Science

Module 1

Life Science: Structure and Function/Growth and Development of Organisms

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:

- Cells (elementary) – All living things are made of cells that have basic structures.
- Heredity – Plants and animals reproduce and transmit hereditary information between generations.
- Cells (middle) – Organisms' cells serve functions necessary for life.

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: Structure and Function/Growth and Development of Organisms 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: Structure and Function/Growth and Development of Organisms. 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 [1]

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
Heredity: Plants and animals reproduce and transmit hereditary information between generations.		
0307.4.1 Select an illustration that shows how an organism changes as it develops.	Identify representations that show how an organism changes as it develops.	Match juvenile organisms to adult organisms.
Cells: All living things are made of cells that perform functions necessary for life.		
0407.1.1 Compare basic structures of plant and animal cells.	Identify basic structures of plant and animal cells.	Identify a representation that shows that organisms are composed of cells.
0707.1.3 Explain the basic functions of a major organ system.	Identify the basic functions of major organ systems.	Recognize major organs of animals.
0707.1.5 Explain how materials move through simple diffusion.	Predict the outcome when materials move through simple diffusion (e.g., when a teabag is placed into a cup of hot water, the water changes color and tastes of tea).	Identify a solution of greater concentration of solute (e.g., salt).

[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.

- Asking questions (for science) and defining problems (for engineering).
  Examples: How are plant and animal cells different? How does the heart and lungs work together? How are you able to smell perfume or a strong smell?

- Developing and using models.
  Examples: Develop a model to show the life cycle of various animals. Use a model of a cell to identify its basic structures. Complete a model to illustrate how different organisms' life cycles can look different. Use a model to identify key differences between plant and animal cells based on structure and function. Create a model to show how particles move from one area to another.

- Planning and carrying out investigations.
  Examples: Design and conduct an investigation to see factors that affect plant growth. Design and conduct an investigation to see how adding food coloring affects a glass of water?

- Analyzing and interpreting data.
  Examples: Describe how specialized groups of cells work together to form tissues (e.g., evidence from data about the kinds of cells found in different tissues, such as nervous, muscular, and epithelial, and their functions).

- Using mathematics and computational thinking.
  Examples: Measure and chart a plant as it grows. Count the number of molecules in a high concentration vs. the number of molecules in a low concentration.

- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Explain how the structure of the cell membrane or cell wall relates to the function of the organelles and the whole cell. Describe how different organs can work together as subsystems to form organ systems that carry out complex functions (e.g., the heart and blood vessels work together as the circulatory system to transport blood and materials throughout the body).

- Engaging in argument from evidence.
  Examples: Use reasoning to connect the relevant and appropriate evidence and construct an argument that includes the idea that plants and animals have structures that, together, support survival, growth, behavior, and/or reproduction.

- Obtaining, evaluating and communicating information.
  Examples: Communicate the idea that the body is a system of interacting subsystems composed of groups of cells to others.

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/

- A variety of sites that provide models or directions to build models:
  - http://kidcourses.com/animal-cell-handout-coloring-page/
  - http://www.weirdunsocializedhomeschoolers.com/how-to-make-an-edible-cell-model/
  - http://www.perkinselearning.org/accessible-science/modeling-backbone-and-spinal-cord
- Presentation on modeling activities for human body systems. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=14&cad=rja&uact=8&ved=0ahUKEwjRpOfy7tTLAhVGGj4KHUOBB4UQFghZMA0&url=http%3A%2F%2Fwww.cascience.org%2Fcsta%2Fpdf%2Fconferencehandouts%2Fvarnaupresentation.ppt&usg=AFQjCNGoPjDMBmU-oWMFPNQ6yeE96j5iRw&sig2=UXQtTMi2O64IPgY6Cn272A
- Presentation on modeling activities for diffusion.
  - http://biologyforcsec.blogspot.com/2012/08/diffusion.html
  - scienceforkidsBlog.blogspots.com
  - http://pmgbiology.com/tag/protein/
- Education.com provides a variety of life science activities and experiments. http://www.education.com/activity/life-science/

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. Life sciences focus on patterns, processes, and relationships of living organisms. For example, understanding patterns of change is a Connecting Concept that applies to growth and development of organisms, rotation of Earth, and the water cycle. Some Connecting Concepts may apply across multiple content areas and instructional emphases (e.g., cause and effect in reading science texts).

