Science

Module 10

High School Biology I – Life Science: Structure and Function/Growth and Development

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:

- Structure and Function (High school)—All living organisms are made of cells and can be characterized by common aspects of their structure and functioning. Living things have characteristics (e.g., maintain internal environment through homeostasis, respond to changes in the environment, reproduce and pass genetic information to their offspring). Viruses appear to share some of these characteristics. However, viruses are considered to be nonliving because viruses are not cells, do not respond to the environment, and do not use energy to grow and develop. The cells of all living organisms contain genetic information in the form of DNA. DNA molecules contain the genetic information that controls inherited traits. Genes are sections of DNA that contain instructions to code for the formation of proteins that control inherited traits. When new cells are formed, DNA replicates, forming two identical daughter cells.
- Growth and Development (High school)—In multicellular organisms, cell division is an essential component of growth, development, and repair. Cell division occurs via a process called mitosis. When a cell divides in two, it passes identical genetic material to two daughter cells. Successive divisions produce many cells. The process is repeated as new cells are needed to replace old cells or to support growth of the organism.

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 High School Biology I – Life Science: Structure and Function/Growth and Development and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

I. Tennessee Academic Standards for Science and Related Knowledge and Skills Statements and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;
III. Crosscutting Concepts;
IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;

V. Overview of Units' Content;
VI. Universal Design for Learning (UDL) Suggestions;
VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
VIII. Tactile Maps and Graphics.

Section I

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

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

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

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

Academic Standard	Knowledge and Skill Statement (KSS)	Underlying Concept (UC) of the Academic Standard
Structure and Function (High School)		
BIO1.LS1.1: Compare and contrast existing models, identify patterns, and use structural and functional evidence to analyze the characteristics of life. Engage in argument about the designation of viruses as non-living based on these characteristics.	**BIO1.LS1.1.a:** Ability to identify characteristics of living things (i.e., respond to environmental stimuli, actively maintain internal environment through homeostasis, and transfer genetic information to their offspring) **BIO1.LS1.1.b:** Ability to identify characteristics of a virus which cause it to be considered a nonliving particle (e.g., does not use energy to grow; does not respond to the environment; cannot make food, take in food, or produce wastes; and cannot replicate its own DNA)	**BIO1.LS1.1.UC:** Recognize that organisms that grow and reproduce are living things.
BIO1.LS1.3: Integrate evidence to develop a structural model of a DNA molecule. Using the model, develop and communicate an explanation for how DNA serves as a template for self-replication	**BIO1.LS1.3.a:** Ability to recognize that genetic information in chromosomes is contained in molecules of DNA **BIO1.LS1.3.b:** Ability to use a model to demonstrate that when DNA replicates, it results in two identical strands of DNA that are exact copies of the original	**BIO1.LS1.3.UC:** Understand that inherited traits of individuals are controlled by genes (i.e., sections of DNA).

and encodes biological information.	**BIO1.LS1.3.c:** Ability to recognize that sections of DNA code for the production of proteins that control inherited traits	
Growth and Development (High School)		
BIO1.LS1.6: Create a model for the major events of the eukaryotic cell cycle, including mitosis. Compare and contrast the rates of cell division in various eukaryotic cell types in multi-cellular organisms.	**BIO1.LS1.6.a:** Ability to identify mitosis as the type of cell division where one cell divides to produce two new identical cells **BIO1.LS1.6.b:** Ability to identify the cell cycle as a regular sequence of growth and division which cells undergo **BIO1.LS1.6.c:** Ability to recognize that the time it takes different cells to complete one cell cycle is different depending on the cell type	**BIO1.LS1.6.UC:** Understand that the human body is constantly replacing old cells with new ones.

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

Section II

Scientific Inquiry and Engineering Design

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

- Asking questions (for science) and defining problems (for engineering).
  Examples: How are characteristics from one generation related to the previous generation? How do the structures of organisms enable life's functions? Why aren't all elephants the same size? Farmers want to spray an herbicide on their crops to kill weeds, but not the crops. Can the DNA of the plant be altered to make it herbicide-resistant? How is society influenced by science and technology (e.g., the bioethics and economics of genetically modified foods)?

