Biology 1 lesson plan with Coon Creek Formation in Tennessee

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The Tennessee science standards (TSS) for teaching Biology “are supported by the National Research Council's *Framework for K-12 Science Education* and establish the disciplinary core ideas (DCIs) and practices of science and engineering that will prepare students to use scientific thinking to examine and evaluate knowledge encountered throughout their lives.” The TSS is a free online resource that details the important topics that should be covered within each life science area including subjects such as Earth’s systems, matter and its interactions, heredity, and biological change. There are four sections within the Biology 1 course in the TSS that contain subsections like heredity, ecosystems, and biological change. The Biology 1 subject that I will focus on for this lesson plan is Biological Change: Unity and Diversity which contains subsections including biodiversity patterns and human activities that impact biodiversity, evidence for evolution and common ancestry, adaptation, and natural selection. The lesson plan contains information as it relates to the DCIs required for Biology 1 as well as discussion topics and powerpoint slides with images and text that are useful in preparing a lecture on Biological Change at the Coon Creek formation in Tennessee.

Biodiversity patterns and human activity

One of the goals of the TSS is help students “identify ecosystem services and asses the role of biodiversity in support of these services”, as well as “analyze the role human activities have on disruption of these services”. In the late 1800s, Coon Creek was formed because of human activity to open the land for farming which resulted in increased erosion rates ultimately causing the area to become very deep. The University of Tennessee, Martin (UTM) purchased the Coon Creek property in early 2020, and since then UTM and its faculty such as geology professor Dr. Michael Gibson help host various educational programs including research opportunities and classes for students of all ages from elementary through graduate school. The Coon Creek Formation is referred to as a “lagerstätte” meaning motherlode in German, making it one of few sites in the US that have as high of abundant fossils (Vrazo, et al., 2018).

Topics for discussion:

(1) Balance between advantageous and disadvantageous impacts that humans have had on the Coon Creek formation.

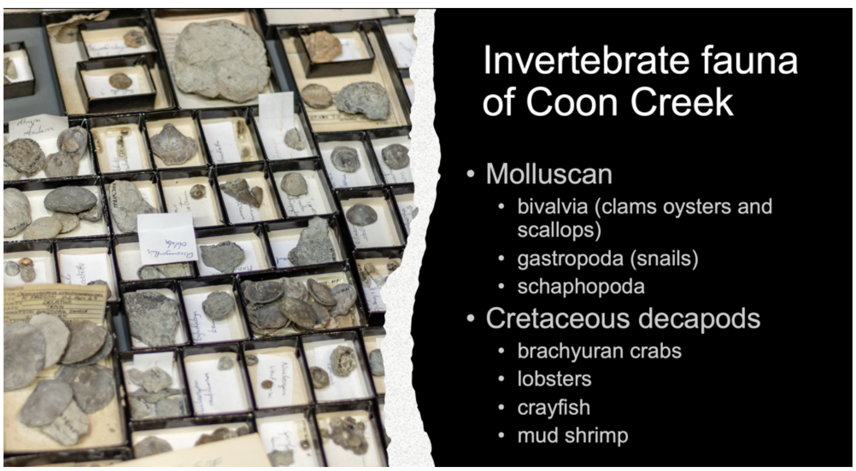
(2) How fossil excavation can increase scientific knowledge, while also contributing to the disruption of the environment. What kind of precautions would UTM need to put in place to make sure that the current ecosystem does not have a disadvantageous impact from scientific efforts in the field?

(3) Discuss the biodiversity that exists at Coon Creek including state fossil Pterotrigonia, (often animals that had shells that surround their soft body, when a clam or oyster falls to the sea floor and dies their hard shell remains allowing it to become a fossil many years

later.) Fossils of the bones and teeth of vertebrates such as marine fish and reptiles including sea turtles and marine lizards such as mosasaurs.

(4) Start to make inferences as to how two organisms could be related to one another, e.g. their shells look similar, their body size is similar, their genetic code could be similar.

