throughout NC meeting fellow science teachers who have been more than generous with their ideas, encouragement, and friendship has been a joy.    **About this project:**  In order to encourage students to learn more about science, we, their teachers have a responsibility to engage our students 100% of the time. Our lessons should reflect this attitude. There should not be one student who sits in the back of the room disengaged and bored. It is my responsibility to find methods, strategies, lessons and experiences and offer them to my students.  When I read about “Teachers training Teachers” as a Kenan fellowship topic, I was very excited to use this venue to help me achieve my goals as mentioned. Partnered with experts from the North Carolina Department of Public Instruction and focusing on the new NC Essential Standards for Science Education, I realized an amazing opportunity to correct my erroneous idea that these standards were basically “the same” as the old ones. In addition, working with the County’s Science Professional Development Team to roll out the NC Essential Standards to our local science teachers helped me delve into the standards to a much deeper level. Without the Kenan DPI Fellowship I would not have been in this position. In addition, it soon became apparent that the differences in the standards are not found so much in content, but in the depth and breadth of the standards. This in turn will require new teaching methodologies to insure that students develop a deeper understanding of the content than through past standards. Through this fellowship I have learned that the Revised Bloom’s Taxonomy (RBT) has influenced how these standards have been written, how they will be tested, and most importantly how they will be taught. In addition, my DPI Mentor, Kimberly Simmons encouraged me to work through NC Falcon the module on formative assessment. I am very glad that I did. Clarifying the learning targets both for the teacher and the student will only help students demonstrate that understanding and help teachers assess accurately and appropriately. This lesson plan attempts to demonstrate how inquiry and discovery learning can meet these new demands. It also attempts to allow students to demonstrate their understanding and be assessed accordingly.  I look forward to continuing to teach and improve this lesson. I will continue to analyze where in the lesson students will be thinking, actively engaging with content, and using content as evidence to make decisions and draw conclusions. To me, these aspects of the lesson are at the heart of the new standards and science as a discipline.  **Mentor:**  Kimberly Simmons  Professional Development Consultant- Northwest Region Educator Recruitment and Development NC Department of Public Instruction  **Acknowledgements:**  This has been a great professional opportunity for me. I would like to thank Lisa Hibler, Matt Misuraca and Tom Knott from Kenan. I would like to thank all the sponsors of Kenan who make this opportunity available to those of us who are looking for ways to make a bigger more profound impact in our classroom, school, and communities. I would like to thank Kimberly Simmons from DPI for her time and assistance. I appreciate that she introduced me to the NC Education modules that have been very helpful. Also through my association with Kimberly and DPI, I was in a position to join our county’s NC Essential Standards Science PD Team**.** Lastly, I would like to thank my CECHS family who has offered their love and assistance whenever needed, and of course my real family who have not seen me at times, but they know that I’m somewhere working. |