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| **Subject / grade level: Evolution and Classification (Grade 9)** |
| **Materials:**   * Student Instructions Packet * Article “The Difficulty in Classifying Life and Directed Notes Taking Form” * Group Assignments * Procedure * Student Data Sheet * Computer with Internet access (UniProt.org) * PowerPoint “Investigating Evolutionary Relationships through Morphology and Molecular Analysis” with Diagram and Organism Pictures (optional: students can look these up online using www.Arkive.org) * Poster Paper * Markers |
| **NGSSS**  [**SC.912.N.1.4**](http://www.floridastandards.org/Standards/PublicPreviewBenchmark1859.aspx)  Identify sources of information and assess their reliability according to the strict standards of scientific investigation.  [**SC.912.N.1.6**](http://www.floridastandards.org/Standards/PublicPreviewBenchmark1861.aspx)  Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.  [**SC.912.N.2.4:**](javascript:ViewBenchmark('PublicPreviewBenchmark1869.aspx',1869);)  Explain that scientific knowledge is both durable and robust and open to change. Scientific knowledge can change because it is often examined and re-examined by new investigations and scientific argumentation. Because of these frequent examinations, scientific knowledge becomes stronger, leading to its durability.  [**SC.912.L.15.1**](http://www.floridastandards.org/Standards/PublicPreviewBenchmark1992.aspx)  Explain how the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change.  [**SC.912.L.15.2**](http://www.floridastandards.org/Standards/PublicPreviewBenchmark1993.aspx)  Discuss the use of molecular clocks to estimate how long ago various groups of organisms diverged evolutionarily from one another.  [**SC.912.L.15.4**](http://www.floridastandards.org/Standards/PublicPreviewBenchmark1998.aspx)  Describe how and why organisms are hierarchically classified and based on evolutionary relationships.  [**SC.912.L.15.5**](http://www.floridastandards.org/Standards/PublicPreviewBenchmark1999.aspx)  Explain the reasons for changes in how organisms are classified  [**SC.912.L.16.10**](http://www.floridastandards.org/Standards/PublicPreviewBenchmark2021.aspx)  Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues. |
| **Essential Questions Addressed:**   * How are organisms classified based on evolutionary relationships? * How were organisms classified in the past, and why did this change? * What are the main lines of scientific evidence that support the scientific theory of evolution by natural selection? * What is biotechnology and some of its uses? |
| **NGSS Performance Expectations**   |  |  | | --- | --- | | **HS-LS4-1.** | Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. | |
| **NGSS Disciplinary Core Ideas**   * Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1) |
| **Science and Engineering Practices Addressed:**  1. Asking questions (for science) and defining problems (for engineering)  2. Developing and using models  3. Planning and carrying out investigations  4. Analyzing and interpreting data  5. Using mathematics and computational thinking  6. Constructing explanations (for science) and designing solutions (for engineering)  7. Engaging in argument from evidence  8. Obtaining, evaluating, and communicating information |
| **Common Core State Standards Connections:**  **ELA/Literacy -**  **RST-11.12.8**  Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS4-5)  **WHST.9-12.2**  Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS4-1),(HS-LS4-2),(HS-LS4-3),(HS-LS4-4)  **WHST.9-12.5**  Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS4-6)  **WHST.9-12.7**  Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS4-6)  **WHST.9-12.9**  Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS4-1),(HS-LS4-2),(HS-LS4-3),(HS-LS4-4),(HS-LS4-5)  **SL.11-12.4**  Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-LS4-1),(HS-LS4-2) |
| **Differentiation strategies to meet diverse learner needs:**  There are a variety of ways to differentiate this lesson to meet a diversity of needs. They a include but are not limited to the following:   * Directed Note Taking, “The Difficult in Classifying Life” * This could be done as an introduction for students who will need more background to complete the assignment. * For students who have very low reading levels or ELLs, teachers can give the students the DNT form with the notes filled in already and require the students to find the text citations and determine which category to classify each note under. * Some intermediate students may need just a little help to get started, teachers in this class may wish to provide the first 3 notes with the classifications already checked and require the students to find the text citations to get them started. With this example, these students should be able to finish the rest of the assignment. * Students may work in groups for those who struggle with the reading or content. * Part 1: Relationships based on Morphology * Teachers may choose to provide students with images of animals to replace the research portion of this section. Teachers may choose to do this via a saved file on the teacher’s website (Edline, Edsby, Dropbox, etc.) or print pictures. * For lower level courses, teachers may wish to provide students with the organism features to compare for each group. * Part 2: Relationships based on Molecular Data * In the case of lower level courses, time, or lack of internet availability, teachers may wish to provide the students with the % Identity for the cytochrome b pairwise comparison of organisms. |
| **ENGAGEMENT**   * **“Hook” students in by showing them 2 videos of a strange/difficult to classify animal. Here I have chosen the aardwolf**. * Students are asked how they would classify the aardwolf based on the first video (Ardwolf- territorial dispute with cheetah; <http://www.arkive.org/aardwolf/proteles-cristata/video-11.html>) and why. This is a great time to use the CER model. Student responses tend to be along the lines of a fox or wolf due to aggressive behavior and features both of which are similar to the canines’. * Show students the second video where the aardwolf is eating ants with its very strange tongue (Aardwolf-overview <http://www.arkive.org/aardwolf/proteles-cristata/video-00.html>). Students are asked how they would classify the animal now based on this new information. Responses tend to be toward anteater or aardvark due to the strange tongue, the eating of ants and the relationship between the names aardwolf and the ant-eating aardvark. Again, the CER model an acceptable framework for student answers. * Give students the background on the aardwolf discussing that it is actually a hyena. * Questions to ask: * How did your responses change after seeing the second video? Why? * What evidence were you using to classify this animal? Why? * What are the pitfalls of your classification system? |
| **EXPLORATION**   * **\*\*\*Teachers may use their professional judgment based on their particular groups of students whether to perform the lab prior to the “Pre-Lab” reading. Performing the Lab first makes this exercise more genuinely inquiry based; however, some groups of students will require the “Pre-Lab” reading prior to the activity depending on their strengths and abilities.\*\*\*** * Group students into small groups (3-4 students per group). Hand out group assignments as listed in the Student Instructions Packet. This can be done randomly or a list can be projected onto the board allowing student groups to choose what interests them. * Students will perform Parts 1 and 2 of the lab exercise “Investigating Evolutionary Relationships through Morphology and Molecular Data”. * Students will present their finds in the CER model following the completion of each Part. * See instructions in the Student Instructions Packet. |
| **EXPLANATION**   * **\*\*\*As mentioned above, it is perfectly acceptable to differentiate this lesson to provide the explanation activity prior to the exploration.\*\*\*** * Students will first define the key terms listed to aid in comprehension of the key concepts being presented in the article. * Students will then be completing the Directed Note Taking activity using “The Difficulty in Classifying Life”. This will be answering the question “How are evolutionary relationships investigated using morphological and molecular data?” |
| **ELABORATION**   * **Teachers may choose to assign the article “Tracing Human Origins through Genetic Data” for homework or in groups. Teachers may choose to use the DNT strategy and assign each group a specific section and topic to read for. Gale Coument Number: GALE/CV2642650150** |
| **EVALUATION**   * Teachers should evaluate for comprehension of the assessed standards utilizing the CER rubric for each of the CERs produce in the lab (Part 1 and Part 2). Recommend doing this during student presentations. |