Science
Module 12

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 – Organisms reproduce and transmit hereditary information.
- Biodiversity and Change – A rich variety and complexity of organisms have developed in response to changes in the environment.

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. Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts;
- II. Scientific Inquiry and Engineering Design;
- III. Connecting 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

Science Academic Standards and Related Alternate Assessment Targets 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 related Alternate
Assessment Targets (AATs) and Underlying Concepts (UCs) covered in the module. The AATs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are basic key ideas or concepts linked to specific AATs. UCs are a basis for developing a more complex understanding of the knowledge and skills represented in the AAT and should not be taught in isolation. It is important to provide instruction on the AAT along with the UC in order to move toward acquisition of the same concepts, knowledge, and skills.

Table 1 includes the academic standards and related AATs 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 AATs and UCs included in the table do not cover all of the concepts that can be taught to support progress and understanding aligned to the standards.

**Table 1. Science Academic Standards and Related AATs and UCs**

<table>
<thead>
<tr>
<th>Academic Standards</th>
<th>Alternate Assessment Targets (AAT)</th>
<th>Underlying Concepts (UC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heredity – Organisms reproduce and transmit hereditary information.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3210.4.4 Determine the probability of a particular trait in an offspring based on the genotype of the parents and the particular mode of inheritance.</td>
<td>Identify the probability (i.e., two out of four) of a particular trait in an offspring based on the interpretation of a Punnett square.</td>
<td>Identify the dominant trait in a given allele pair (i.e., trait shown in a gene pair represented by a capital letter).</td>
</tr>
<tr>
<td>3210.4.5 Apply pedigree data to interpret various modes of genetic inheritance. (HS-LS3–3)</td>
<td>Identify a model showing how parents and offspring may have different traits.</td>
<td>Compare traits of parents and offspring.</td>
</tr>
<tr>
<td><strong>Biodiversity and Change – A rich variety and complexity of organisms have developed in response to changes in the environment.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3210.5.1 Compare and contrast the structural, functional, and behavioral adaptations of animals or plants found in different environments.</td>
<td>Identify how a plant or animal adapts to changes in their environments.</td>
<td>Compare physical characteristics of animals advantageous for survival in their environments.</td>
</tr>
<tr>
<td>3210.5.3 Recognize the relationships among environmental change, genetic variation, natural selection, and the emergence of a new species.</td>
<td>Identify how the traits of particular species allow them to survive in their specific environments.</td>
<td>Categorize plants or animals by similar traits.</td>
</tr>
</tbody>
</table>

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1 Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the AATs 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, rather 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. 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.

Science Practices

• Asking questions (for science) and defining problems (for engineering).
  
  Examples: What is the probability that an organism will have the same traits as its parents? What is the likelihood of transmitting a recessive gene through two generations? Why do some animals have big features such as long legs and big ears? How are traits passed from parents to offspring? What determines the expression of traits?

• Developing and using models.
  Examples: Two models—a Punnett square and a pedigree—can be used to predict and identify traits among genetically related individuals. Complete a Punnett square to determine the probability of eye color of an offspring. Use symbols to represent the alleles in a genotype. Develop a model that can show inherited traits as a pedigree. A pedigree shows phenotypes of genetically related family members.

• Planning and carrying out investigations.
  Examples: Is the human hand span a Mendelian trait? Observe an animal to determine what adaptations allow it to survive in its environment.

• Analyzing and interpreting data.
  Examples: Analyze and interpret a Punnett square to determine probability of traits being passed from parents to offspring.

• Using mathematics and computational thinking.
  Examples: Determine the probability of dominant and recessive traits passed from parents to their offspring using a Punnett square or a pedigree.

• 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. Explain how the types of adaptations of an animal help it survive and reproduce in its environment.

• 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. Use
evidence to argue how an animal’s adaptation would need to change for the animal to survive if the environment changed (e.g., a subdivision replacing woodland).

- Obtaining, evaluating, and communicating information.
  Examples: Interpret pedigree data to determine the possibility of a defective trait being passed across multiple generations and explain the probability. Evaluate and describe the relative survival rates of organisms with different traits in a specific environment.