- Developing and using models.
  Examples: Use a model based on evidence to illustrate the role of cellular division (mitosis). Evaluate the merits and limitations of two different models of the process of mitosis. Use a model based on evidence to illustrate the relationships between DNA, genes, and proteins in controlling inherited traits. Students might demonstrate that all cells in an organism have the same genetic content by using paper models, manipulatives, or computer simulations to simulate DNA replication.

- Planning and carrying out investigations.
  Examples: Collaboratively plan and conduct an investigation to produce data to serve as the basis for evidence that a plant is living. Conduct an investigation to observe the process of cell multiplication (i.e., mitosis) using garlic or onion roots. Investigate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

- Analyzing and interpreting data.
  Examples: Interpret data collected on viruses to determine if they are living or nonliving. Use data to illustrate the multiplication of cells. Analyze data in m*odels that show the number of cells at different stages of development.*

- Using mathematics and computational thinking.
  Example: Data could be collected from observing the different stages of mitosis using a microscope or virtual or computer simulations. Graphs and functions could be used to show growth rate in terms of cell division. Interpret data related to homeostasis (e.g., the concentration of sugar in an animal's blood three hours after being fed a strong sugar solution).

- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Make a qualitative claim about the relationship between a person's internal processes and external environmental factors. Construct and revise an explanation of how the human body continually replaces old cells with new ones. Support explanations about the relationship between

the role of DNA and chromosomes in coding instructions for characteristic traits passed from parents to offspring. Create a situation in which a character is under a stressful situation. Develop solutions or activities to reduce the character's stress and a plan to monitor successes and setbacks.

- Engaging in argument from evidence.
  Examples: Make and defend a claim based on evidence of how feedback mechanisms allow an animal to remain alive even as external conditions change within some range. Use reasoning to explain why the ability of organisms to reproduce offspring is the best characteristic to distinguish living things from nonliving matter on a cellular basis. Evaluate the evidence behind currently accepted explanations that genes are regions in DNA that contain instructions that code for the formation of proteins.

- Obtaining, evaluating, and communicating information.
  Examples: Critically read scientific text adapted for classroom use to determine central ideas of homeostasis and summarize the process in simpler, but accurate terms. Compare information from different sources regarding the status of viruses as living or nonliving and present the evidence for both. Communicate scientific information about the effectiveness of modifying the DNA of organisms in order to prevent a problem such as cystic fibrosis.

Science Practices Resources[2]

- Safety in the Elementary Science Classroom provides safety information for teachers and students. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/safetypractices/safety-in-the-elementary-school-science-classroom.pdf
- This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. http://www.justsciencenow.com/inquiry/
- Education.com provides a variety of life science activities and experiments. http://www.education.com/activity/life-science/

Section III

Crosscutting Concepts

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

Crosscutting Concepts are a common link between multiple standards and units of study. The Crosscutting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. Life sciences focus on patterns, processes, and relationships of living organisms. For example, understanding patterns of change is a Crosscutting Concept that applies to similarities in the traits of a parent and the traits of an offspring, the relationships between DNA and inherited traits, and the patterns of interactions that occur between organisms and their environments. Some Crosscutting Concepts may apply across multiple content areas and instructional emphases (e.g., cause and effect in reading science texts). The Crosscutting Concepts of stability and change provide a framework for understanding how our bodies maintain an internal environment when the external environment changes.

This content module, High School Biology I – Life Science: Structure and Function/Growth and Development, addresses characteristics of living things, how genetic information is controlled and passed to offspring, and the process of cell division.

Teaching Crosscutting Concepts

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

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

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

Patterns

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena (e.g., base pair of DNA).
- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced, thus requiring improved investigations and experiments (e.g., classification based on DNA comparisons versus those based on visible characteristics).
- Patterns of interactions of organisms with their environments, both living and nonliving, may be observed.

Causality

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects (e.g., Genes correlate with diseases such as diabetes but do not cause them.).
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system (e.g., understand how feedback mechanisms maintain a living system's internal conditions).