The first science content module, Structure and Function/Growth and Development of Organisms, addresses how individual organisms are configured and how these structures function to support life, growth, behavior, and reproduction. A critical concept is the unifying principle that cells are the basic unit of life.

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., Plants and animals have predictable characteristics at different stages of development.),
- critical features (e.g., Special structures within cells are responsible for specific cellular functions.),
- big ideas (e.g., Large groups of cells work together to form systems of tissues and organs.), and
- relationships (e.g., making the connection that adult plants and animals can have young).

For example, when learning about insects and mammals, point out the patterns: both reproduce, have life cycles, are made of cells, etc. In addition, build connections between familiar and new information (e.g., identify all the organisms within the classroom and school).

Following are **Connecting Concepts** for this Content Module — Life Science: Structure and Function/Growth and Development.

Patterns

- Models can be used to describe that although organisms can display life cycles that look different, they all follow the same pattern.
- Patterns can be used to determine similarities and differences.
- Make predictions related to a phenomenon, based on identified patterns among life cycles (e.g., prediction could include that if there are no births, deaths will continue and eventually there will be no more of that type of organism).
- 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.

Systems and System Models

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.
- System parts work together.
- Models can be used to describe a causal account for the phenomenon, including how different parts of a cell contribute to how the cell functions as a whole, both separately and together with other structures (e.g., maintaining the structure of the cell and controlling what enters and leaves the cell).

Structure and Function

- The body contains organs and organ systems that interact with each other to carry out all necessary functions for survival and growth of the organism (e.g., the digestive, respiratory, and circulatory systems are involved in the breakdown and transport of food and the transport of oxygen throughout the body to cells, where the molecules can be used for energy, growth, and repair).
- Cells and their organelles have shapes and parts that serve specific functions.
- The function of complex and microscopic structures and systems depends on the shapes, composition, and relationships among their parts.

Connecting 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 three through six. http://www.uen.org/3-6interactives/science.shtml
- 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., basic structures of a plant cell) and in the context of the specific content (e.g., teach the terms cell wall, membrane, nucleus, and vacuole while exploring a model of a cell).

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 "energy" helps students to connect many different types of energy and how they are created, stored, and used. 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., chloroplasts) connect to general words (e.g., energy) related to how plants make their own food. 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., predator is an animal that eats other animals) and an example of the word (e.g., a lion is an example of a predator because it needs to eat other animals to survive). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., a cell membrane keeps thing in and out) and a possible connection to a general vocabulary word (e.g., a cell membrane is part of a cell).

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 the collection of bones in our bodies as the skeletal system as opposed to defining skeletal system.

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., cell – the smallest unit of living matter that can exist by itself. *Example: red blood cells and skin cells).*			
• adult	• diffusion	• organ	• plant
• animal	• juvenile	• organ system	• protein
• cell	• living thing	• organism	• solution
• concentration	• offspring	• parent	• survival

Table 3. Specific Content Words

Specific Content Words — words that specify a particular thing (e.g., cell membrane) or phenomena (e.g., evaporation). Describe the word and when possible make the connection to a Connecting Concept (e.g., The heart, the lungs, the blood vessels, and the blood together make the human circulatory system. The circulatory system helps carry food and oxygen throughout the body to cells.)		
• cell membrane	• cell organelles	• larvae
• cell nucleus	• circulatory system (including key components)	• respiratory system (including key components)
• cell vacuole	• digestive system (including key components)	• nervous system (including key components)
• cell wall	• egg	• skeletal system (including key components)

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)[1]

Ideas	Examples
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	Provide a description and analogy for a cell: "A cell is the basic structure of all organisms. A cell is like a factory. It has many different parts which serve different functions. Like a factory, all the parts must work together for the cell to survive."

