

Unit Summary		
<p><b><i>How do we know when an organism (fossil) was alive?</i></b></p> <p><b><i>How do we know that birds and dinosaurs are related?</i></b></p> <p>In this unit of study, students analyze graphical displays and gather evidence from multiple sources in order to develop an understanding of how fossil records and anatomical similarities of the relationships among organisms and species describe biological evolution. Students search for patterns in the evidence to support their understanding of the fossil record and how those patterns show relationships between modern organisms and their common ancestors. The crosscutting concepts of <i>cause and effect</i>, <i>patterns</i>, and <i>structure and function</i> are called out as organizing concepts for these disciplinary core ideas. Students use the practices of <i>analyzing graphical displays</i> and <i>gathering, reading, and communicating information</i>. Students are also expected to use these practices to demonstrate understanding of the core ideas.</p> <p>This unit is based on MS-LS4-1, MS-LS4-2, and MS-LS4-3.</p>		
Student Learning Objectives		
<p><b>Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.</b> <i>[Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]</i> (<a href="#">MS-LS4-1</a>)</p>		
<p><b>Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.</b> <i>[Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]</i> (<a href="#">MS-LS4-2</a>)</p>		
<p><b>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.</b> <i>[Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]</i> (<a href="#">MS-LS4-3</a>)</p>		
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Unit Sequence	
<b>Part A: How do we know when an organism (fossil) was alive?</b>	
Concepts	Formative Assessments
<ul style="list-style-type: none"> <li>The fossil record documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.</li> <li>The collection of fossils and their placement in chronological order as identified through the location of sedimentary layers in which they are found or through radioactive dating is known as the fossil record.</li> <li>Relative fossil dating is achieved by examining the fossil's relative position in sedimentary rock layers.</li> <li>Objects and events in the fossil record occur in consistent patterns that are understandable through measurement and observation.</li> <li>Patterns exist in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in rock layers.</li> <li>Patterns can occur within one species of organism or across many species.</li> </ul>	<p><i>Students who understand the concepts can:</i></p> <ul style="list-style-type: none"> <li>Use graphs, charts, and images to identify patterns within the fossil record.</li> <li>Analyze and interpret data within the fossil record to determine similarities and differences in findings.</li> <li>Make logical and conceptual connections between evidence in the fossil record and explanations about the existence, diversity, extinction, and change in many life forms throughout the history of life on Earth.</li> </ul>

Unit Sequence	
<b>Part B: How do we know that birds and dinosaurs are related?</b>	
Concepts	Formative Assessments
<ul style="list-style-type: none"> <li>Similarities and differences exist in the gross anatomical structures of modern organisms.</li> <li>There are anatomical similarities and differences among modern organisms and between modern organisms and fossil organisms.</li> <li>Similarities and differences exist in the gross anatomical structures of modern organisms and their fossil relatives.</li> <li>Similarities and differences in the gross anatomical structures of modern organisms enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.</li> <li>Patterns and anatomical similarities in the fossil record can be used to</li> </ul>	<p><i>Students who understand the concepts can:</i></p> <ul style="list-style-type: none"> <li>Apply scientific ideas to construct explanations for evolutionary relationships.</li> <li>Apply the patterns in gross anatomical structures among modern organisms and between modern organisms and fossil organisms to construct explanations of evolutionary relationships.</li> <li>Apply scientific ideas about evolutionary history to construct an explanation for evolutionary relationships evidenced by similarities or differences in the gross appearance of anatomical structures.</li> </ul>

identify cause-and-effect relationships. <ul style="list-style-type: none"> <li>Science assumes that objects and events in evolutionary history occur in consistent patterns that are understandable through measurement and observation.</li> </ul>	
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Unit Sequence	
<b>Part C:</b> <i>Other than bones and structures being similar, what other evidence is there that birds and dinosaurs are related?</i>	
Concepts	Formative Assessments
<ul style="list-style-type: none"> <li>Relationships between embryos of different species show similarities in their development.</li> <li>General patterns of relatedness among embryos of different organisms can be inferred by comparing the macroscopic appearance of diagrams or pictures.</li> <li>Pictorial data can be used to identify patterns of similarities in embryological development across multiple species.</li> <li>Similarities in embryological development across multiple species show relationships that are not evident in the fully formed organisms.</li> </ul>	<p><i>Students who understand the concepts can:</i></p> <ul style="list-style-type: none"> <li>Use diagrams or pictures to identify patterns in embryological development across multiple species.</li> <li>Analyze displays of pictorial data to identify where the embryological development is related linearly and where that linear nature ends.</li> <li>Infer general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.</li> </ul>

