Unit Synopsis

Students observe pictures and watch videos about the evolution of dogs, then generate questions and create a driving question board to guide the rest of the unit. They will begin inquiry to answer the question: How are dogs related to wolves?

In this sequence, students explore how scientists study and describe the geologic time scale and determine the age of fossils. They will investigate the principles behind the Law of Superposition and relative and absolute dating, and use that information to examine and analyze fossil records. In connection to the phenomenon, and to help with the culminating activity for this unit, the students will construct a brief claim, evidence, reasoning response regarding dogs and the fossil record evidence that they are descended from wolves.

Students will describe and analyze comparative anatomy (homologous structures, vestigial structures, and analogous structures in whales, birds, humans, and bats), comparative embryology, and comparison of structures of modern organisms with fossil record structures. Students will make parallels between the development of individuals from embryo to adult and the evolution of a species over time.

Students survey the appearance of common human traits in class members and formulate questions about small differences in DNA having significant effects on the expression of traits. After posing questions such as "what is DNA?" and "how does DNA code for traits?" students will research answers by watching short videos on each topic. Each student will make a model of DNA (bead bracelet or paper double-helix) that represents the base pairs in short segments of DNA in specific species. After establishing the role of codons in DNA and expression of traits, students will explore mutations in dogs and humans. They will then create a simple evolutionary tree of dog species based on their physical characteristics such as leg length, skull shape, body size, and fur texture.

Students will construct explanations that describe how genetic variations increase some individuals' probability of surviving and reproducing, and will use mathematical representations to model how natural selection leads to increases and decreases of specific populations - and of specific traits in those populations - over time.

Students will synthesize an explanation for the phenomenon of the wolf-dog relationship. After students have constructed their explanations, they will participate in focused discussions in small groups, larger teacher-led groups, or pairs. Having developed a significant understanding of natural selection, they will need to begin gathering evidence from multiple sources, including print and digital, to support analysis of information about technologies that have changed how humans can influence the inheritance of desired traits in organisms (artificial selection). Students will cite the information they gathered and quote or paraphrase relevant data and conclusions from their resources.

Suggested Time Frame:
50-55 hours

Anchoring Phenomenon/Design Problem:
Dogs and wolves

Unit Driving Question:
How are dogs related to wolves?

Culminating Performance Task:
Students develop a model to describe how the wolf has evolved to modern dogs.

NGSS Performance Expectations: (Hyperlinks will bring reader to NGSS Evidence Statements)

- MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
  - [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.]
  - [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]
- MS-LS4-1. 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.
  - [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.]

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- MS-LS4-2. 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.
  - [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.]
- MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evidence in the fully formed anatomy.
  - [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.]
- MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
  - [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]
- MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.
  - [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]
- MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
  - [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.]
  - [Assessment Boundary: Assessment does not include Hardy Weinberg calculations.]

Three Dimensions that form the Foundation for these NGSS Performance Expectations:

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
Developing and Using Models • Develop and use a model to describe phenomena. Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings. • Analyze displays of data to identify linear and nonlinear relationships. Constructing Explanations and Designing Solutions • Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. Obtaining, Evaluating, and Communicating Information • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. Using Mathematics and Computational Thinking • Use mathematical representations to support scientific conclusions and design solutions.	LS3.A: Inheritance 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. LS3.B: Variation of Traits • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others are harmful, and some neutral to the organism. LS4.A: Evidence of Common Ancestry and Diversity • The collection of fossils and their placement in	Structure and Function • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. Patterns • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data. Cause and Effect • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

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	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. ● 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. ● Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. LS4.B: Natural Selection ● Natural selection leads to the predominance of certain traits in a population, and the suppression of others. ● In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed onto offspring. LS4.C: Adaptation ● Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	

Possible Common Core State Standards Connections:

ELA

- SL.8.1 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)*(MS-LS4-4)*
- SL.8.4 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. (MS-LS4-2)(MS-LS4-4)
- SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and

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evidence, and add interest. (MS-LS3-1)

Mathematics -

- MP.4 Model with mathematics. (MS-LS4-6)

PROGRESSION OF LEARNING

Learning Sequence 1:

- Learning Sequence Driving Question: How are dogs related to wolves?
- Learning Sequence 1
- Relationship to Anchoring Phenomena/Design Problem: This is the introduction to the anchoring phenomenon.
- Student Expected Outcomes:
  - Students will connect their prior knowledge of and interest in dogs with questions sparked by the image of a wolf and dogs.
  - Students will generate driving questions for the unit around the following topics genetics, evolution, and the fossil record.