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal the systems' or structures' function and/or solve a problem. (e.g., Identifying the characteristics of living things helps in determining life in other organisms or materials. Studying DNA is vital to understanding its function and finding ways to prevent diseases.).

Systems

Systems and System Models

- Models (e.g., physical, mathematical, computer) can be used to simulate systems and—including energy, matter, and information flows—within and between systems at different scales (e.g., computer models showing the sequence of cell division).

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system (e.g., maintaining internal environment through homeostasis. Genetic programs modified over generations result in a different trait that helps an animal survive better in its environment).

Crosscutting Concept Resources

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

Section IV

Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., living things) and in the context of the specific content (e.g., Teach the terms "grow," "reproduce," and "homeostasis" while students determine if something is living or nonliving.).

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 "model" helps students to connect to models in life science, physical science, and Earth and space science. The second type, **specific content words**, represents groups of words that are associated with an organism, system, process, or phenomena. For example, the specific word "DNA" connects to the general words "characteristics," "traits," and "division" when learning about how living things grow and reproduce. Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Organisms inherit alleles from their parents. That is why most organisms look a little like both parents.) and an example of the word (e.g., One human trait that is controlled by a gene with multiple alleles is blood type.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., Mitosis is a type of cell division where the cell divides into two identical cells.) and a possible connection to a general vocabulary word (e.g., Mitosis helps organisms grow.).

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 characteristics of inherited traits instead of giving a formal definition.

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., Stimuli cause something to happen. *Example: Exercise and heat are stimuli that makes you sweat.).*		
• cell	• food	• organism
• characteristics	• grow/growth	• reproduce
• copies	• identical	• response
• develop/development	• inherited	• stimuli
• divide	• internal	• strand
• division	• living	• traits
• energy	• model	• virus
• environment/environmental	• nonliving	• waste
• external	• offspring	

Table 3. Specific Content Words

Specific Content Words—words that specify a particular thing (e.g., sedimentary rock) or phenomena (e.g., biodiversity). Describe the word and when possible make the connection to a Crosscutting Concept (e.g., A cell cycle is when a cell divides to make two new cells. The cell cycle is a cause and effect relationship showing how mechanisms within a system affect the more complex system.).		
• abiotic	• daughter cell	• mitosis
• allele	• DNA	• natural selection
• biotic	• gene	• proteins
• cell cycle	• genetic information	• replication
• chromosome	• genetic variation/mutation	• sex cells
• cytoplasm	• homeostasis	

Ideas to Support Vocabulary Learning

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

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)[1]

Ideas	Examples
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	• Provide a description and an example of a characteristic, "A characteristic is a distinctive feature of a person or thing. Red hair is one characteristic she has that is different from her brother."
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 "offspring." Help students make connections that they are offspring of their parents.
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	Have students create a "fake" social media post which describes a vocabulary term using an online site (e.g., https://www.classtools.net/) or create a paper version (see Figure 1 • Figure 1). [Individualization idea: Provide students with phrases and short sentences to choose from to create their post.] • Have students sort pictures of organisms or objects into categories: living or nonliving, reproduce or do not reproduce, grow or do not grow, etc.
Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, but rather distributed trials in different ways or contexts. Reference http://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	• Read books or watch videos related to the vocabulary and concepts. (e.g., mitosis: https://www.youtube.com/watch?v=f-ldPgEfAHI). • Have students access online texts about mitosis (e.g., http://www.biology4kids.com/files/cell2_mitosis.html). [Individualization idea: Have students use a screen reader to access the text.] • Create a word wall with vocabulary terms and pair with images.
Ask students to discuss the vocabulary words with each other.	• Have students share a favorite word and explain why. [Individualization idea: Place a description of a few vocabulary words on a voice output device and have the student choose which one to share with a classmate using an adapted switch.] • Have students share their representations (e.g., drawings or pictures) of a vocabulary word with each other.