What It Looks Like in the Classroom
<p>Prior to middle school, students know that some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago. In this unit of study, students will build on this knowledge by examining how the fossil record documents the existence, diversity, extinction, and change of many life forms through Earth's history. The fossil record and comparisons of anatomical similarities between organisms and their embryos enable the inference of lines of evolutionary descent.</p> <p>Students analyze images or data to identify patterns in the locations of fossils in layers of sedimentary rock. They can use their understanding of these patterns to place fossils in chronological order. Students may make connections between their studies of plate movement in grade 7 and the possible shifting of layers of sedimentary rock to explain inconsistencies in the relative chronological order of the fossil record as it is seen today.</p> <p>Students can analyze data on the chronology of the fossil record based on radioactive dating. An explanation of radioactive dating can be provided to students along with data, but students are not expected to complete any calculations. Information can be provided in the form of data tables correlating fossil age with half-life. This information could also be presented in the form of a graph.</p> <p>Students may analyze images from the fossil record to identify patterns of change in the complexity of the anatomical structures in organisms. For example, students can observe pictures of fossilized organisms with similar evolutionary histories in order to compare and contrast changes in their anatomical structures over time. Students may be placed in groups, with each group examining changes in anatomical structures over time within one evolutionary lineage (e.g., the whale, the horse,</p>

cycads). Once students have identified patterns of change within one evolutionary lineage, they can meet with students from other groups to discuss patterns of change across multiple evolutionary lineages. Students could then present their findings using a variety of media choices (PowerPoint, poster, short skit or play, comic strip, etc.). This activity would provide application of the real-world phenomenon that life on Earth changes over time.

Students could be provided with multimedia experiences in order to analyze visual displays of the embryological development of different species. They can analyze the linear and nonlinear relationships among the embryological developments of different species. For example, students can analyze data about embryological development to determine whether development across species shares a similar rate, similar size of embryos, or similar characteristics over a period of time. If these characteristics are consistent across species, a linear relationship can be inferred. At the point where the rate, size, or general characteristics of development diverge, the relationship can then be classified as nonlinear.

Students can integrate the patterns they identified in the fossil record by studying sedimentary rock images and radioactive dating data provided by the teacher and the relationships they discovered through their study of embryological development with evidence from informational texts to develop an explanation of changes in life forms throughout the history of life on Earth. This explanation could be presented in the form of a claim, with students required to cite evidence from their studies of diagrams, images, and texts to explain that life on Earth has changed over time.

### Connecting with English Language Arts/Literacy and Mathematics

#### *English Language Arts/Literacy*

- Cite specific textual evidence to support the analysis of patterns found in the fossil record to document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth.
- Use scientific, precise details in the explanations.
- Integrate quantitative or technical information about the fossil record that is expressed in words into a version of that information expressed visually in the form of a flowchart, diagram, model, graph, or table.
- Attending to the precise details of explanations or descriptions, cite specific textual evidence to support analysis of science texts' information on the relationships between the anatomical similarities and differences among modern organisms and between modern and fossil organisms and their fossil relationships.
- Write informative/explanatory text examining anatomical similarities and differences among modern organisms and between modern and fossil organisms and their fossil relationships. The text should convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- Draw evidence from informational texts to support an analysis of, reflection on, and research about anatomical similarities and differences among modern organisms and between modern and fossil organisms used to infer evolutionary relationships.
- Engage in a range of collaborative discussions about the anatomical similarities and differences among modern organisms and between modern and fossil organisms used to infer evolutionary relationships. Discussions must provide opportunities for students to clearly express their own ideas and exchange ideas with others. The discussions may be one on one, in groups, or led by the teacher.
- Present claims and findings to explain the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. Emphasize the important points in a focused, coherent manner with relevant evidence, valid reasoning, and well-chosen details. During the presentation, students must use appropriate eye contact, adequate volume, and clear pronunciation.

- Cite specific textual evidence to support the analysis of pictorial data comparing patterns of similarities in embryological development across multiple species to identify relationships not evident in the fully formed anatomy. Attention must be paid to the precise details of explanation or descriptions.
- Integrate quantitative or technical information about general patterns of relatedness among embryos of different organisms expressed in words in a text with a version expressed in a flowchart, diagram, model, graph, or table.
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with the information gained from reading a text about embryological development across multiple species in order to identify relationships not evident in the fully formed anatomy.

#### Mathematics

- Use variables to represent numbers and write expressions to represent patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearances in the rock record to document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth, under the assumption that natural laws operate today as in the past. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.
- Use variables to represent numbers and write expressions showing patterns that can be used to identify cause-and-effect relationships among the anatomical similarities and differences among modern organisms and between modern and fossil organisms. This representation will be used to infer evolutionary relationships. Understand that a variable can represent an unknown number or, depending on the purpose at hand, any number in a specified set.