Slide 1. The coon creek formation ecosystem changes throughout the seasons in Tennessee, e.g. during the summer months the formation contains more tree fauna growth (right image) than during late winter (left image). Left image from Cypress Magazine available https://www.cypressmag.com/blog/2019/7/22/the-lagerstitte-to-end-all-motherlodes. Right image taken by Christina Chavez available upon request by email.



Slide 2. Biodiversity of invertebrate fossils at the Coon Creek formation include many species of bivalves, snails, crabs and shrimp. Images from Cypress Magazine available https://www.cypressmag.com/blog/2019/7/22/the-lagerstitte-to-end-all-motherlodes.

Slide 3. Biodiversity of invertebrate fossils at the Coon Creek formation. Right image shows the fossil guide of Coon Creek that includes clams, oysters, snails, and shrimp claws. The three images on the right are fossils of brachyuran crab, Bivalvia clam and shelled body of a mud shrimp. https://www.cypressmag.com/blog/2019/7/22/the-lagerstitte-to-end-all-motherlodes.

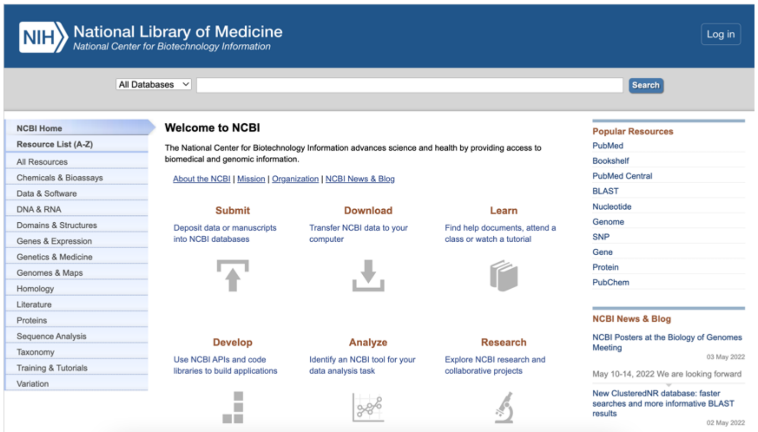
Evidence for evolution and common ancestry

Organisms that look similar are often closer related which is observed in the comparative morphology of extinct and extant mollusks. A goal in the TSS is to help students find evidence for common ancestry (homology between species) to evaluate scientific data collected from analysis of molecular sequences and fossil records to identify chronological patterns, and communicate that biological evolution is supported by multiple lines of empirical evidence. This goal could be achieved with a field trip to Coon Creek for a fossil excavation project, in which students go through the process to collect various invertebrate fossils, and learn how to preserve them on site at the Coon Creek Science Center with Dr. Gibson and his interns. The students can learn about the various morphology differences exhibited by extinct mollusks shells and crustacean claws by uncovering fossils in the creek and surrounding areas of the Coon Creek formation. A follow up in class project could consist of students bringing in their preserved fossils from Coon Creek, which should have been identified during the field trip, and discuss the range of species that were identified (the teacher would ask students for the names of fossils they identified and write them somewhere in which all students could see i.e. whiteboard if in person, or written as a word document and emailed to the students if online). Students would spend time researching extant species that are related to some of the fossils identified by themselves or their fellow classmates. Every student would then identify one interesting extant species to use to collect information utilizing the open source database National Center for Biotechnology Information (NCBI) (https://www.ncbi.nlm.nih.gov/). The images below provide a step-by-step example of using NCBI's Taxonomy Browser database to identify *Mytilus californianus* taxonomic position using NCBI's various resources.

Topics for discussion:
(1) Discuss field trip to Coon Creek and in class activity, and gauge students ability to learn about evolution through multiple means of evidence (fossils and molecular sequences).