**Science Practices Resources**

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/

- This site provides an activity to model the principles of inheritance.
  https://sbs.wsu.edu/evolutionary/9_12heredity.html

- This site has a variety of investigations on heredity and evolution.
  http://olympia.osd.wednet.edu/media/olympia/departments/science/smith/genetics/c1_crazt_traits.pdf

- This site provides information on a variety of ecology topics.
  http://www.nature.com/scitable/knowledge/ecology-102

**Section III**

**Connecting Concepts**

Grade-level science content includes Connecting Concepts, which are concepts that connect information between different science strands and grade levels. The Connecting 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). Connecting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

Connecting Concepts are a common link between multiple standards and units of study. The Connecting 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. For example, understanding that some phenomena may have more than one cause is a Connecting Concept that applies when studying how offspring inherit traits from their parents; another cause could be how animal behaviors change due to both environmental and genetic variation. Some Connecting Concepts may apply across multiple content areas and instructional emphases (e.g., understanding how things may change slowly or rapidly when reading an informational text about animals changing).

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2 The resources in this module may change over time and no longer be available.
Teaching Connecting Concepts

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

- patterns (e.g., Illustrate the pattern of traits passed from parents to their offspring.),
- critical features (e.g., Emphasize how specific adaptations help an animal survive in its environment.),
- big ideas (e.g., Highlight the importance of animal behavioral adaptations to survival.), and
- relationships (e.g., Show the relationship between environmental change and evolution of a species.)

For example, Show the relationship between environmental change and animals changing their behavior (species of fish migrating earlier due to warmer water temperatures). In addition, build connections between familiar and new information (e.g., Make the connection between the species and one students are familiar with.).

Following are Connecting Concepts for this Content Module – Life Science: Variation of Traits.

Patterns
- Patterns can be used to determine similarities and differences.
- Observed similarities and differences can be used to sort and classify natural objects and designed products.
- Patterns in rates of change and cycles can be used to make predictions.
- Patterns can be observed and used as evidence.
- Patterns can be used to identify cause-and-effect relationships.

Cause and Effect
- Events that occur together with regularity might or might not have a cause-and-effect relationship.
- Some phenomena may have more than one cause.
- Cause-and-effect relationships may explain change.
- There are cause-and-effect relationships between DNA, the proteins it codes for, and the resulting traits observed in an organism.
- The relationship between a trait’s occurrence within a population and environmental factors can be determined.

Scale, proportion, and quantity
- Natural objects and observable phenomena exist from the very small to the immensely large.
- Standard units can be used to measure and describe physical quantities such as weight, time, temperature, and volume.
- Models using scale can be used to study systems that are too large or too small.
- Data can be organized by the frequency, distribution, and variation of expressed traits in the population.

Structure and Function
- Substructures of different organisms have shapes and parts that serve functions.
- All cells contain genetic information in the form of DNA molecules.
Stability and Change

- Some things stay the same while some things change.
- Things may change slowly or rapidly.
- Small changes in one part of a system might cause large changes in another part.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.
- In sexual reproduction, chromosomes can sometimes swap sections during cell division, creating more genetic variation.

Connecting Concept Resources:

Grant Wiggins talks about “big ideas” in this article.
http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99

Teacher Vision provides ten science graphic organizers that are free and printable.

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., heredity) and in the context of the specific content (e.g., Teach the terms “trait,” “dominant,” “recessive,” “alleles,” “parents,” “offspring,” etc., when teaching about heredity.).

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 words “characteristic” and “traits” helps students understand what they learn about the physical traits and observable characteristics during instruction on heredity and adaptations. The second type, specific content words, represents groups of words that are associated with an organism, system, process, or phenomena. Specific content words (e.g., behavioral adaptation) connect to general words (e.g., survive). 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. The vocabulary words span across grades three through eight; refer to the TN science standards for grade-specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Adaptation is a change in the way something looks or acts to survive in its environment.) and an example of the word (e.g., The shape of a bird’s beak, the color of fur, or the shape of teeth are examples of physical adaptations that help animals survive.) Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., Bird calls for migration are an example of a behavioral adaptation birds use to survive.) and a possible connection to a general vocabulary word (e.g., Some birds migrate south to survive cold winters.).