Ideas	Examples
Play vocabulary word games with students.	• Present groups of four words. In each group include three words that relate to each other and one that does not (e.g., offspring, trait, characteristic, rotate). Have students pick the one that does not belong.
Have students watch a dramatization or have them act out the vocabulary term.	• Have students solve a mystery by using clues to determine if something is living or nonliving (e.g., https://www.uen.org/lessonplan/view/28279). • Have students use or observe hand movements to show the mitosis (e.g., https://www.youtube.com/watch?v=5Xlg_AMyHWo or https://www.youtube.com/watch?v=khoYx5BgT18).

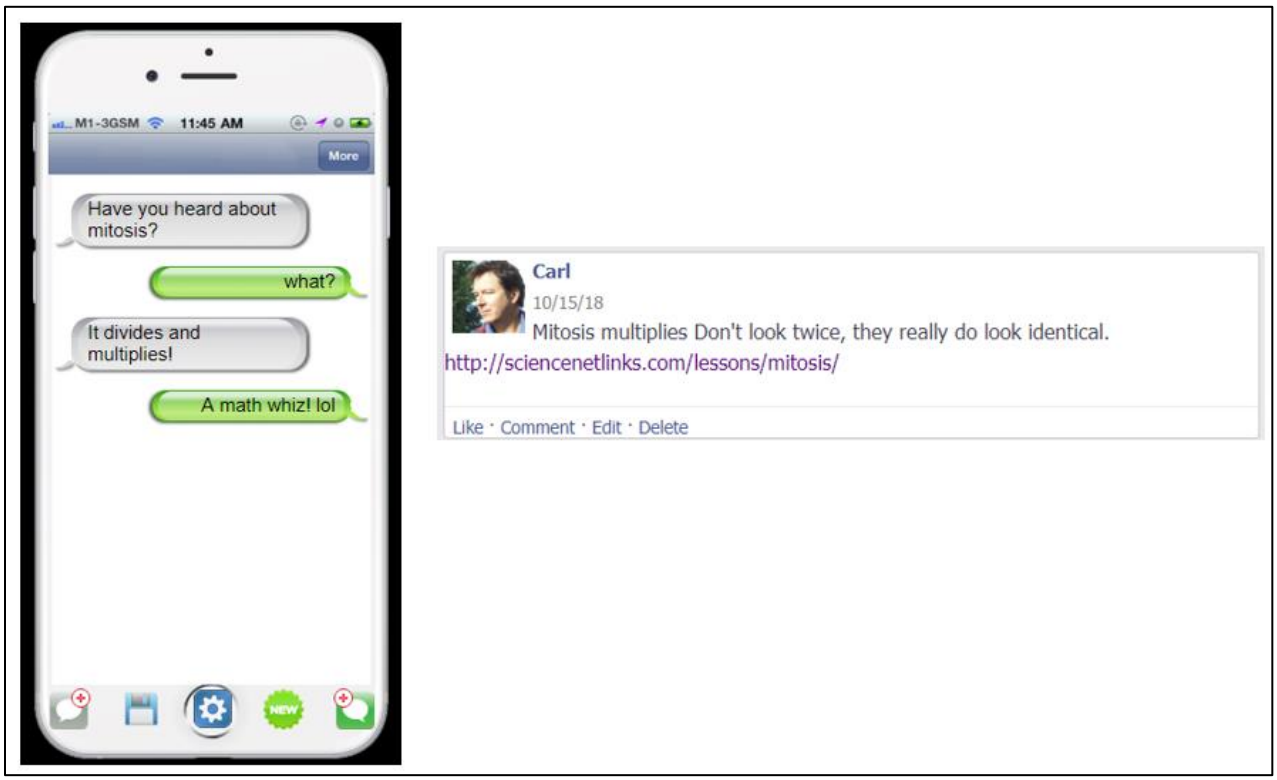
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students create a social media post which describes a vocabulary term using an online site (e.g., https://www.classtools.net/) or create a paper version (see Figure 1). [Individualization idea: Provide students with phrases and short sentences to choose from for the post.] 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 Social Media Vocabulary Activities