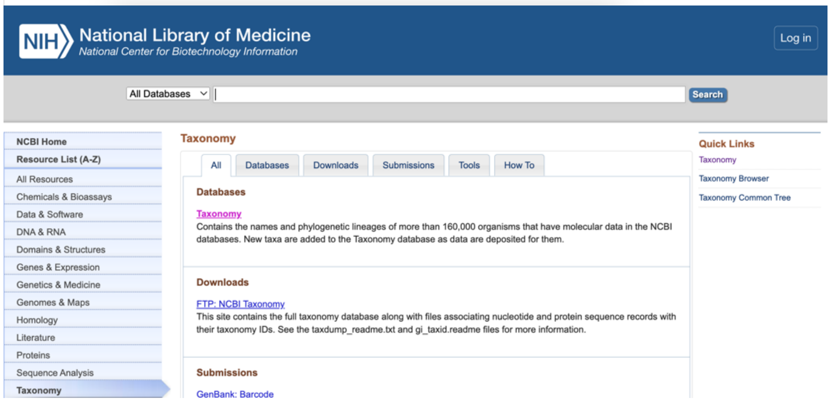
(2) Why is it important to include molecular sequence information, such as the data available from NCBI, when determining homology between organisms? Students should understand that DNA sequence data is more informative than comparative morphology for determining the taxonomic position of an organism.

(3) What are other ways to identify evolutionary patterns (e.g. discuss new techniques such as experimental evolution with microbes)?



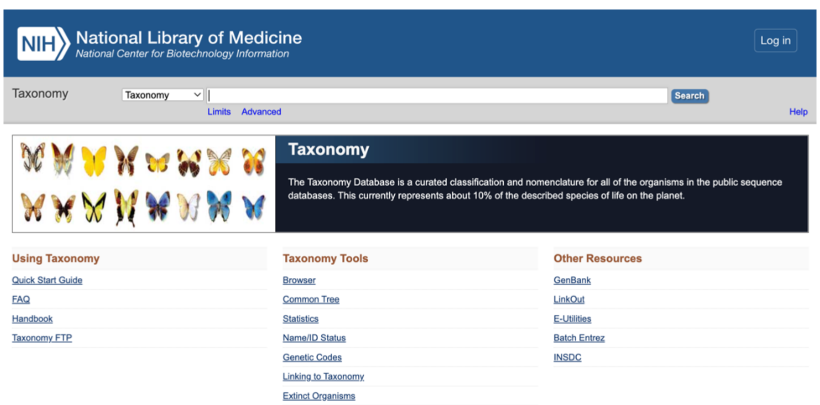
Slide 1. NCBI home page contains a list of resources available on the website on the left side. Click "Taxonomy" to proceed to the next page.

https://www.ncbi.nlm.nih.gov/



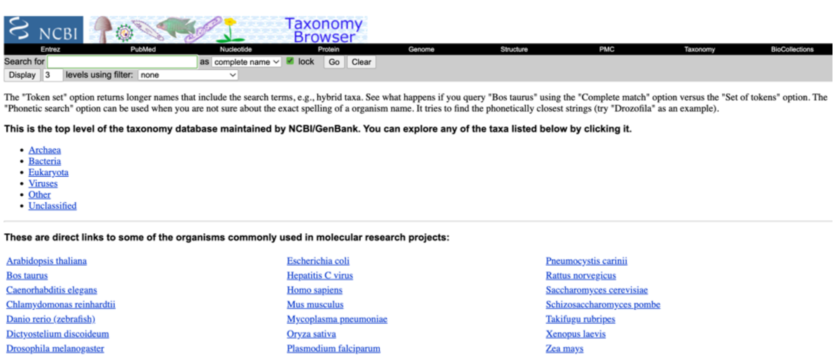
Slide 2. NCBI taxonomy home page contains various links for resources related to taxonomy. In the middle of the page, under "Databases" click "Taxonomy" to proceed to the next page.

https://www.ncbi.nlm.nih.gov/guide/taxonomy/



Slide 3. The NCBI taxonomy database page contains resources such as quick start and FAQ on the left under "Using Taxonomy", as well as "Taxonomy Tools" and "Other Resources". In the middle of the page under "Taxonomy Tools", click "Browser" to proceed to the next page.

