HIGH SCHOOL LIFE SCIENCE: EVOLUTIONARY DEVELOPMENT

Standards Bundle:

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (SEP: 8; DCI: LS4.A; CCC: Patterns) [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]

HS-LS4-7 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. (SEP: 4; DCI: LS4.A ; CCC: Patterns) [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Several sources of evidence are used when determining how organisms evolved from shared ancestors. These sources include comparing similar parts that form either when developing or are present in adulthood, how similar their DNA or protein components are, and fossils evidence showing similar structures. These sources include the comparison between similar parts present during development or adulthood, the similarity in DNA or protein components, and the fossil evidence showing similar structures.

As organisms develop from a fertilized egg, some structures (e.g. tails, gills) may be present at early stages that disappear in later stages in the fully formed animal.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Pictures of several different animals in the embryonic stages showing gills and tails
- Cladograms
- Wings of bats, birds, and flies - analogous structures (similar function)
- Feathers on birds and scales on lizards - homologous structures (similar structure and embryology)

- Photos of present and prehistoric armadillos
- Photos of Archaeopteryx fossils and actual modern day bird feathers
- Fossils from limestone deposits and shells of modern snails
- Amino acid sequences recovered from fossilized remains and modern day
- Amino acid sequences of different bacterial species
- Forearm skeletal anatomy of a human, dog, bird and whale
- Photos of the evolution of modern horses from Eohippus

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information ● Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). **Analyzing and Interpreting Data** ● Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. ● Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.	**LS4.A: Evidence of Common Ancestry and Diversity** ● 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.	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. ● Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena.

In this standards bundle, students differentiate between homologous and analogous structures citing evidence for form, function, and common ancestry. Questions may be formed about what other types of data can show patterns of relatedness. Given several types of data (e.g. anatomical, fossils, DNA sequences, embryological), students identify and communicate the connections between each line of evidence and the claims of common ancestry. Students must consider the limitations of the data when making the analyses. When analyzing archival data, students must operate on the assumption that natural laws operate the same today as they have done in the past. Students must be able to discuss evolutionary theory, in a variety of modes, as dependent on a body of

knowledge that is repeatedly confirmed but changeable in light of new scientific evidence.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

SEP Obtain, Evaluate, and Communicating Information

- Compare and contrast homologous and analogous structures (e.g. wings, front appendage x-rays).

SEP Analyzing and Interpreting Data

- Given DNA sequences and cladograms for several organisms, construct a cladogram to show relatedness based on degree of similarity of DNA sequences.
- Using models of Archaeopteryx and a modern bird, compare the two models for similarities and differences citing evidence for the evolutionary relationship between the two.

CCC Patterns

- After presenting students with pictorial evidence of the evolution of modern day horses from Eohippus with a time scale, Using pictures of horses from Eohippus to today, predict what will happen to horses in the future
- What are some similarities and differences between modern day armadillos and their prehistoric counterparts? Discuss any further evidence that would strengthen the idea that they are truly ancestors.
- Given a set of organisms, arrange them according to common ancestry according to patterns evident from given data about them (e.g. pictorial, DNA, amino acids, embryology, adult physical structures).
- Given DNA sequences and amino acid sequences for two or more organisms, discuss how amino acid sequences can be more similar than DNA sequences. (This builds upon prior knowledge of the process of how DNA codes for amino acids.)

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Ask questions** about what processes by which all organisms have evolved *over time* from shared ancestors.
- Utilize the fossil record to show relatedness to modern day organisms citing common *patterns* as **evidence**.
- **Explain using evidence**, changes in the fossil record due to *changes* in DNA *patterns*.
- **Discuss** how *similarities* in embryological development patterns may or may not show relatedness in organisms.
- **Cite multiple lines of evidence** for how organisms of a species are *similar yet different* due to inheritance of DNA.
- **Communicate** how DNA sequences vary between species yet overlap. It is the sum of **multiple lines of evidence** from amino acid sequences, embryological data, and anatomical similarities to provide a case for *degree of relatedness*.