Vocabulary Resources

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

Section V

Overview of Units' Content

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

Structure and Function

Content

- Characteristics of living things include:
  - made of one or many cells,
  - maintain internal environment through homeostasis,
  - use energy (metabolism),
  - grow and develop,
  - respond to changes in the environment,
  - feedback mechanisms maintain internal conditions within certain limits,
  - eliminate waste, and
  - reproduce and pass genetic information to their offspring.
- Viruses are nonliving particles and cannot:
  - use energy to grow,
  - respond to the environment,
  - make food,
  - take in food,
  - produce waste, or
  - replicate their own DNA.
- All cells contain genetic information in the form of DNA molecules.
- Traits are distinguishing features or characteristics each person has.
- Inherited traits of individuals are controlled by genes.
- Genes are specific segments of DNA.
- The gene segment of DNA contains instructions that tell the cell how to make a particular protein.
- Proteins specify inherited traits.
- Proteins carry out most of the work of cells.
- Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.
- DNA replication occurs when a double-stranded DNA molecule is copied to make two identical DNA molecules.
- The two identical DNA molecules are exact copies of the original.
- Models can demonstrate DNA replication.

Growth and Development

Content

- Cells make up all living organisms.
- All cells in an organism have the same genetic content.
- The human body is constantly replacing old cells with new ones.
- The regular sequence of growth and division that cells undergo is known as the cell cycle.
- The cell cycle is a regular sequence of growth and division the cells undergo:
    - The cell grows to its mature size, makes a copy of its DNA, and prepares to divide into two cells.
    - One copy of the DNA is distributed into each of the two daughter cells.
    - The cytoplasm divides, distributing the organelles into each of the two new cells.
- Each daughter cell repeats the process, creating more cells.
- Cells pass identical genetic material in the form of homologous chromosome pairs to both daughter cells.
- Mitosis is a type of cell division in which one cell's nucleus divides to produce two new identical cells.
- Mitosis is mostly used for growth and to replace old cells.
- In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow.
- The cell type determines how long it takes for a cell to complete one cell cycle.
- Models can be used to illustrate cell division and multiplication (e.g., pipe cleaners to represent the position of chromosomes at different stages of mitosis).

Unit Content Resources

- Interactive Sites for Education provides a wide variety of topics that include interactive animations. http://interactivesites.weebly.com/science.html

Characteristics of Living Things

- This site has information on the characteristics of life. http://spot.pcc.edu/~jvolpe/b/bi112/lec/examples/112examplesCh1_Ch3.htm
- This site includes a lesson plan on characteristics of living things. http://annex.exploratorium.edu/imaging_station/activities/classroom/characteristics/ca_characteristics.php
- This site has information on characteristics of living things including pictures and videos. https://kidsbiology.com/biology-basics/living-things/
- Science Learning Hub has information and an activity on characteristics of living and nonliving thing. https://www.sciencelearn.org.nz/resources/14-characteristics-of-living-things
- Khan Academy provides information on signs of life and viruses. https://www.khanacademy.org/test-prep/mcat/cells/viruses/a/are-viruses-dead-or-alive

DNA

- Scientific American has an article on how traits are passed on through DNA. https://www.scientificamerican.com/article/how-are-traits-passed-on/
- Scitable has information on DNA replicating. https://www.nature.com/scitable/topicpage/cells-can-replicate-their-dna-precisely-6524830
- This site has animations and other materials about DNA and genes. https://geneed.nlm.nih.gov/topic_subtopic.php?tid=15
- Ducksters has information on DNA and genes. https://www.ducksters.com/science/biology/dna.php
- Science NetLinks has a lesson plan on DNA and genetics. http://sciencenetlinks.com/lessons/cell-dna/
- Owlcation has information on DNA for kids. https://owlcation.com/academia/explaining-dna-to-a-six-year-old
- This site has multiple links related to basic genetics. https://learn.genetics.utah.edu/content/basics/

Cell Cycle (Mitosis)