https://www.ncbi.nlm.nih.gov/taxonomy

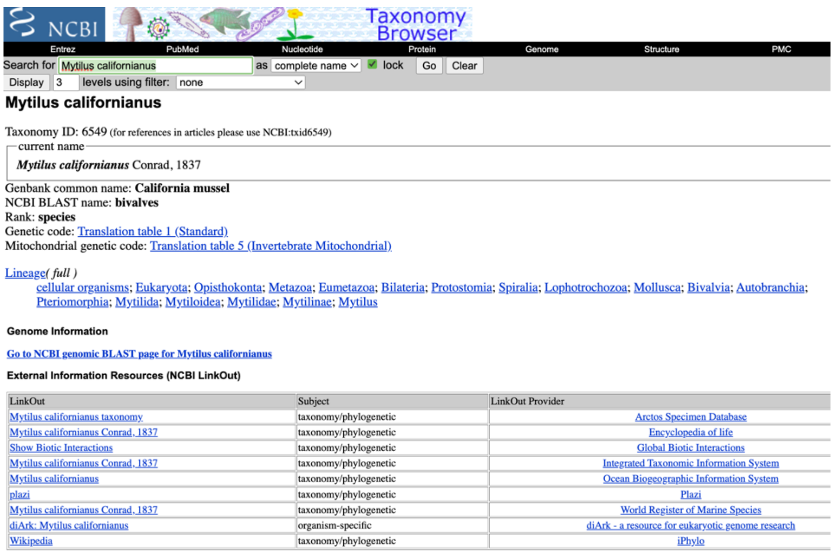


Slide 4. The NCBI Taxonomy Browser database contains a search bar at the top of the page underneath the navigation links in the black bar. The navigation bar allows the user to quickly get to the other databases NCBI contains such as "Nucleotide" will take the user to a database that contains genome sequences (https://www.ncbi.nlm.nih.gov/nucleotide).

https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi

Slide 5. Type the species of interest, e.g. *Mytilus californianus*, in the search bar after “Search for”. Then press “Go” to proceed to the next page of the database.

https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi



LinkOut	Subject	LinkOut Provider
Mytilus californianus taxonomy	taxonomy/phylogenetic	Arctos Specimen Database
Mytilus californianus Conrad, 1837	taxonomy/phylogenetic	Encyclopedia of life
Show Biotic Interactions	taxonomy/phylogenetic	Global Biotic Interactions
Mytilus californianus Conrad, 1837	taxonomy/phylogenetic	Integrated Taxonomic Information System
Mytilus californianus	taxonomy/phylogenetic	Ocean Biogeographic Information System
plazi	taxonomy/phylogenetic	Plazi
Mytilus californianus Conrad, 1837	taxonomy/phylogenetic	World Register of Marine Species
diArk: Mytilus californianus	organism-specific	diArk - a resource for eukaryotic genome research
Wikipedia	taxonomy/phylogenetic	iPhylo

Slide 6. The Taxonomy Browser contains useful information, as well as links for external resources for genomic sequence for *Mytilus californianus*. The taxonomic position for the organism can be found under “Lineage (*full*)”.

https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi

Adaptation

Adaptation occurs when an organism adjusts their characteristics (and over time traits) to suit environmental conditions more favorably. It is important to understand the environment of Coon Creek at the time in which organisms were fossilized. The upper Campanian-lower Maastrichtian Coon Creek Formation is exposed from west-central Tennessee through eastern Mississippi and located in the southeastern margin of the Western Interior Seaway (WIS). Sea level rise covered many coastal areas during the Campanian period, thus allowing Coon Creek to contain high diversity during the upper Cretaceous-lower Maastrichtian geologic time period (Pryor & Glass, 1961). The Cretaceous Thermal Maximum (CTM) caused climatic warming around 90 million years ago (MYA), thus afterwards during the mid-Campanian and early Maastrichtian there occurred a shift toward intense global cooling (Vrazo et al., 2018).