Ideas	Examples
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 state in their own words or give an example of an offspring. Help students make the connection that they are the offspring of their parents or that a puppy is an offspring of its parents. Then generalize this connection to other less familiar organisms. Adapt by using pictures of parents and offspring.
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	Ask students to complete a vocabulary concept map; providing support as needed (e.g., help from peer or adult, viewing model, using Alternative and Augmentative Communication, etc.) (See Figure 1 Example Concept Definition Map). Adapt the task as needed to include more pictures, objects, and/or textures.
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_trials.html for information on learning trials.	• Expose students by incorporating vocabulary into daily activities when it is appropriate (e.g., After the students have been playing outside, ask, "Do you feel your heart beating? Your heart is part of your circulatory system."). • Read books or watch videos related to the vocabulary and concepts (e.g., Have students watch a video clip on the circulatory system.). • Have students complete activities such as sorting words into categories (e.g., Have students sort different organs into the correct organ system.).
Ask students to discuss the vocabulary words with each other.	• Have students use their preferred mode of communication to share their favorite word and why. Adapt by placing the vocabulary word description on a voice output device and have the student share with a classmate. • Have students share their representations (e.g., drawings or pictures) with each other.
Play vocabulary word games with students.	• Have students use their communication system to describe a word and have peers guess what it is. • Have students organize vocabulary words/pictures/representative objects on a graphic organizer. • Have students match a description or representative picture to a word.

Ideas	Examples
Have students watch a dramatization or have them act out the vocabulary term.	Watch a video of the circulatory, nervous, or respiratory system. Act out a body system (circulatory, nervous, or respiratory).

[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

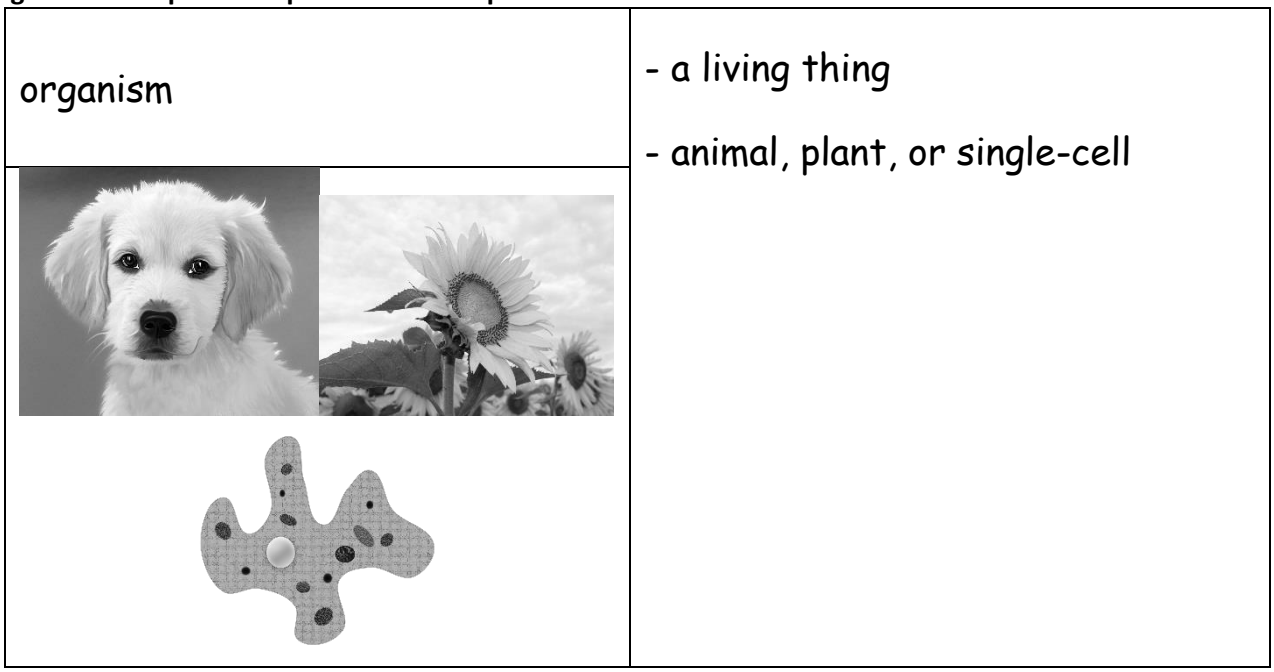
Vocabulary Example

Use a concept map, a graphic organizer that depicts graphics representing the vocabulary word and descriptive characteristics, to build student understanding (see