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 be able to identify a hereditary trait instead of defining the word “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., An instinct is a natural impulse or behavior. Example: Bears have an instinct to hibernate in the winter.)

<table>
<thead>
<tr>
<th>• adapt/adaptation</th>
<th>• flight</th>
<th>• organism</th>
</tr>
</thead>
<tbody>
<tr>
<td>• behavioral</td>
<td>• fur</td>
<td>• parents</td>
</tr>
<tr>
<td>• camouflage</td>
<td>• genes/genetics</td>
<td>• physiological</td>
</tr>
<tr>
<td>• characteristic</td>
<td>• habitat</td>
<td>• probability</td>
</tr>
<tr>
<td>• competition</td>
<td>• hibernation</td>
<td>• recessive</td>
</tr>
<tr>
<td>• cross</td>
<td>• instinct</td>
<td>• reproduce</td>
</tr>
<tr>
<td>• dominant</td>
<td>• migrate/migration</td>
<td>• species</td>
</tr>
<tr>
<td>• environment</td>
<td>• molecule</td>
<td>• survival</td>
</tr>
<tr>
<td>• evolve</td>
<td>• mutation</td>
<td>• variation</td>
</tr>
<tr>
<td>• express</td>
<td>• offspring</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3. Specific Content Words**

**Specific Content Words** - words that specify a particular thing (e.g., Punnett square) or phenomenon (e.g., natural selection)

Describe the word and when possible make the connection to a Connecting Concept (e.g., phenotype is the physical appearance of a plant or animal resulting from heredity and the environment. Phenotypes can have more than one cause.

<table>
<thead>
<tr>
<th>• alleles</th>
<th>• genetic variation</th>
<th>• pedigree</th>
</tr>
</thead>
<tbody>
<tr>
<td>• autosomal</td>
<td>• genotype</td>
<td>• phenotype</td>
</tr>
<tr>
<td>• behavioral adaptation</td>
<td>• heredity/inherited</td>
<td>• physiological adaptation</td>
</tr>
<tr>
<td>• chromosome</td>
<td>• heterozygous</td>
<td>• Punnett square</td>
</tr>
<tr>
<td>• DNA</td>
<td>• homozygous</td>
<td>• structural adaptation</td>
</tr>
<tr>
<td>• environmental change</td>
<td>• natural selection</td>
<td>• trait</td>
</tr>
</tbody>
</table>
Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words.

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)³

<table>
<thead>
<tr>
<th>Ideas</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.</td>
<td>Provide a description and an example of structural adaptation, “The physical features of a plant or animal. An eagle’s sharp hooked beak is a structural adaptation that helps it cut its food into bites.”</td>
</tr>
<tr>
<td>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.</td>
<td>Have students explain inherited traits (verbally or using alternative and augmentative communication [AAC] system) by describing their eye and hair color compared to that of their parents.</td>
</tr>
</tbody>
</table>
| Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models). | • Have students complete a graphic organizer by pasting animal adaptations into the type of adaptation (e.g., structural, behavioral, physiological). See Figure 1. Science Vocabulary Graphic Organizer for an example.  
  • Have students view words paired with pictures and recorded definitions:  
    o Punnett square (e.g., https://quizlet.com/172590692/punnett-square-flash-cards/),  
    o pedigree data chart (e.g., https://quizlet.com/147883662/pedigree-flash-cards/), and  
    o adaptation (e.g., https://quizlet.com/109389143/adaptation-flash-cards/). |
| Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, rather distributed trials in different ways or contexts. Reference http://projectlearnet.org/tutorials/learning_trial | • Expose students to vocabulary by incorporating it into daily activities such as pointing out inherited traits using family photos and highlighting adaptations of local |

³ Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.
<table>
<thead>
<tr>
<th>Ideas</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>s.html for information on learning trials.</td>
<td>plants and animals.</td>
</tr>
<tr>
<td>• Read books or watch videos related to the vocabulary and concepts:</td>
<td></td>
</tr>
<tr>
<td>o heredity (e.g., <a href="http://www.livescience.com/27332-genetics.html">http://www.livescience.com/27332-genetics.html</a>),</td>
<td></td>
</tr>
<tr>
<td>o plant adaptations (e.g., <a href="http://www.ck12.org/biology/Plant-Adaptations/lesson/Plant-Adaptations-BIO/">http://www.ck12.org/biology/Plant-Adaptations/lesson/Plant-Adaptations-BIO/</a>), and</td>
<td></td>
</tr>
<tr>
<td>o animal adaptations (e.g., <a href="http://www.nationalgeographic.org/encyclopedia/adaptation/">http://www.nationalgeographic.org/encyclopedia/adaptation/</a>).</td>
<td></td>
</tr>
<tr>
<td>• Have students find genetic terms in a talking glossary (e.g., Talking glossary of genetic terms <a href="https://www.genome.gov/glossary/">https://www.genome.gov/glossary/</a>).</td>
<td></td>
</tr>
<tr>
<td>Ask students to discuss the vocabulary words with each other.</td>
<td>• Have students use vocabulary words to describe pictures of animals, their environment, and adaptations.</td>
</tr>
<tr>
<td></td>
<td>• Have students share their representations (e.g., drawings or pictures) of a word with each other.</td>
</tr>
<tr>
<td>Play vocabulary word games with students.</td>
<td>• Have students play online Jeopardy style vocabulary game (e.g., <a href="https://www.quia.com/cb/415703.html">https://www.quia.com/cb/415703.html</a>).</td>
</tr>
<tr>
<td></td>
<td>• Have students work with an interactive word wall (e.g., <a href="http://nstacommunities.org/blog/2013/10/16/putting-science-words-on-the-wall/">http://nstacommunities.org/blog/2013/10/16/putting-science-words-on-the-wall/</a>).</td>
</tr>
<tr>
<td>Have students watch a dramatization or have them act out the vocabulary term.</td>
<td>Have students participate in plant or animal adaptation simulations (e.g., <a href="http://www.hometrainingtools.com/a/whale-blubber-project">http://www.hometrainingtools.com/a/whale-blubber-project</a>).</td>
</tr>
</tbody>
</table>
Vocabulary Example

Have students complete a vocabulary graphic organizer by pasting animal adaptations next to the correct animal and beneath the type of adaptation (see Figure 1). The activity can be modified as needed for individual students. For example, one student may copy and write the information instead of pasting. Another student may use a communication board to tell a peer where to place the information, while another student may complete a digital version using an adaptive keyboard. 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](https://wiki.ncscpartners.org)
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. [https://wiki.ncscpartners.org](https://wiki.ncscpartners.org)

Figure 1. Science Vocabulary Graphic Organizer

<table>
<thead>
<tr>
<th>Animal</th>
<th>Structural Adaptation</th>
<th>Behavioral Adaptation</th>
<th>Physiological Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monarch butterfly</td>
<td>bright colors make it look poisonous</td>
<td>migrates south every year</td>
<td>tastes bad because it eats milkweed</td>
</tr>
<tr>
<td>Mallard duck</td>
<td>camouflage - brown feathers blend with marshes</td>
<td>female quacks loudly and flies away to draw a predator to herself and away from the young</td>
<td>oily feathers - water resistant to keep them dry</td>
</tr>
<tr>
<td>Polar bear</td>
<td>large feet - help walk on ice and snow</td>
<td>covers its nose to blend into the snow and not be easily seen by its prey</td>
<td>stores fat - uses as energy</td>
</tr>
</tbody>
</table>

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/](http://www.vocabulary.com/)

Text Project provides Word Pictures that are free for educators to use. It 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/

This site provides effective strategies for teaching science vocabulary.  
http://www.learnnc.org/lp/pages/7079

The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms.  

This site provides a wide range of science graphic organizers, including some that are vocabulary specific.  

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 AATs and to build students’ knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

Heredity – Organisms reproduce and transmit hereditary information.