- This site provides information on cell growth and division, including images, a time-lapse video, and models. https://askabiologist.asu.edu/content/cell-division
- This site provides the big idea of mitosis. https://www.reference.com/science/mitosis-occur-4d6fe937748de4ca?qo=contentSimilarQuestions
- This site provides information on mitosis. http://www.yourgenome.org/facts/what-is-mitosis
- Science-Class has a variety of resources for teaching cell division. http://science-class.net/archive/science-class/Biology/Cell_Division.htm
- Khan Academy provides information on cell cycles and mitosis. https://www.khanacademy.org/science/biology/cellular-molecular-biology/mitosis/a/cell-cycle-phases
- This site has a lesson plan on teaching mitosis. https://www.biologycorner.com/2009/09/27/teaching-mitosis/
- This site has a mini lesson on mitosis. http://www.indiana.edu/~ensiweb/lessons/gen.mm.html
- CPALMS has a lesson plan on mitosis. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/75954
- This site has a lesson plan on cell division. https://www.ngsslifescience.com/science.php?/biology/lessonplans/C396/

Section VI

Universal Design for Learning (UDL) Suggestions

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

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

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

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

Multiple Means of Representation	
Strategies	**Examples**
Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Involve the students in extracting DNA from food (e.g., https://learn.genetics.utah.edu/content/labs/extraction/howto/). [Individualization idea: Provide students with a model of measurements (e.g., line drawing of a measuring cup with an arrow pointing to ½-cup mark). Have students use an adapted switch to operate the blender.] **P** Listen to a podcast on viruses being nonliving things (e.g., https://medium.com/the-philipendium/is-a-virus-a-living-creature-8664a9496ece). [Individualization idea: Preview the podcast and give students key words, phrases, or concepts to listen for during the podcast. Ask students questions after listening to the podcast and share key ideas (e.g., viruses are nonliving because . . .).] Share a video on proteins (e.g., https://learn.genetics.utah.edu/content/basics/proteins/). Share an animation of mitosis (e.g., http://www.johnkyrk.com /mitosis.html). Involve students in creating and exploring a tactile model of mitosis (e.g., http://www.perkinselearning.org/accessible-science/activities/mitosis-student-built-model).
Model content through pictures, dramatization, videos, etc.	Show videos on: • characteristics of living things (e.g., https://www.youtube.com/watch?v=30qOijVBS7o or https://www.youtube.com/watch?v=cQPVXrV0GNA), • DNA (e.g., https://www.youtube.com/watch?v=IN8pKyQz2RQ) and • DNA replication (e.g., https://www.youtube.com/watch/?v=5qSrmeiWsuc). [Individualization idea: Sign a summary of the video before watching, sign the narration while watching, and sign the key concepts after watching the video.] **H** Create a DNA model (e.g., https://www.wikihow.com/Make-a-Model-of-DNA-Using-Common-Materials). [Individualization idea: Use jumbo pipe cleaners and larger beads. **P** Use four different textured beads to differentiate the nitrogen bases found in DNA. **V**]
Present information using graphic organizers and models.	Use a KWHL to help students make connections between what they already **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (Here's a slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** Use an extended version of the KWHL: What do I **K**now? What do I **W**ant to know about or wonder about (e.g., a phenomena)? **H**ow will I find out (e.g., determine how to organize investigations)? What have I