Figure 1). Educators may need to support, modify, or adapt steps as needed for individual students. For example, choose a picture to represent the word rather than drawing, choose descriptions from multiple options, etc. 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 Concept Definition Map



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/

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

Cells (elementary) – All living things are made of cells that perform functions necessary for life.

Content:

- Plants and animals have internal and external structures that serve specific functions.
- Plants and animals are living organisms.
- All organisms are composed of cells.
- Cells are building blocks of all organisms.
- Plant cells and animal cells have:
  - similar and different structures and
  - each serves a specialized function.

Heredity – Plants and animal reproduce.

Content:

- Plants and animals change as they develop and grow (life cycle).
  - Plants and animals have common life cycles (birth, growth, reproduction, death).
  - Plants and animals have unique and diverse life cycles that include being born (sprouting in plants), growing, developing into adults, reproducing, and eventually dying.
- Plants and animals:
  - reproduce in maturity and
  - reproduce for the continuation of the species.
- All living things can be characterized by common aspects of their structure and functioning.

Cells (middle)

Content:

- Major plant cells and animal cells have organelles; each serves a specific function.
- Different types of cells serve specialized functions.
- The cell membrane forms the boundary that controls what enters and leaves the cell.
- There is a relationship among cells, tissues, organs, and organ systems.
- Organ systems interact with each other (needed for survival and growth of an organism).
- Molecules pass through cell membranes (e.g., diffusion and osmosis).
- Recognize hierarchy in relative sizes, ranging from molecules to organisms.

Unit Content Resources:

- Interactive Sites for Education provides a wide variety of topics that include interactive animations. http://interactivesites.weebly.com/science.html
- Better Lesson provides science lesson plans for all grades. https://betterlesson.com/next_gen_science/
- These sites provide diffusion explanations:
  - http://astrocampschool.org/diffusion/
  - http://faculty.southwest.tn.edu/rburkett/GB1-osmosis.htm (has good graphics)
  - http://www.biologycorner.com/bio1/notes_diffusion.html
- Khan academy – explains solvent, solute, solution; diffusion https://www.khanacademy.org/science/biology/membranes-and-transport/diffusion-and-osmosis/v/diffusion-and-osmosis
- Cells:
  - cell structure: http://www.biology4kids.com/files/cell_main.html
  - cell video: https://www.brainpop.com/health/bodysystems/cells/
  - cell images: https://www.brainpop.com/make-a-map/?topic=/health/bodysystems/cells/
  - cell organization: http://www.scsc.k12.in.us/SMS/Teachers/Martin/replacelevelsoforganization.htm
  - cell structure and function with images: http://www.biologyjunction.com/cell_functions.htm
  - variety of information with images and videos about cells, their size and scale, and how they communicate information. http://learn.genetics.utah.edu/content/cells/
  - variety of interactive models and games. http://www.cellsalive.com/
- PBS Learning Media offers an interactive microscope activity that teaches the parts of a microscope, how to use it, and provides viewing of a variety of specimens. http://www.pbslearningmedia.org/resource/f4f6097a-807f-4488-b874-0bae0d8446c8/microscope-activity/en/

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:

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).	Provide a tactile version of parent animals and their offspring. Have students match the parent to its offspring. **V** Build models of digestive system, backbone and spinal cord, etc. See http://www.perkinselearning.org/accessible-science/activities/life-science for ideas. **V**
Model content through pictures, dramatization, videos, etc.	Have students observe diffusion by adding a colored liquid to water and watching a video or animation of diffusion. **H/P** Have students explore a cell by creating a room-size cell (e.g., http://www.perkinselearning.org/accessible-science/cell-activity-room-cell). **V**
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 **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (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). **V/H/P**
Provide appropriate and accessible text on the content for students to listen to or read.	Paraphrase information from a textbook on large sticky notes. Place the sticky note over the original text, leaving the graphics. 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**
Teach information using songs.	The Plant Song by Kendle White: https://www.youtube.com/watch?v=0dsmAu764nc Plant Parts put to a song: http://www.perkinselearning.org/accessible-science/plant-parts-put-song

