Science

Module 12

High School Biology I – Life Science: Variation of Traits

Module Goal

The goal of this module is to provide information that will help educators increase their knowledge of grade-appropriate science concepts, knowledge, and skills to support effective planning or modification of their existing science instructional units for students with significant cognitive disabilities. The module includes important concepts, knowledge, and skills for the following instruction:

- Heredity: Inheritance and Variation of Traits—Variation in organisms of the same species can be explained by both genetic and environmental factors. In sexual reproduction, both parents contribute half of each chromosome pair to the offspring. This produces a unique combination of genes. Mutations, however rare, which alter the genetic information can occur. An organism's genotype (i.e., combination of genes inherited from its parents) and environmental factors result in an organism's phenotype (i.e., observable characteristics). The shuffling of chromosome pairs, possible mutations occurring during the process, and environmental factors cause a variation in traits in organisms. A pedigree analyzes a pattern of inherited traits throughout a family and is used to predict how a trait will be passed on in the future.
- Biological Change: Unity and Diversity—Biological evolution, the process by which all living things have evolved over many generations from shared ancestors, explains both the unity and the diversity of species. The unity is illustrated by the similarities found between species, which can be explained by the inheritance of similar characteristics from related ancestors. The diversity of species is also consistent with common ancestry; it is explained by the branching and diversification of lineages as populations adapted, primarily through natural selection, to local circumstances. Evidence for common ancestry can be found in the fossil record, from comparative anatomy and embryology, from similarities of cellular processes and structures, and from comparisons of DNA sequences between species.

Module Objectives

The content module supports educators' planning and implementation of instructional units in science by:

- Developing an understanding of the concepts and vocabulary that interconnect with information in the module units.
- Learning instructional strategies that support teaching students the concepts, knowledge, and skills related to the module units.
- Discovering ways to transfer and generalize the content, knowledge, and skills to future school, community, and work environments.

The module provides an overview of the science concepts, content, and vocabulary related to Life Science: Variation of Traits and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

I. Tennessee Academic Standards for Science and Related Knowledge and Skills Statements and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;

III. Crosscutting Concepts;
IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;
V. Overview of Units' Content;
VI. Universal Design for Learning (UDL) Suggestions;
VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
VIII. Tactile Maps and Graphics.

Section I

Tennessee Academic Standards for Science and Related Knowledge and Skills Statements and Underlying Concepts

It is important to know the expectations for each unit when planning for instruction. The first step in the planning process is to become familiar with the identified academic standards and the Knowledge and Skills Statements (KSSs) and Underlying Concepts (UCs) covered in the module. The KSSs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are entry-level knowledge and skills that build toward a more complex understanding of the knowledge and skills represented in the KSSs and should not be taught in isolation. It is important to provide instruction on the KSSs along with the UCs to move toward acquisition of the same knowledge and skills.

Table 1 includes the academic standards and related KSSs and UCs for Life Science: Variation of Traits. While only the academic standards targeted for the Tennessee Comprehensive Assessment Program/Alternate (TCAP/Alt) are included, instruction on additional standards will aid in student understanding. Standards that are not included still represent important content for students to master. Therefore, the KSSs and UCs included in the table do not cover all the concepts that can be taught to support progress and understanding aligned to the standards.

Table 1. Tennessee Academic Standards for Science and Related KSSs and UCs [1]

Academic Standards	Knowledge and Skills Statement (KSS)	Underlying Concepts (UC)
Heredity: Inheritance and Variation of Traits		
BIO1.LS3.3: Through pedigree analysis, identify patterns of trait inheritance to predict family member genotypes. Use mathematical thinking to predict the likelihood of various types of trait transmission.	**BIO1.LS3.3.a:** Ability to identify examples of phenotypes in a family pedigree **BIO1.LS3.3.b:** Ability to identify examples of genotypes in a family pedigree **BIO1.LS3.3.c:** Ability to use a pedigree to predict likelihood (i.e., possible, impossible) of transmitting a trait to an offspring	**BIO1.LS3.3.UC:** Locate a specific relative of an individual in a pedigree.
Biological Change: Unity and Diversity		
BIO1.LS4.1: Evaluate scientific data collected from analysis of molecular sequences, fossil records, biogeography, and embryology. Identify chronological patterns of change and communicate that biological evolution is supported by multiple lines of empirical evidence that identify similarities inherited from a common ancestor (homologies).	**BIO1.LS4.1.a:** Ability to identify evidence of shared ancestry (i.e., fossil record, from comparative anatomy and embryology, from the similarities of cellular processes and structures, and from comparisons of DNA sequences between species)	**BIO1.LS4.1.UC:** Recognize that characteristics that positively affect survival are more likely to be passed on to offspring.

[1] Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the KSSs and UCs listed in Table 1.