Multiple Means of Representation	
Strategies	**Examples**
	Learned? What **A**ction will I take (e.g., share with others, apply to daily life, etc.)? What new **Q**uestions do I have? More information can be found at http://langwitches.org/blog/2015/06/12/an-update-to-the-upgraded-kwl-for-the-21st-century/. [Individualization idea: Use strategies for the KWHL chart for accessibility ideas: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf.] Create and share a flowchart model of mitosis (e.g., http://dailyrevshare.com/mitosis-and-meiosis-flow-chart/mitosis-and-meiosis-flow-chart-awesome-mitosis-and-meiosis/). Create a wall chart to display evidence that something is living or nonliving (e.g., https://www.biologycorner.com/worksheets/martian.html). [Individualization idea: Provide students with prewritten evidence that they can attach to the wall chart.] **P**
Provide appropriate and accessible text on the content for students to listen to or read.	Provide an article or textbook pages on characteristics of living things, DNA replication, or mitosis. [Individualization idea: Paraphrase the information from the article on a large sticky note and place over the original text. Keep any graphics visible.] Provide online books that have an embedded text reader (e.g., http://bookbuilder.cast.org/view.php?op=view&book=8880&page=1 *(requires free account)*) or create book(s) on the unit topics (e.g., http://bookbuilder.cast.org/). [Individualization idea: Have students use an adapted mouse to turn the pages of the online book.] **P** Provide an online article about genes, DNA, and proteins that has a screen reader and text size options (e.g., https://kidshealth.org/en/kids/what-is-gene.html).
Teach information using songs, poems, or rhymes.	Use an acronym to learn the characteristics of living things (e.g., https://www.sciencealert.com/are-viruses-alive). Play songs about mitosis (e.g., https://www.youtube.com/watch?v=f7Dmhfo7XXA or https://www.youtube.com/watch?v=pOsAbTi9tHw). [Individualization idea: Only sing the chorus (or key words) and add motions to the words.]

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

Multiple Means of Action and Expression	
Strategies	**Examples**
Use technology/assistive technology to optimize student access and interaction with the instructional materials and content.	Have students complete an online interactive activity demonstrating mitosis (e.g., https://biomanbio.com/HTML5GamesandLabs/Genegames/mitosismoverpage.html or http://www.mhhe.com/biosci/genbio/virtual_labs_2K8/labs/BL_03/index.html). [Individualization idea: Read text to students and provide any support needed to answer questions. Have students perform the tasks using an adapted mouse. **P**] Have students read an online article about viruses (e.g., https://www.sciencedaily.com/terms/virus.htm). [Individualization idea: Have students use a screen reader. **V** Summarize the text using an online program (e.g., http://textsummarization.net/text-summarizer or https://www.splitbrain.org/services/ots).] Have students read online text about mitosis with a built-in screen reader (e.g., http://bookbuilder.cast.org/view.php?op=view&book=29902&page=1).
Allow for instructional materials that can be modified to provide access.	Place printed text and pictures on a slant board. **V/P** Research characteristics of living things and complete a checklist to determine if things are living or nonliving. [Individualization idea: Provide links to key information on a visual bookmarking board (e.g., https://www.educatorstechnology.com/2017/05/10-good-bookmarking-tools-for-teachers.html). Provide a checklist with images for each characteristic for students to use in determining if something is living or nonliving. Allow students to use a stamp to select living or nonliving. **P**] Provide students with multiple ways to demonstrate understanding of DNA replication (e.g., pointing to stages on a model and explaining, putting a model together, answering yes/no questions, etc.). [Individualization idea: Have students sign answers. **H** Provide a tactile model. **V**]
Provide multiple means for students to make choices and select answers.	Have student dictate answers. [Individualization idea: Place answer options in the student's AAC device or on multi-select voice output switch.] **P** Provide answer choices. [Individualization idea: Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then choose their answer.] **V/P** Allow multiple ways to indicate an answer when working with paper materials. [Individualization idea: Allow student to select answer using touch, large pencil grip, paper stabilizer, eye gaze board, etc.] **P**
Provide simulation activities.	Help students create a simulation of a cell cycle by creating a flip book (e.g., http://www.hannasd.org/cms/lib2/PA01001586/Centricity/Domain/662/Mitosis-Simulation-Activitystudent.pdf). [Individualization idea: Print the templates on card stock paper to make cutting easier. Take

Multiple Means of Action and Expression	
Strategies	**Examples**
	a picture of each completed page of the flip book and insert each on a separate slide in a slide presentation (e.g., Microsoft PowerPoint, Google slides, etc.). Allow a student to use an adapted switch to move through the presentation.] **P**
Provide graphic organizers and templates.	Help students create a classroom graphic showing characteristics of living things (e.g., slide 4 in https://www.slideshare.net/kyle_kauffman/characteristics-of-life-66274211). [Individualization idea: Provide preprinted names, descriptions, and pictures for students to use to complete the graphic organizer. Provide a model for students to use as they complete the graphic organizer.] Have students create a DNA replication foldable (e.g., https://www.youtube.com/watch?v=AEYUQ2sCCRI).