Content:

- The laws of probability govern Mendelian inheritance. However, patterns of genetic inheritance are often more complex than predicted by simple Mendelian genetics.
- A Punnett square predicts the results of a genetic cross between individuals of a known genotype.
- Each gene contains two alleles for traits.
- Each parent provides one allele with possible combinations of AA (homozygous), Aa (heterozygous), and aa (homozygous).
  - If an organism has two identical alleles for a particular character, then that allele is present as a single copy in all gametes.
  - If different alleles are present, then 50% of the gametes will receive one allele and 50% will receive the other.
- A dominant trait in an allele pair, represented with a capital letter (e.g., A), can mask a recessive trait, represented by a lowercase letter (e.g., a).
- Pedigree analysis uses a diagram (e.g., pedigree chart or tree) to study inherited gene traits (e.g., genetic defects) in humans.
- The combination of alleles creates an organism’s genetic information (genotype).
- Some traits are physical traits (phenotype) that can be observed.
- Each chromosome consists of a single DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species’ characteristics are carried in DNA.
- Each parent contributes half of the genes acquired by the offspring.
- In sexual reproduction, both parents contribute different genetic information. The offspring chromosomes will reflect a combination of genetic material from both parents. Therefore, offspring contain new combinations of genes (genetic variation) that make offspring chromosomes distinct from those of either parent.
**Biodiversity and Change** – A rich variety and complexity of organisms have developed in response to changes in the environment.

**Content:**
- Animals and plants adapt to survive in their environments.
- Structural adaptations are physical features of an organism that help it survive in its environment (e.g., fur on an animal).
- Behavioral adaptations are activities that an organism does to help it survive (e.g., migration) and can be learned or instinctive.
- Physiological adaptations are changes within an organism’s cells or tissues (e.g., body temperature regulation) to help it survive in its environment.
- Environmental change (e.g., climate change) affects the evolution of some species.
- Genetic variations within a species allow the survival of the species in the long term.
- Natural selection affects the evolution of some species.
- A new species may emerge due to environmental change, genetic variations, and/or natural selection.
- Environmental factors can also cause mutations in genes, and viable mutations are inherited.
- The variation and distribution of traits observed depend on both genetic and environmental factors.
- Individuals in a species have genetic variation (through mutations and sexual reproduction) that is passed on to their offspring.
- Individuals can have specific traits that give them a competitive advantage relative to other individuals in the species.
- Individuals with traits that give competitive advantages can survive and reproduce at higher rates than individuals without the traits. Thus, individuals that survive and reproduce at a higher rate will provide their specific genetic variations to a greater proportion of individuals in the next generation.
- Genetic information can be altered because of mutations.

**Unit Content Resources:**

**Heredity**
- PBS Learning provides a video on heredity
- Biology Corner has information on how to solve a Punnett square and a practice worksheet to determine genetic crosses that involve two traits.
  - [https://www.biologycorner.com/worksheets/genetics_2traits_bio2.html](https://www.biologycorner.com/worksheets/genetics_2traits_bio2.html)
- Lab Center has a variety of information on Mendelian Inheritance.
- This site provides a hands-on activity on Mendel’s pea experiment.
- These sites provide information on pedigree analysis.
  - [http://www.cs.cmu.edu/~genetics/units/instructions/instructions-PBA.pdf](http://www.cs.cmu.edu/~genetics/units/instructions/instructions-PBA.pdf)
  - [https://www.ndsu.edu/pubweb/~mcclean/plsc431/mendel/mendel9.htm](https://www.ndsu.edu/pubweb/~mcclean/plsc431/mendel/mendel9.htm)
- Better Lesson provides a lesson plan on a pedigree chart.
  - [http://betterlesson.com/lesson/635181/pedigrees](http://betterlesson.com/lesson/635181/pedigrees)
Biodiversity and Change