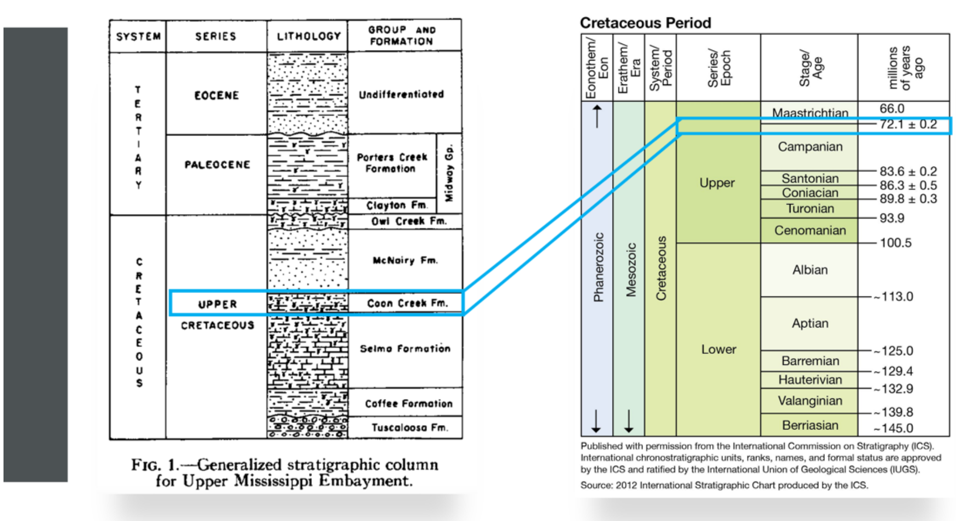
Topics for discussion:

(1) What kind of adaptations does an organism need to acquire to adjust from warming periods to cooling periods?

(2) What type of extant organisms would be unable to adapt to extreme shifts in temperature changes, and are thus at risk due to climate change?

(3) How does learning about geologic history help inform efforts to combat current climate change?

Coon Creek was formed ~70 MYA



Slide 1. Stratigraphy of the Coon Creek formation and surrounding formations (left), and expanded geologic time scale (right) to help explain to students the relationship between geology and time.

Left image available from (Pryor & Glass, 1961), right image available from https://stratigraphy.org/

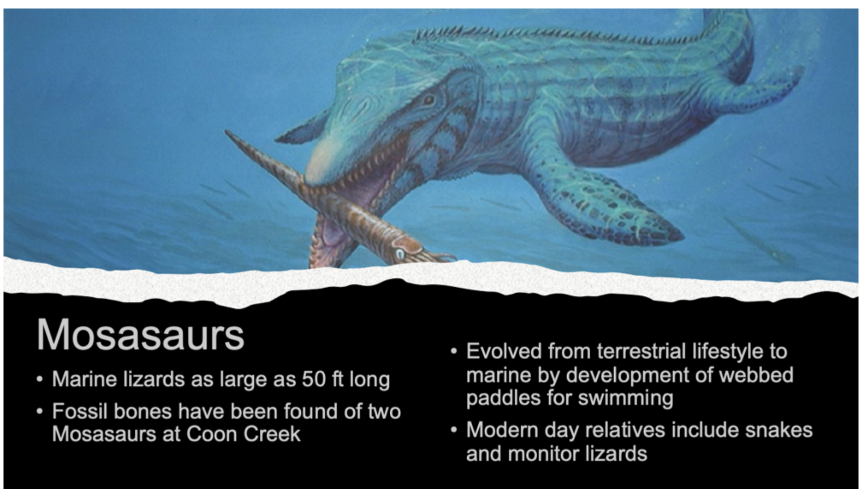
Natural selection

Natural selection is a mechanism of evolution by which organismal traits are inherited genetically over time. It can be helpful to explain natural selection in terms of change in allele frequencies over time that lead to disadvantageous or advantageous changes in phenotypes or traits. Natural selection provides a mechanism for species to adapt to their environment resulting in selection pressures that influence the survival and reproduction of organisms over many generations, these changes in the shift of the distribution of traits in the population (e.g. balancing or stabilizing selection).

Topics of discussion:
(1) How does a terrestrial organism evolve to become a marine organism (e.g. Mosasaurs)?

(2) How does a marine organism evolve to become terrestrial?

(3) What are other mechanisms of evolution (i.e. positive selection is the accumulation of advantageous changes to improve fitness of the organism, whereas negative selection results in the removal of disadvantageous changes to keep the fitness of the organism constant)?



Slide 1. Vertebrate fossils at the Coon Creek formation include large marine lizards called Mosasaurs. Image available https://www.nps.gov/articles/000/mosasaur.htm