Section II

Scientific Inquiry and Engineering Design

It is important for students with significant cognitive disabilities to have the opportunity to explore the world around them and learn to problem solve during science instruction. This approach to science instruction does not involve rote memorization of facts; instead it involves scientific inquiry. A Framework for K-12 Science Education (2012) unpacks scientific inquiry, providing eight practices for learning science and engineering in grades K–12. These practices provide students an opportunity to learn science in a meaningful manner. Students should combine the science and engineering practices as appropriate to conduct scientific investigations instead of using a practice in isolation or sequentially moving through each practice. Support should be provided as necessary for students with significant cognitive disabilities to actively use the practices. A link to *Safety in the Elementary Science Classroom* is in the resources of this section. See Section VI. Universal Design for Learning Suggestions for support ideas. Following are the eight science and engineering practices (National Research Council, 2012) with added examples.

- Asking questions (for science) and defining problems (for engineering)
  Examples: How does inheritable genetic variation occur? What is the likelihood of transmitting a recessive gene through two generations? What determines the expression of traits? Does the fact that birds and bats both have wings prove they have a shared ancestor? How can we ensure that altering genes to create pest-resistant crops will not affect the health of people consuming genetically modified food?
- Developing and using models
  Examples: Use symbols to represent the alleles in a genotype. Develop a pedigree model to analyze how a specific trait expresses across multiple generations of a family. Use a model of the fossil record to demonstrate a shared ancestry. Create a model (e.g., an evolutionary tree https://www.pbs.org/wgbh/nova/labs/lab/evolution/) to show how different organisms are connected. Analyze DNA sequences, amino acid sequences in proteins, and homologous structures in organisms using various models.
- Planning and carrying out investigations
  Examples: Investigate nicotine addiction in a family using a pedigree analysis. Manipulate variables and collect data about a complex model of a process of comparative anatomy to identify limitations. Investigate evidence for evolution such as fossil evidence, structural evidence, and genetic evidence and present this information (e.g., http://www.pbs.org/wgbh/evolution/educators/lessons/lesson3/act2.html).
- Analyzing and interpreting data
  Examples: Analyze and interpret a pedigree chart to determine likelihood of transmitting a trait to an offspring. Organize given data by the frequency, distribution, and variation of expressed traits in the population. Analyze data to determine the relationship between a trait's occurrence with a population. Interpret pedigree data to determine the likelihood of a defective trait being passed across multiple generations and explain the likelihood. Identify character data that could extend or improve the phylogenetic tree.

- Using mathematics and computational thinking
  Example: Apply the concept of probability to explain the concept of variation of expressed traits in a population. Use mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.
- Constructing explanations (for science) and designing solutions (for engineering)
  Examples: Describe how the genotypes RR and Rr result in the same phenotype. Explain where the alleles for a given trait are inherited from. Construct and revise an explanation on the similarities and variances among species' DNA sequences.
- Engaging in argument from evidence
  Examples: Describe how plant breeders and animal breeders use a method for predicting how often traits will appear in offspring that does not require performing the crosses thousands of times. Evaluate currently accepted claims regarding comparisons of DNA sequences between species to support a shared ancestry. Evaluate a claim about the effectiveness of a design solution to study comparative embryology. Use data to support arguments for the ways inheritable genetic variation occurs.
- Obtaining, evaluating, and communicating information
  Examples: Use multiple formats to communicate scientific information that supports common ancestry and biological evolution. Communicate information regarding patterns found in the fossil records and pattern of anatomical and embryological similarities. Write a text describing common ancestry and biological evolution, including the narration of historical events. Use multiple formats to communicate scientific information that supports common ancestry and biological evolution. Cite information on the similarities and variances among species' DNA sequences. Communicate information regarding patterns found in the fossil records and pattern of anatomical and embryological similarities. Gather and analyze information on common ancestry and biological evolution and communicate the information in multiple formats.

Science Practices Resources[2]

- Safety in the Elementary Science Classroom provides safety information for teachers and students. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/safetypractices/safety-in-the-elementary-school-science-classroom.pdf
- This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. Each type provides a wide range of example lessons grouped by elementary and middle school. http://www.justsciencenow.com/inquiry/

Section III

Crosscutting Concepts

Grade-level science content includes Crosscutting Concepts, which are concepts that connect information between different science strands and grade levels. The Crosscutting Concepts are intended to work together with the science inquiry and engineering practices, in addition to core content, to enable students to reason with evidence, make sense of phenomena, and design solutions to problems. Helping students make connections between these types of concepts and new content information supports comprehension of the concepts, knowledge, and skills as well as transference and generalization (see Section VII for more information). Crosscutting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

Crosscutting Concepts are a common link between multiple standards and units of study. The Crosscutting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. Life science focuses on patterns, processes, and relationships of living organisms. For example, understanding that different patterns may be observed at each of the scales within a system is a Crosscutting Concept that applies to the transmitting of traits through generations of a family, variations in the traits, and similarities of organisms over time. Some Crosscutting Concepts may apply across multiple content areas and instructional emphases (e.g., cause and effect in reading science texts).

This content module, Life Science: Variation of Traits, addresses how genetic and environmental factors affect the variation and distribution of traits in a population. It addresses how multiple sources of evidence support evolution (i.e., comparative DNA, fossil data, resemblance of species, and shared anatomical structures between species).