- Encyclopedia Britannica provides information on adaptation in plants and animals. [Visit here](https://www.britannica.com/science/adaptation-biology-and-physiology)
- BBC has information and examples of animal and plant adaptations. [Visit here](http://www.bbc.co.uk/nature/adaptations)
- This site has information on plant adaptations. [Visit here](http://www.mbqnet.net/bioplants/adapt.html)
- This site has a lesson plan on animal adaptations. [Visit here](https://www.brown.edu/academics/science-center/outreach/stem_orc/lessons/detail/76dc4a7f-c3c0-79d4-015c-d3a74458bb46)
- Animal Planet provides images and descriptions of ten animal adaptations. [Visit here](http://www.animalplanet.com/wild-animals/animal-adaptations/)
- Vision Learning has information on adaptation and penguins. [Visit here](http://www.visionlearning.com/en/library/Biology/2/Adaptation/68)
- Live science has information on global warming and changes in animals. [Visit here](http://www.livescience.com/3864-global-warming-changing-wild-kingdom.html)
- Boundless provides information on how genetic variation affects the evolution of populations. [Visit here](https://www.boundless.com/biology/textbooks/boundless-biology-textbook/the-evolution-of-populations-19/population-genetics-131/genetic-variation-530-12943/)
- This site provides a lesson plan on population biology. [Visit here](http://naturalsciences.sdsu.edu/ta/classes/lab2.8/TG.html)
- PBS has information on an origin of a species. [Visit here](http://www.pbs.org/wgbh/evolution/darwin/origin/index.html)
- This site has lesson plans on animal adaptations. [Visit here](http://www.zoosociety.org/Education/SchoolPrograms/SelfGuidedTours.php)
- Study.com has information on desert animal adaptations. [Visit here](http://study.com/academy/lesson/desert-animal-adaptations.html#lesson)

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of UDL guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. Students with significant cognitive disabilities, especially students with visual and/or hearing impairments and students with complex communication needs, require additional scaffolds, adaptations, and modifications to access content and support learning. The three principles of UDL establish a framework for providing these. UDL provides guiding principles to create instructional materials and activities in a flexible manner to address the needs of different types of learners. Additionally, the flexibility allows for further individualization.

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.

These strategies can assist all students in understanding the basic concepts. Some of the examples include adaptation ideas for students with vision, hearing, and/or physical limitations. Each example has a code to indicate when it includes specific adaptation ideas for these needs:
### Multiple Means of Representation

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile). | Have students model Mendel’s experiments using a tactile model (e.g., [http://www.perkinselearning.org/accessible-science/tactile-model-mendelian-trait-pea-plants](http://www.perkinselearning.org/accessible-science/tactile-model-mendelian-trait-pea-plants)). **V**  
Have students explore an animation of Mendel’s experiment on transmission of traits (e.g., [http://www.sumanasinc.com/webcontent/animations/content/mendel/mendel.html](http://www.sumanasinc.com/webcontent/animations/content/mendel/mendel.html)).  
Have students listen to sounds of animals and then discuss the various adaptations each animal has (e.g., [https://seaworld.org/en/Animal-Info/Animal-Sounds](https://seaworld.org/en/Animal-Info/Animal-Sounds)). |
| Model content through pictures, dramatization, videos, etc.               | Watch videos on:  
• inheritance (e.g., [http://learn.genetics.utah.edu/content/basics/inheritance/](http://learn.genetics.utah.edu/content/basics/inheritance/)),  
• animal adaptations (e.g., [https://www.youtube.com/watch?v=fRX2JtKFUzk](https://www.youtube.com/watch?v=fRX2JtKFUzk)), and  
• plant adaptations (e.g., [http://studyjams.scholastic.com/studyjams/jams/science/plants/plant-adaptations.htm](http://studyjams.scholastic.com/studyjams/jams/science/plants/plant-adaptations.htm)).  
• 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](https://web.archive.org/web/20120227034335/http://www.fi.edu/guide/knox/Traits/traitsexamples.pdf)). **H** |
| Present information using modified graphic organizers (e.g., simplified organizers with pictures) and models (e.g., tactile and pictures). | Use a KWHL to help students make connections between what they already Know, What they want to know, How they can find out, and finally, what they Learn. (slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: [http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf](http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf)). **V/H/P**  
Provide a tactile version of a Punnett square (e.g., [http://www.perkinselearning.org/accessible-science/punnett-squares](http://www.perkinselearning.org/accessible-science/punnett-squares)). **V/H** |
| Provide appropriate and accessible text on the content for students to listen to or read. | Paraphrase information to reduce text difficulty and length (e.g., [http://textcompactor.com/](http://textcompactor.com/)) and write or type with a bold and plain font (e.g., Verdana, 18 pt. font) with good spacing between lines (e.g., 1.5 vs. single spacing). **V**  
Provide students with online text (e.g., [http://news.nationalgeographic.com/news/2014/05/140506-climate-change](http://news.nationalgeographic.com/news/2014/05/140506-climate-change)). **V** |
Teach information using songs.