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

Multiple Means of Action and Expression	
Strategies	**Examples**
Use assistive technology to allow the student to interact with the instructional materials and content.	Create a narrated slide show using simple text and pictures and have students use a single switch to advance slides. **P** Provide a USB microscope. **V/P** Set up an adaptive keyboard or a computer access switch to allow the student to record data. **P** Create a graph using hook and loop tape and small blocks to use when graphing. **V/P**
Present instructional materials in a manner that provides access.	Place printed text and pictures on a slant board. **V/P** Make a template of a cell and cell parts with hook and loop tape or magnets. Place the template and the cell parts within students' range of motion and have the student assemble a model of a cell. **V/P** Have students create and explore three-dimensional models. **V** Provide a USB microscope that transfers the image to the computer screen or an online microscope activity (e.g., http://www.pbslearningmedia.org/resource/f4f6097a-807f-4488-b874-0bae0d8446c8/microscope-activity/en/). **V/P**
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. **P** 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. **V/P**
Provide simulation activities.	Have students work through a simulation of diffusion. **H/P** Provide a simulation of the cells forming tissues, tissues forming organs, and organs forming organ systems using connecting blocks. Sign all conversations and decisions. **H**
Create a digital graphic organizer that allows drag and drop.	Have students drag and drop pictures of offspring next to the parent. Use a screen reader and an adapted mouse. **P**

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

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule and visual timer.	Provide a schedule with tangible symbols. Have students select the next activity on the schedule and set the visual timer to indicate how long the student has before a break.
Vary the challenge and amount of information presented at a time.	Begin with matching very similar parent plants and animals to their offspring. After the students are familiar with this concept, have them match parents and offspring that have more differences. Increasingly provide more information about how traits are passed from parent to offspring.
Make connections to topics or activities that are motivating.	Use the computer, P.E., recess, etc., to explore science concepts. For example, have students watch an animation of the circulatory system on the computer, act as a blood cell moving through the circulatory system in P.E. class, or observe their heart beating after running on the playground.
Allow choices as possible.	Allow students to choose whether to look at/listen to a book or watch a video about cells during independent work time.
Provide opportunities to work collaboratively with peers.	Provide opportunities for students to work in a general education classroom with peers when learning about life cycles or have peer tutors come into the special education classroom to work on a project about life cycles.
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately.

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 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

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

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).	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	Provide information through reading books and articles on science concepts while working on reading comprehension.	Provide practice on communication skills when students are answering questions about the book or article.
Mathematics	Teach measuring and graphing during investigations.	Provide practice on number identification, sequence, relative quantity or size (e.g., which is more?).
Age-Appropriate Social Skills	Make connections between the Connecting Concepts and real-life experiences showing how they can help students make decisions (e.g., understanding they are part of a larger system and play an important role in the system/community).	Provide opportunities to work along same age peers to practice age appropriate social skills and serve a vital role in the group.
Independent Work Behaviors	Encourage and reinforce independent completion of tasks to build independent work skills.	Use positive behavior supports to encourage and reinforce independent work skills.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers and adults when working on the content.	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 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 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 tactilely.
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

References

National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Joint Project of the Braille Authority of North America and the Canadian Braille Authority L'Autorite Canadienne du Braille. (n.d.). *Guidelines and Standards for Tactile Graphics, 2010.* Retrieved February 19, 2014, from Braille Authority of North America: http://www.brailleauthority.org/tg.

CAST (2011). *Universal Design for Learning Guidelines version 2.0.* Wakefield, MA.

Marzano, R. J. (2004). *Building Background Knowledge for Academic Achievement*. Alexandria: ASCD.

Sprenger, M. (2013). *Teaching the Critical Vocabulary of the Common Core*. Alexandria: ASCD.

Picture Citations

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