Teaching Crosscutting Concepts

The following strategies pulled from the principles of UDL (CAST, 2011) are ways in which to teach Crosscutting Concepts to help students understand the concepts and make connections between different curricular content. During instruction, highlight:

- patterns (e.g., point out patterns in the shape of a graph or repeating pattern on a chart),
- critical features (e.g., provide explicit cues or prompts, such as highlighting, that help students to attend to important features),
- big ideas (e.g., present and reinforce the “big ideas” that students should take and apply to the students’ lives.), and
- relationships (e.g., make the connection between the unit concepts and how they apply to the students’ lives).

Following are **Crosscutting Concepts** for this Content Module—Life Science: Variation of Traits. According to *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (2012), these concepts help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.

Patterns

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 (e.g., patterns of similar DNA sequences, patterns of fossil record, and pattern of anatomical and embryological similarities).

Causality

Cause and Effect

- Environmental factors and mutagens can cause gene mutation and the alteration of gene expressions, resulting in new genetic combinations.

Structure and Function

- The relationship between the non-protein coding sections of DNA and their functions (e.g., regulatory functions) in an organism clarifies relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Systems

Scale, Proportion, and Quantity

- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., inherited traits, mutations, environmental factors). Predict how future environmental change such as global warming could drive changes in dominant traits as conditions change.

Crosscutting Concept Resources

- Grant Wiggins talks about "big ideas" in this article. http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99
- A Framework for K-12 Science Education, Appendix G explains the crosscutting concepts and how the concepts help students deepen their understanding of the information. http://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
- Teacher Vision provides ten science graphic organizers that are free and printable. https://www.teachervision.com/graphic-organizers/science/52539.html
- Utah Education Network provides a variety of student interactives for grades seven through twelve. http://www.uen.org/7-12interactives/science.shtml

Section IV

Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., pedigree analysis) and in the context of the specific content (e.g., Teach the terms "inherit," "mutation," "recessive trait" and "dominant trait" while students are viewing and creating a pedigree analysis model).

This module includes two types of vocabulary words, both equally important to teach. The first type, **general vocabulary words**, labels groups of words that generalize to a variety of animals, plants, organisms, and activities. For example, understanding the meaning of the word "characteristic" helps students understand phenotype, analogous structure, homologous structure, etc. The second type, **specific content words**, represents groups of words that are associated with an organism, system, process, or phenomena. For example, the specific term "embryology" connects to the general words "characteristic," "heredity," "trait," and "species" when learning about evidence of a shared ancestry. Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Anatomy is the parts of an organism.) and an example of the word (e.g., A horse's head, body, legs, and tail are all part of the horse's anatomy.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., Genotype is the genetic makeup of an organism.) and a possible connection to a general vocabulary word (e.g., An offspring's genotype is inherited from his/her parents.).

Do not teach memorization of vocabulary words; instead, place emphasis on understanding the word as a result of observation, investigation, viewing a model, etc. For example, a student should learn to identify an animal's or a person's observable traits instead of giving a formal definition of trait.

Table 2. General Vocabulary Words

General Vocabulary—words that generalize to different animals, plants, organisms, and activities. Describe the word and provide examples (e.g., Probability is how likely something is to happen. *Example: The probability of a child having brown eyes when both parents have brown eyes is approximately 75%.).*		
• anatomy	• evolve/evolution	• offspring
• ancestor/ancestry	• extinct	• population
• cell	• fossil	• probability
• characteristic	• generation	• species
• classification	• heredity	• theory
• embryo	• inherit	• trait
• environment	• mutation	• variation

Table 3. Specific Content Words

Specific Content Words—words that specify a particular thing (e.g., sedimentary rock) or phenomena (e.g., biodiversity). Describe the word and when possible make the connection to a Crosscutting Concept (e.g., The fossil record is the history of life documented by fossils. Patterns in the fossil record provides an explanation and evidence of evolution.).		
• adaptation	• embryonic development	• inheritance
• alleles	• fossil record	• natural selection
• amino acid sequences	• genes/genetics	• pedigree
• analogous structure	• genetic variation	• phenotype
• DNA sequences	• genotype	• recessive trait
• dominant trait	• heterozygous	• sedimentary rock
• ecosystem	• homologous structure	• sexual reproduction
• embryology	• homozygous	

Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words. The examples include ideas on how to provide individualization, indicated in brackets, for unique student needs. These individualization ideas are provided to guide educators in ways to create access to vocabulary instruction for individual students.