#### Modifications

*(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: [All Standards, All Students/Case Studies](#) for vignettes and explanations of the modifications.)*

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.

- Restructure lesson using UDL principals ([http://www.cast.org/our-work/about-udl.html#VXmoXcfD\\_UA](http://www.cast.org/our-work/about-udl.html#VXmoXcfD_UA))

### Research on Student Learning

Some research suggests that students' understanding of evolution is related to their understanding of the nature of science and their general reasoning abilities. Findings indicate that students who cannot argue with evidence tend to retain nonscientific beliefs such as "evolutionary change occurs as a result of need" because they fail to examine alternative hypotheses and their predicted consequences, and they fail to comprehend conflicting evidence. Thus, they are left with no alternative but to believe their initial intuitions or the misstatements they hear (NSDL, 2015).

### Prior Learning

*By the end of Grade 5, students understand that:*

- Some kinds of plants and animals that once lived on Earth are no longer found anywhere.
- Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.

### Future Learning

*Life science*

- Genetic information 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.

*Earth and space science*

- Continental rocks, which can be more than 4 billion years old, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

### Connections to Other Units

#### Grade 7, Unit 6: Inheritance and Variation of Traits

- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.
- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes)

inherited.

**Grade 6, Unit 8: Earth Systems**

- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.
- Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.

**Sample of Open Education Resources**

[NOVA: Judgement Day: Intelligent Design on Trial: Human Chromosome 2](#): This video segment from NOVA: "Judgment Day: Intelligent Design on Trial" reveals how genetic evidence helped to confirm an important component of Darwin's theory of evolution by natural selection: the common ancestry of humans and apes. In particular, it explains that humans have one fewer chromosome pair in their cells than apes, due to a mutation found in chromosome number 2 that caused two chromosomes to fuse into one.

[The Day the Mesozoic Died](#) This three-act film tells the story of the detective work that solved the mystery of what caused the disappearance of the dinosaurs at the end of the Cretaceous period. Shot on location in Italy, Spain, Texas, Colorado, and North Dakota, the film traces the uncovering of key clues that led to the discovery that an asteroid struck the Earth 66 million years ago, triggering a mass extinction of animals, plants, and microorganisms.

Appendix A: NGSS and Foundations for the Unit		
<p>Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. <i>[Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]</i> (MS-LS4-1)</p>		
<p>Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. <i>[Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]</i> (MS-LS4-2)</p>		
<p>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. <i>[Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]</i> (MS-LS4-3)</p>		
The performance expectations above were developed using the following elements from the NRC document <a href="#">A Framework for K-12 Science Education</a> :		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Analyzing and Interpreting Data</b></p> <ul style="list-style-type: none"> <li>Analyze displays of data to identify linear and nonlinear relationships. (MS-LS4-3)</li> <li>Analyze and interpret data to determine similarities and differences in findings. (MS-LS4-1)</li> </ul> <p><b>Constructing Explanations and Designing Solutions</b></p> <ul style="list-style-type: none"> <li>Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. (MS-LS4-2)</li> </ul> <p>-----</p> <p><b>Connections to Nature of Science</b></p> <p><b>Scientific Knowledge is Based on Empirical Evidence</b></p> <ul style="list-style-type: none"> <li>Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-LS4-1)</li> </ul>	<p><b>LS4.A: Evidence of Common Ancestry and Diversity</b></p> <ul style="list-style-type: none"> <li>The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)</li> <li>Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2)</li> <li>Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-</li> </ul>	<p><b>Patterns</b></p> <ul style="list-style-type: none"> <li>Patterns can be used to identify cause and effect relationships. (MS-LS4-2)</li> <li>Graphs, charts, and images can be used to identify patterns in data. (MS-LS4-1),(MS-LS4-3)</li> </ul> <p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4),(MS-LS4-5),(MS-LS4-6)</li> </ul> <p>-----</p> <p><b>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</b></p> <ul style="list-style-type: none"> <li>Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and</li> </ul>



	formed anatomy. (MS-LS4-3)	observation. (MS-LS4-1),(MS-LS4-2)
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English Language Arts	Mathematics
<p>Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-LS4-1),(MS-LS4-2),(MS-LS4-3) <b>RST.6-8.1</b></p> <p>Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS4-1),(MS-LS4-3) <b>RST.6-8.7</b></p> <p>Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-LS4-3) <b>RST.6-8.9</b></p> <p>Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-2) <b>WHST.6-8.2</b></p> <p>Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-2) <b>WHST.6-8.9</b></p> <p>Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS4-2) <b>SL.8.1</b></p> <p>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. (MS-LS4-2) <b>SL.8.4</b></p>	<p>Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-LS4-1),(MS-LS4-2) <b>6.EE.B.6</b></p>