Have students listen to songs about phenotype (e.g., [https://www.youtube.com/watch?v=9G2lvdQfSr4](https://www.youtube.com/watch?v=9G2lvdQfSr4)) and animal adaptations (e.g., [https://www.youtube.com/watch?v=0N0wVq4nUBU](https://www.youtube.com/watch?v=0N0wVq4nUBU)).

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

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Use assistive technology to allow the student to interact with the instructional materials and content. | Have students use an adapted mouse for online activities about animal adaptations (e.g., [http://interactivesites.weebly.com/animal-adaptations.html](http://interactivesites.weebly.com/animal-adaptations.html)). Provide texts online that include a text reader:  
  - Punnett square (e.g., [http://bookbuilder.cast.org/view.php?op=view&book=16228&page=1](http://bookbuilder.cast.org/view.php?op=view&book=16228&page=1)), and  
| Present instructional materials in a manner that provides access. | Label models with high contrast or tactile print (e.g., [http://www.visionaware.org/info/everyday-living/home-modification-/labeling-and-marking/125](http://www.visionaware.org/info/everyday-living/home-modification-/labeling-and-marking/125)). Place symbols for Punnett square and pedigree chart on hook and loop tape for students to move around. Tack or tape materials to the desk or a slant board to prevent unnecessary movement. |
| Provide voice output devices for students to select an answer. | Record correct answers and distractors on a voice output multiple message switch or multiple voice output switches and have students answer questions using the switch. 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 select the correct answer. Ask questions that can be answered with yes/no or with answer choices. |
| Provide simulation activities. | Have students participate in a simulation on:  
  - heredity using popsicle sticks (e.g., [https://www.biologycorner.com/worksheets/genetics_heredity_simulation.html](https://www.biologycorner.com/worksheets/genetics_heredity_simulation.html)), and  
  - bird beak (e.g., [http://mrscienceut.net/BirdBeaks.pdf](http://mrscienceut.net/BirdBeaks.pdf)). |
| Create a digital graphic organizer that allows drag-and- | Have students use an online pedigree data chart (e.g., [http://learn.genetics.utah.edu/content/addiction/pi/](http://learn.genetics.utah.edu/content/addiction/pi/)). Use a screen reader and an adapted mouse. |
Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Multiple Means of Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide a schedule and visual timer.</td>
<td>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., <a href="http://theautismhelper.com/using-mini-schedules-classroom/">http://theautismhelper.com/using-mini-schedules-classroom/</a>) and a behavior/routine checklist (e.g., <a href="http://www.buildingblox.net/images/behavior_check.pdf">http://www.buildingblox.net/images/behavior_check.pdf</a>) for each class or academic subject.</td>
</tr>
<tr>
<td>Vary the challenge and amount of information presented at a time.</td>
<td>Allow frequent breaks when introducing new material (e.g., Punnett square and heredity). Allow less frequent breaks when reviewing information or making connections to familiar information (e.g., personal and family traits).</td>
</tr>
<tr>
<td>Make connections to topics or activities that are motivating.</td>
<td>Provide students communication symbols that allow them to comment or write about the topic. Play human traits bingo (e.g., <a href="https://www.biologycorner.com/2016/05/29/human-traits-bingo/">https://www.biologycorner.com/2016/05/29/human-traits-bingo/</a>). Listen to interviews of people discuss their family members to help complete a pedigree data chart (e.g., <a href="http://learn.genetics.utah.edu/content/addiction/pi/pedigree.swf">http://learn.genetics.utah.edu/content/addiction/pi/pedigree.swf</a>).</td>
</tr>
<tr>
<td>Allow choices as possible.</td>
<td>Allow students to use a “fidget” (e.g., <a href="https://www.pinterest.com/explore/fidget-toys/">https://www.pinterest.com/explore/fidget-toys/</a>). Allow students to use preferred communication (e.g., high-tech device, low-tech device, gestures, etc.) to answer questions or participate in class discussion.</td>
</tr>
<tr>
<td>Provide opportunities to work collaboratively with peers.</td>
<td>Provide opportunities for students to work in a general education classroom with peers when working on a solar eclipse project.</td>
</tr>
<tr>
<td>Teach students self-regulation skills.</td>
<td>Provide communication symbols to request a break or express feelings and model how to use them appropriately. Provide students with stress balls, finger fidgets, etc. Scaffold instruction on using self-regulation skills (e.g., modeling, cueing, fading support).</td>
</tr>
</tbody>
</table>
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