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)

Ideas	Examples
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	• Provide a description and example of an analogous structure, "Analogous structures are structures of different species that serve a similar function, but not the same evolutionary origin. An example of an analogous structure are wings on birds and bats. They both use them for flying; however, birds and bats are different species. [Individualization idea: Provide pictures of the provided examples and when possible pair with representative objects or textures such as a feather and a tactile representation of a bat's wing.] **V**
Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.	• Have students explain inherited traits using themselves or an animal. [Individualization idea: Allow students to use multiple communication modes to describe and/or give examples of vocabulary words (e.g., Student points to similar traits on pictures, using AAC system, points to his/her hair and says, "like mom's," etc.).]
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	• Have students complete a genotype and phenotype vocabulary graphic organizer (see • • Figure 1. Example Graphic Organizer). [Individualization idea: Enlarge the graphic organizer by placing genotype and phenotype on two different pieces of paper. Provide cards with facts about each and have students sort the cards.] • Have students keep a science notebook in which they add a vocabulary word, description of the word, and related information each day during the unit. [Individualization idea: Provide students with preprinted words, descriptions, and related information to choose from and either copy or paste in the science notebook.] • Have students view words paired with pictures and recorded definitions – pedigree data chart (e.g., https://quizlet.com/147883662/pedigree-flash-cards/).
Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, but rather distributed trials in different ways or contexts. Reference	• Expose students to vocabulary by incorporating it into daily activities such as pointing out inherited traits using family photos and

Ideas	Examples
http://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	highlighting adaptations of local plants and animals. • Read books or watch videos related to the vocabulary and concepts – heredity (e.g., http://www.livescience.com/27332-genetics.html). • Have students find genetic terms in a talking glossary (e.g., Talking glossary of genetic terms https://www.genome.gov/glossary/).
Ask students to discuss the vocabulary words with each other.	• Have students identify a vocabulary word from their science notebook and present and describe the word to the class or small group. [Individualization idea: Have students play a recording that describes the vocabulary word using a single switch.] **P**
Play vocabulary word games with students.	• Have students work with an interactive word wall (e.g., http://nstacommunities.org/blog/2013/10/16/putting-science-words-on-the-wall/). • Play common word games (concentration, matching, word search) using terminology from the units. [Individualization idea: Play online games using an adapted mouse and a screen reader.] **P/V**
Have students watch a dramatization or have them act out the vocabulary term.	• Have students write a play which describes heredity, variation of traits, fossil record, etc. [Individualization idea: Have students gather pictures and dictate a story. Publish the story online (e.g., requires a free registration http://bookbuilder.cast.org/create.php).]

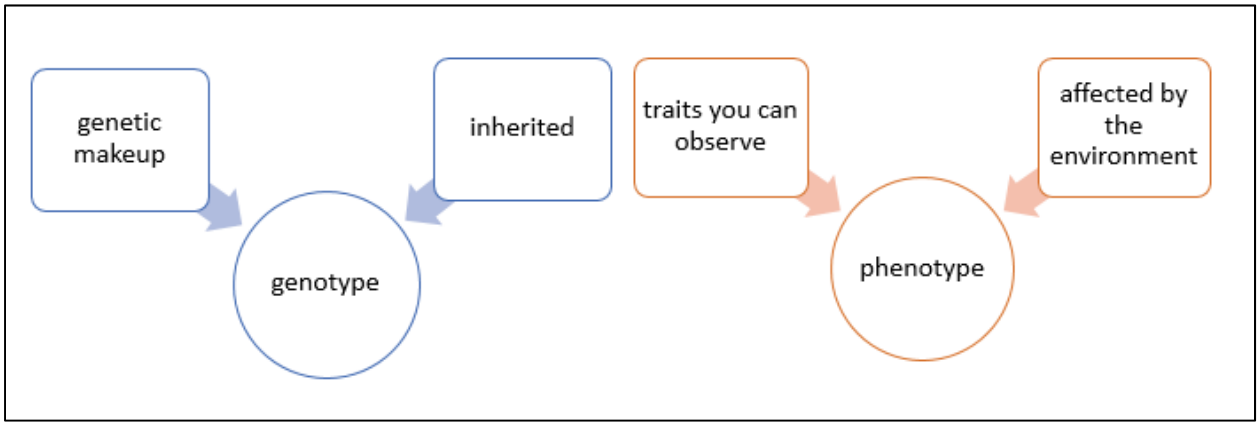
Vocabulary Example

Have students complete a genotype and phenotype vocabulary graphic organizer (see

Figure 1. Example Graphic Organizer). [Individualization idea: Enlarge the graphic organizer by placing genotype and phenotype on two different pieces of paper. Provide cards with facts about each and have students sort the cards.] Two National Center and State Collaborative (NCSC) resources are available and may prove helpful:

- Use systematic instruction as described in the NCSC Instructional Guide. https://wiki.ncscpartners.org
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. https://wiki.ncscpartners.org

Figure 1. Example Vocabulary Graphic Organizer



Vocabulary Resources

- Vocabulary.com provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. http://www.vocabulary.com/
- TextProject provides Word Pictures that are free for educators to use. Their site includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the Word Pictures page where you can select the category of words you want to use. http://textproject.org/classroom-materials/textproject-word-pictures/
- The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html

Section V

Overview of Units' Content

This section of the module contains additional content and references to support educators' understanding and instruction of the instructional units. The information reflects important content to address the KSSs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