Learning Sequence 2:

- Learning Sequence Driving Question: What evidence is there to connect dogs and wolves based on the fossils and fossil record?
- Learning Sequence 2
- Relationship to Anchoring Phenomena/Design Problem:
  - Articles and video on wolves and dogs will allow students to make the connection between fossils and fossil record with the evolution/connection between wolves and dogs.
- Student Expected Outcomes:
  - Students will identify the conditions that make fossils possible.
  - Students will provide evidence from the geologic record that fossil varieties may be found within discrete periods of time.
  - Students will interpret the chronology of the geologic record using fossils.
  - Students will construct an evidence-supported argument to explain the evolutionary history of dogs as descendents of wolves.
  - Students will analyze and interpret data to identify patterns and relationships between fossils and modern organisms.
  - Students will use mathematical applications to describe changes and observable patterns in the fossil record.

Learning Sequence 3:

- Learning Sequence Driving Question: How does the presence of anatomical structures and embryological development suggest an evolutionary connection between organisms specifically wolves and dogs?
- Learning Sequence 3
- Relationship to Anchoring Phenomena/Design Problem:
  - The embryo of the dog was shown as part of the introduction to this sequence. How is the embryo of a dog similar and different from other organisms, especially the wolf? Does this suggest a common ancestor?
- Student Expected Outcomes:
  - Students will identify commonalities between embryos of different species.
  - Students will make connections between modern species and their ancient relatives in terms of morphology and development.
  - Students will construct an evidence-supported argument regarding similarities between species evolution and individual development from embryo to adult.

Learning Sequence 4:

- Learning Sequence Driving Question: Why is there variation in the expression of traits?
- Learning Sequence 4
- Relationship to Anchoring Phenomena/Design Problem:
  - There are over 200 different dog breeds. Dogs show the greatest variability of traits (e.g. size) of any species. How do the dog breeds differ on a genetic level?
- Student Expected Outcomes:
  - Students will be able to model the physical nature of genes and chromosomes.
  - Students will be able to analyze genetic data to predict the probability of mutations.
  - Students will be able to classify mutations by various criteria including causes and the effect on the organism.

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Learning Sequence 5:

- Learning Sequence Driving Questions: Why do populations of the same species look slightly different? How can changes to the genetic code and the environment increase or decrease an individual's chances of survival? Learning Sequence 5
- Relationship to Anchoring Phenomena/Design Problem:
  - Natural selection and the resulting traits impact a species survival.
- Student Expected Outcomes:
  - Students will differentiate between traits that distinguish individuals from each other and those that distinguish species from other species.
  - Students will construct an explanation about how genetic variations cause differences in characteristics that favor the survival and reproduction of some individuals over others.
  - Students will model the processes of natural selection and the effects individuals in the short term and populations over time.

Learning Sequence 6:

- Learning Sequence Driving Question**:** How do you think the world has got so many different breeds of dogs?
- Learning Sequence 6
- Relationship to Anchoring Phenomena/Design Problem:
  - There are more than 200 breeds of dogs; how do so many different kinds evolve from wolves, and why are there still wolves?
- Student Expected Outcomes:
  - Students will be able to explain how changes in genetic information affect the expression of traits in individuals and subsequent generations.
  - Students will analyze and interpret information from the fossil record to establish a linear morphological relationship between wolves and modern dogs.
  - Students will explain that the appearance of traits is affected by probability based on environmental factors as well as heredity.
  - Students will create an evidence-supported model and argument (CER) that show how natural and artificial selection have produced from wolves the wide variety of modern dogs, and why wolves also still exist.

Assessments:

- **Culminating Performance Task**
  - Students develop a model to describe how dog breeds have developed from wolves..

- Grade 8 Assessment Tasks and Rubrics
- 2019-2020 - G3-G8 Interim Assessment Blocks (IABS) by CREC Bundle

Additional Resources:

- Teacher Resources
  - PBS Video Dogs & Humans: a 30,000-Year Friendship
  - https://www.amnh.org/ology/features/layersoftime/game_noCheck.php
  - http://news.cornell.edu/stories/2017/09/3-d-analysis-dog-fossils-sheds-light-domestication-debat
  - https://docs.google.com/document/d/12DYfDHxxsCwSLhWxtWMgZcECVQFz86YnMDg9YH7WOA8/edit?usp=sharing -
  - http://www.iflscience.com/plants-and-animals/modern-dogs-evolved-germany-wolves-according-study/
  - https://www.theverge.com/2017/7/18/15992572/dog-genetics-archaeology-fossils-evolution-domestication-wolves
  - http://www.pbs.org/wgbh/evolution/library/01/5/l_015_02.html
  - https://www.the-scientist.com/?articles.view/articleNo/38279/title/Origin-of-Domestic-Dogs/
  - https://news.nationalgeographic.com/news/2011/08/110819-dogs-wolves-russia-domestication-animals-science-evolutio
  - http://www.hhmi.org/biointeractive/dog-breeding

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