This Perkins School for the Blind video, 20 minutes long, 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

DeafTEC has a Lab Sciences ASL video dictionary. https://www.deaftec.org/resources/stem-signs/lab-sciences

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, mathematic 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

<table>
<thead>
<tr>
<th>Area</th>
<th>Instruction</th>
<th>Opportunity to Embed Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>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.</td>
<td>Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems.</td>
</tr>
<tr>
<td>Reading and Listening Comprehension</td>
<td>Provide information through reading books and articles on science concepts while working on reading comprehension.</td>
<td>Provide practice on communication skills when students are answering questions or telling about the book or article.</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Teach measuring and data collection during investigations.</td>
<td>Provide practice on number identification, sequence, relative quantity or size (e.g., which is more?), etc.</td>
</tr>
<tr>
<td>Age-Appropriate Social Skills</td>
<td>Make connections between the Connecting Concepts and real-life experiences showing how they can help students make decisions (e.g., understanding that cause-and-effect relationships can predict change helps understand that their behavior affects how others react).</td>
<td>Provide opportunities to work alongside same age peers to practice age-appropriate social skills and serve a vital role in the group.</td>
</tr>
<tr>
<td>Independent Work Behaviors</td>
<td>Encourage and reinforce independent completion of tasks to build independent work skills.</td>
<td>Use positive behavior supports to encourage and reinforce independent work skills.</td>
</tr>
<tr>
<td>Skills in Accessing Support Systems</td>
<td>Encourage students to ask appropriately for assistance from peers and adults when working on the content.</td>
<td>Use this time to have the student work on behavior and communication skills.</td>
</tr>
</tbody>
</table>

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 and social studies 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. Social studies instruction often uses maps and timelines to illustrate where and when people existed and events occurred. 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](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 map to illustrate location of key countries would not need state lines and capital cities and may not need all of the surrounding countries.

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 tactiley.

5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., line that indicates a body of water), and remove any that are not.

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 pencil, an example of goods, with a pencil).

**Specific Graphic Type Guidance**

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

**Graphic Organizers/Concept Maps**

- It is best to present information to compare or make connections in 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 – print
- 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)
- Sandpaper

Raised lines can be made from:
- Glue (best not to use water-based glue)
- Wax pipe cleaners

Resources
Creating Tactile Graphics, created by the High Tech Center Training Unit, provides basic principles of tactile graphics, characteristics of good tactile graphics, the planning process, guidelines for designs, and more. http://www.htctu.net/trainings/manuals/alt/Tactile_Graphics.pdf

The Texas School for the Blind and Visually Impaired provided 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 short videos that explain the importance of tactile graphics and information on spatial relationships and graphic literacy, moving from models to graphics, and strategies for reading tactile graphics. [http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics](http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics)
References


Picture Citations
Prepared by edCount, LLC in collaboration with Educational Testing Service as part of the TCAP/Alt Science and Social Studies contract.