Heredity: Inheritance and Variation of Traits

Content

- Genes are transferred from parent(s) to offspring and help determine inherited traits.
- Each gene contains two alleles for traits.
- Each parent provides one allele with possible combinations of AA (homozygous dominant), Aa (heterozygous), and aa (homozygous recessive).
- The combination of alleles creates an organism's genetic information (i.e., genotype).
- Some traits are observable physical or biochemical traits (i.e., phenotype).
- Genotype and the environment influence an organism's phenotype (i.e., observable characteristics).
- The variations and distributions of traits observed depend on both genetic and environmental factors.
- A dominant trait in an allele pair, represented with a capital letter (e.g. A), can mask a recessive trait, represented by a lower-case letter (e.g., a).
    - For example, an offspring who inherits a recessive trait for cystic fibrosis and a dominant other trait will not have the disease.
- Pedigree analysis uses a diagram (e.g., pedigree chart) to study inherited gene traits and the likelihood that a trait (e.g., hemophilia) will be transmitted to offspring.

Biological change: Unity and Diversity

Content

- Environmental change (e.g., climate change) affects the evolution of all species.
- Genetic variations within a species allow the survival of the species.
- Individuals can have specific traits that give them a competitive advantage relative to other individuals in the species (i.e., natural selection).
- A new species may emerge due to environmental change, genetic variations, and/or natural selection.
- Fossils document the existence of extinct species that are related to present-day species.
- Comparative anatomy studies the similarities and differences in structures of different species to understand how they evolved.
    - Homologous structures are similar because they were inherited from a common ancestor.
    - Analogous structures are structures that are similar in unrelated organisms.
- DNA sequence of genes can determine if species are related and have a shared ancestor.
- Similarities between embryos (comparative embryology) suggest that the organisms have common ancestors.

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.
- Evolution is a theory substantiated by explanations of the natural world that are based on facts, observations, experiments, and evidence.
- 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.
- Different patterns in multiple lines of empirical evidence may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of common ancestry and biological evolution.
- Patterns in the fossil record (e.g., presence, location, and inferences possible in lines of evolutionary descent for multiple specimens).
- Patterns observed at multiple spatial and temporal scales (e.g., DNA sequences, embryological development, fossil records) provide evidence for causal relationships relating to biological evolution and common ancestry.

Unit Content Resources

- Understanding Evolution has information on genotype versus phenotype. https://evolution.berkeley.edu/evolibrary/article/genovspheno_01
- Science Learning Hub has information on genotype and phenotype. https://www.sciencelearn.org.nz/resources/207-genotype-and-phenotype
- Khan Academy describes pedigrees. https://www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-pedigrees/v/pedigrees and https://www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-pedigrees/a/hs-pedigrees-review
- These sites provide information on pedigree analysis.
  - http://www.cs.cmu.edu/~genetics/units/instructions/instructions-PBA.pdf
  - https://www.ndsu.edu/pubweb/~mcclean/plsc431/mendel/mendel9.htm
- This site has an activity to analyze simple pedigrees. https://1.cdn.edl.io/beeJVoYpoH71vgRUfDZzGFB2RqemxB3f78xAdUgUptv8lmKx.pdf
- CPALMS has a lesson plan on reading, understanding, and creating a pedigree given a scenario. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/45998
- CPALMS has a lesson on genotype and phenotype. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/75796
- Science Teacher Program has a short lesson plan on understanding how to trace a trait that is inherited. http://www.scienceteacherprogram.org/biology/McNeil08.html
- Better Lesson provides a lesson plan on a pedigree chart. http://betterlesson.com/lesson/635181/pedigreesSeasons
- This site has a three- to five-day lesson plan on pedigree. https://www.glassbarn.org/media/pdf/highSchoolandMiddleSchoolLessonPlans/New_What%20is%20Your%20Pedigree.pdf

- Science Buddies has a lesson plan on pedigree analysis. https://www.sciencebuddies.org/science-fair-projects/project-ideas/Genom_p010/genetics-genomics/pedigree-analysis-a-family-tree-of-traits#summary

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of the UDL—multiple means of representation, multiple means of action and expression, and multiple means of engagement—guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. A well-designed lesson using the principles of UDL reduces the need to make accommodations and modifications. However, some students with significant cognitive disabilities, especially students with visual and/or hearing impairments, physical disabilities, and students with complex communication needs, may require additional scaffolds, adaptations, and modifications to access content and support learning. UDL's three guiding principles guide educators in creating instructional materials and activities in a flexible manner to address the needs of different types of learners. Utilizing the three principles of UDL as a framework when designing instruction allows for individualization when needed. Table 5 provides strategies and examples for the UDL Principle I, **Multiple Means of Representation**: presenting information in a variety of ways to address the needs of different types of learners. Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**: providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding. Table 7 provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

The strategies and examples provided in Tables 5 through 7 are based on UDL principles and can assist all students in understanding the basic concepts. The strategies and examples, as well as individualization ideas, should serve as a catalyst for ideas that can be individualized to meet the needs of each student. Some of the examples include activities that work exceptionally well for students with vision, hearing, and/or physical limitations as well as for all students. Each example has a code to indicate when it includes specific ideas or activities that meet these needs:

V = visually impaired (low vision, blind, or deaf-blind)
H = hearing impaired (deaf, hard of hearing, or deaf-blind)
P = physical disability (limited use of hands)

Table 5. Instructional strategy ideas using the UDL Principle: Multiple Means of Representation

Multiple Means of Representation	
Strategies	**Examples**
Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Present a pedigree chart analyzing eye or hair color of fictional family. [Individualization idea: Create a tactile version of the pedigree chart. **V** Pair pictures for each person with their specific eye/hair color.] Share three-dimensional images of fossils (e.g., http://humanorigins.si.edu/evidence/3d-collection/fossil). [Individualization idea: Have students manipulate the images using an adapted mouse.] **P** Present a slide show on comparative embryology (e.g., attachment on CPALMS site – http://www.cpalms.org/Public/PreviewResourceLesson/Preview/128858).
Model content through pictures, dramatization, videos, etc.	Watch a video on: • inheritance (e.g., https://learn.genetics.utah.edu/content/basics/inheritance/) and • genotype vs. phenotype (e.g., https://www.youtube.com/watch?v=I7tZPYhIQXw). Provide pictures of traits as they are taught (e.g., https://web.archive.org/web/20120227034335/http://www.fi.edu/guide/knox/Traits/traitsexamples.pdf). **H**
Present information using graphic organizers and models.	Help students complete a Venn diagram comparing physical appearance embryos of animals with similar structures (e.g., https://betterlesson.com/lesson/637398/embryonic-development-evidence-for-evolution). [Individualization idea: Provide tactile versions of characteristics.] **V** Use a KWHL to help students make connections between what they already **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (Here's a slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** Use an extended version of the KWHL: What do I **K**now? What do I **W**ant to know about or wonder about (e.g., a phenomena)? **H**ow will I find out (e.g., determine how to organize investigations)? What have I **L**earned? What **A**ction will I take (e.g., share with others, apply to daily life, etc.)? What new **Q**uestions do I have? More information can be found at http://langwitches.org/blog/2015/06/12/an-update-to-the-upgraded-kwl-for-the-21st-century/. [Individualization idea: Use strategies for the KWHL chart for accessibility ideas: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf.]

Multiple Means of Representation	
Strategies	**Examples**
Provide appropriate and accessible text on the content for students to listen to or read.	Provide an article on: • species adapting to environmental change (e.g., https://news.nationalgeographic.com/news/2014/05/140506-climate-change-adaptation-evolution-coral-science-butterflies/) and • shared ancestry (e.g., https://www.the-scientist.com/news-opinion/ancient-dna-maps-early-american-migrations-in-new-detail-65057). [Individualization idea: Have students read using a screen reader.]
Teach information using songs, poems, or rhymes.	Teach about topics using songs: • phenotype (e.g., https://www.youtube.com/watch?v=9G2lvdQiSr4 or https://www.youtube.com/watch?v=FryDW4BjJhY) and • evolution (e.g., https://www.youtube.com/watch?annotation_id=annotation_1995223833&feature=iv&src_vid=MhkIbBSKLjY&v=MhkIbBSKLjY#t=50s answers – https://www.sciencewithtom.com/04-evolution-answers). [Individualization idea: Provide each student a different word to complete the sentence in the song. Students can either sing, activate a recording with the word, or hold the card up at the correct time.]

Table 6. Instructional strategy ideas using the UDL Principle: Multiple Means of Action and Expression

Multiple Means of Action and Expression	
Strategies	**Examples**
Use technology/assistive technology to optimize student access and interaction with the instructional materials and content.	Provide an online activity to complete an evolution tree (e.g., https://www.pbs.org/wgbh/nova/labs/lab/evolution/research#/chooser). [Individualization idea: Have students work with a partner and use a screen reader and/or an adapted mouse to move items on the screen.] **P** Have students complete an online game on comparative embryology (e.g., https://www.pbs.org/wgbh/nova/evolution/guess-embryo.html).
Allow for instructional materials that can be modified to provide access.	Label models with high contrast or tactile print (e.g., http://www.visionaware.org/info/everyday-living/home-modification-/labeling-and-marking/125). **V** Place symbols for a pedigree chart on hook and loop tape for students to move around. **P** Tack or tape materials to the desk or a slant board to prevent unnecessary movement. **P/V**
Provide multiple means for students to make choices and select answers.	Have a student dictate answers. [Individualization idea: Place answer options in the student's AAC device or on multi-select voice output switch.] **P** Provide answer choices. [Individualization idea: Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then choose their answer.] **V/P** Allow multiple ways to indicate an answer when working with paper materials. [Individualization idea: Allow students to select an answer using touch, large pencil grip, paper stabilizer, eye gaze board, etc.] **P**
Provide simulation activities.	Have students simulate inherited traits (e.g., https://www.biologycorner.com/worksheets/genetics_heredity_simulation.html). [Individualization idea: glue or tape two craft sticks together to ease manipulation. **P** Add Braille letters to the craft sticks (e.g., http://braillebug.afb.org/braille_deciphering.asp) **V**.]
Provide graphic organizers and templates.	Have students complete a drag-and-drop pedigree analysis chart (e.g., http://www.zerobio.com/drag_gr11/pedigree/pedigree1.htm). Have students create an online pedigree analysis chart (e.g., http://learn.genetics.utah.edu/content/addiction/pi/, or http://bcs.whfreeman.com/webpub/Ektron/Hillis%20Principles%20of%20Life2e/Animated%20Tutorials/pol2e_at_0802_pedigree_analysis_simulation/pol2e_at_0802_pedigree_analysis_simulation.html). [Individualization idea: Have students use a screen reader and an adapted mouse.] **P/V**

Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule.	Adapt an assignment book using pictures or symbols to help students independently locate classes (e.g., images of the same clocks used in classrooms and hallways, pictures of each teacher in front of his/her door, etc.). Provide mini-schedules (e.g., http://theautismhelper.com/using-mini-schedules-classroom/) and a behavior/routine checklist (e.g., http://www.buildingblox.net/images/behavior_check.pdf) for each class or academic subject.
Vary the challenge and amount of information presented at a time.	Allow frequent breaks when introducing new material (e.g., pedigree and heredity). Reduce breaks when reviewing information or making connections to familiar information (e.g., personal and family traits).
Make connections to topics or activities that are motivating.	To engage and help students understand how to make a pedigree chart, use a popular TV or movie cast (e.g., https://www.chartgeek.com/star-wars-family-tree/ or http://gosu.talentrank.co/harry-potter-family-tree-chart/).
Allow choices as possible.	Provide seating options (placement, type of seat, etc.). Allow students to use multiple ways to add to the discussion and answer questions. [Individualization idea: Ensure content specific language is included in students' AAC systems. Ask some questions that can be answered with a yes/no response.]
Provide opportunities to work collaboratively with peers.	Have students play games (e.g., https://www.flocabulary.com/vocabulary-mini-games/) related to unit content topics together. Have students work in cooperative groups with mixed abilities. [Individualization ideas: Present instructions and group expectations using a task checklist and group rules. Develop and read a social story (e.g., https://www.special-learning.com/article/what_are_social_stories) about working in a group to the students. Provide the students with the necessary communication tools to participate in the group activity. Assign specific pieces of the task to each student.]
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately. Have students self-evaluate on acquisition of skills and knowledge using a simple chart such as a "I Can . . . " where the skills and knowledge (e.g., identify a observable trait) are listed and the students color in a smiley face or check the box when they are able to perform the skill or demonstrate knowledge of the skill (e.g., http://www.sparklebox.co.uk/class-management/targets-monitoring/i-can-sheets/#.W6E3_uj24dU).

UDL Resources

- The National Center on Universal Design for Learning has a plethora of information on UDL along with examples and resources. www.udlcenter.org
- The UDL Curriculum Toolkit provides two applications for science. http://udl-toolkit.cast.org/p/applications/l1
- Perkins School for the Blind provides life science activities for students who are blind or have low vision. http://www.perkinselearning.org/accessible-science/activities/life-science
- This Perkins School for the Blind 20-minute video describes the techniques used to make science accessible for students who are blind and deaf-blind. https://www.youtube.com/watch?v=tpAejot1-Ec
- Symbaloo is a free online tool that allows an educator to create bookmarks using icons. It is easy to create and allows an educator to provide students links to sources of information that can be used for specific instructional units. www.symbaloo.com
- This site provides a brief description of Symbaloo and multiple ways to use the online tool. https://www.theedublogger.com/2014/04/09/11-ways-to-use-symbaloo-in-the-classroom/
- Perkins School for the Blind provides information on using tangible symbols to increase communication, create personal schedules, and provide choices. http://www.perkinselearning.org/videos/webcast/tangible-symbols

Section VII

Transference and Generalization of Concepts, Knowledge, and Skills

For learning to be meaningful for all students, including students with significant cognitive disabilities, it is important to intentionally make connections to future content, real-world application, and college and career readiness skills. For example, students can learn that the way they discover information through observation and investigation can also be used to problem solve daily living tasks. Additionally, the instruction of science concepts, knowledge, and skills may be the catalyst to developing other areas such as needed communication skills, reading/listening comprehension, mathematics skills, age-appropriate social skills, independent work behaviors, and skills in accessing support systems. Table 8 provides instructional ideas to help transfer and generalize concepts, knowledge, and skills and suggested opportunities to embed other skills into instruction.

Table 8. Transfer and Generalization Ideas

Area	Instruction	Opportunity to Embed Skills
Communication	While teaching vocabulary, make connections to real-life or future opportunities to use the words (e.g., discussing a topic with co-workers) or understand the concepts (e.g., while watching a TV show). Sign ASL STEM terms to provide students with vocabulary needed for science labs and future employment.	Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems.
Reading and Listening Comprehension	Reinforce Crosscutting Concepts of patterns and cause and effect relationships when reading articles and informational books about evolution.	Provide practice on identifying sight words while reading science texts.
Mathematics	Teach percentages when analyzing the likelihood of inheriting a trait and talk about how percentages are used in future activities.	Practice number identification and relative quantity (what is likely).
Age-Appropriate Social Skills	Provide instruction on appropriate ways to gain attention when asking questions and communicating information while working on Science and Engineering Practices.	Provide opportunities to work alongside same age peers to practice age-appropriate social skills and serve a vital role in the group.
Independent Work Behaviors	Provide a task checklist and a time to support independent work behaviors.	Use positive behavior supports and teach self-reflection to encourage and reinforce independent work skills.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers and adults when researching information on evidence of a shared ancestry.	Use this time to have the student work on behavior and communication skills.

Section VIII

Tactile Maps and Graphics

The maps and graphics guidelines will help create tactile versions of instructional maps, diagrams, models, and timelines to use with students who are blind or deaf-blind. The tactile maps and graphics may be beneficial to other students as well. A tactile graphic is a representation of a graphic (e.g., picture, drawing, diagram, map, etc.) in a form that provides access through touch. It is not an exact copy of the graphic. The section provides basic guidance and links to more comprehensive resources.

Importance of Tactile Maps and Graphics

It is important to provide tactile graphics for young readers (BANA, 2010). It helps students understand and gain information when presented with science concepts, knowledge, and skills. Science instruction often presents diagrams (e.g., water cycle) and two-dimensional models of living and nonliving things (e.g., model of cell) to teach the related concepts. The following guidance includes information to build upon when creating tactile graphics.

Tactile Graphic Guidance

1. **Determine need for graphic:** When encountering graphics in instructional materials, determine if the graphic is essential to understanding the concept. The Braille Authority of North America (2010) provides a decision tree to help in this determination. It can be accessed online at http://www.brailleauthority.org/tg/web-manual/index.html by selecting "Unit 1 Criteria for Including a Tactile Graphic."
2. **Consult with the local educator trained to work with students with visual impairments.**
3. **Determine the essential information in the graphic.** Read the surrounding information and the caption to determine which information in the graphic to exclude. For example, a model to illustrate the cell wall, nucleus, chloroplast, and vacuole would not need to include the nuclear membrane, Golgi body, and ribosomes.
4. **Reduce unnecessary detail in the graphic.** Identify details that are not necessary for interpreting the information in the graphic. For example, a model of the water cycle may show crevices on the mountains, leaves on a tree, and waves in an ocean. Eliminate unnecessary details, as they are difficult to interpret tactilely.
5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., the lines showing the river), and remove any that are not (e.g., ripples in the water).
6. **Modify the size of the graphic.** Modify the graphic as needed to reduce clutter and allow a blank space between adjacent textures. Additionally, consider the size of the student's hand.
7. **Use solid shapes as feasible.** When solid shapes do not clearly represent the information, use clear solid lines.
8. **Systematically teach exploration and interpretation of tactile graphics.** Systematic instruction and repetition are important when teaching a student to understand a tactile graphic. Pairing the tactile graphic with a 3-dimensional object may help (e.g., pair a raised line drawing of a plant, an example of plants and their parts, with a real plant).

Specific Graphic Type Guidance

Following is information for specific types of graphics that may support instruction in science.

Graphic Organizers/Concept Maps

- It is best to present information to compare or make connections using a tactile graphic. A tactile graphic presents the information in a spatial display and aids in comparison better than a list.

Diagrams/Models

- Limit the number of areas, lines, and labels. Having more than five makes interpretation difficult.
- Consider pairing a tactile graphic with a 3-dimensional model.

Timelines

- Present timelines in the same direction every time (i.e., horizontal or vertical).

Maps

- Distinguish water from land using a consistent background texture for the water.
- Align the direction of the compass rose arrows with the lines of longitude and latitude on the map.

Creating Tactile Graphics

Following are some ways to create tactile graphics. Additional information can be found at www.tactilegraphics.org.

Commercial products:

- Capsule paper or swell paper for printing, and
- Thermoform.

Textured shapes can be made from:

- Sticky back textured papers found at craft stores,
- Corrugated cardboard,
- Fabric with texture (e.g., corduroy, denim),
- Silk leaves,
- Cork,
- Felt,
- Vinyl,
- Mesh tape (used for drywall), and
- Sandpaper.

Raised lines can be made from:

- Glue (best not to use water-based glue), and
- Wax pipe cleaners.

Resources

- The American Foundation for the Blind provides basic principles for preparing tactile graphics. http://www.afb.org/info/solutions-forum/electronic-files-and-research-work-group/tactile-graphics/345
- The Texas School for the Blind and Visually Impaired provides basic principles for preparing tactile graphics, element arrangement on a tactile graphic, resources for preparing quality graphics, etc. http://www.tsbvi.edu/graphics-items/1465-basic-principles-for-preparing-tactile-graphics
- Perkins School for the Blind has tips for reading tactile graphics in science with a focus on state assessment. http://www.perkinselearning.org/accessible-science/blog/tips-reading-tactile-graphics-science-focus-state-assessment

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[2] All resources provided for this module only. Mention does not imply endorsement, recommendation, or approval by the Tennessee Department of Education.

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