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

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule.	Provide personal schedules 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. Use a first-then schedule (e.g., https://www.autismclassroomresources.com/visual-schedule-series-first-then/). Provide a checklist of tasks to complete in a particular order. [Individualization idea: Place words paired with pictures on a sheet with a "To Do" column and a "Finished" column using hook and loop tape.]
Vary the challenge and amount of information presented at a time.	Chunk the information provided to the student in five-minute intervals or less. Address the big ideas first (e.g., people grow and reproduce, and they are living). Then, expand on the characteristics of people as living. Next, apply the characteristics to animals and plants. Continue to stress the big idea throughout. [Individualization idea: Have students sort living and nonliving things as you introduce the information.]
Make connections to topics or activities that are motivating.	Watch a video that relates DNA enzymes to video game characters (e.g., https://www.youtube.com/watch/?v=5qSrmeiWsuc). Make the connection between living things or cell division and a student's favorite animal.
Allow choices as possible.	Allow students to choose where to sit and options of types of seats (e.g., stool, exercise ball, etc.).
Provide opportunities to work collaboratively with peers.	Provide opportunities for students to work in a general education classroom with peers when learning about unit topics or have peer tutors come into the special education classroom to work on a project about DNA. Have students work in cooperative groups with mixed abilities. [Individualization ideas: Present instructions and group expectations using a task checklist and group rules. Develop and read a social story (e.g., http://www.pbisworld.com/tier-2/social-stories/) about working in a group to the student. Provide the student with the necessary communication tools to participate in the group activity. Assign specific pieces of the task to each student.]
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately. Provide students with stress balls, finger fidgets, etc. Teach students how to self-reflect on their performance using scaffolding.

UDL Resources

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

Section VII

Transference and Generalization of Concepts, Knowledge, and Skills

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

Table 8. Transfer and Generalization Ideas

Area	Instruction	Opportunity to Embed Skills
Communication	When students are engaging in Scientific Inquiry and Engineering Design practices (see Section II), help students make the connections between analyzing and interpreting data and understanding data in real-world situations (e.g., favorite sports team data).	Work on communication skills (e.g., speaking in complete sentences, using AAC system, asking questions) during science instruction.
Reading and Listening Comprehension	Expose students to a variety of information sources on unit topics (e.g., online information, text books, magazines) and provide students access (e.g., screen reader).	While reading or accessing online information, have students work on fine motor skills (e.g., turning pages of the book, pointing to pictures in the text, operating the computer mouse).
Mathematics	Teach coding patterns during DNA instruction. Make sense of quantities and relationships to describe and predict the variation and distribution of expressed traits in a population. Use data to calculate the percent of offspring that have a given trait.	Provide practice on number identification and general number sense.
Age-Appropriate Social Skills	Make connections between the Crosscutting Concepts (e.g., cause and effect) and real-life experiences (e.g., student sweats during exercise).	Practice social skills (e.g., taking turns, listening to others, actively participating in discussion or conversation) while working with peers in a small group.
Independent Work Behaviors	Encourage and reinforce independent completion of tasks to build independent work skills.	Use this time to have the student work on following task completion checklists independently.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers and adults when researching information on the characteristics of living things.	Use this time to have the student work on behavior and communication skills.

Section VIII

Tactile Maps and Graphics

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

Importance of Tactile Maps and Graphics

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

Tactile Graphic Guidance

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

Specific Graphic Type Guidance

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

Graphic Organizers/Concept Maps

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

Diagrams/Models

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

Timelines

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

Maps

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

Creating Tactile Graphics

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

Commercial products:

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

Textured shapes can be made from:

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

Raised lines can be made from:

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

Resources

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

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Picture Citations

Fakebook post created using https://www.classtools.net/FB/home-page
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[2] All resources provided for this module only. Mention does not imply endorsement, recommendation, or approval by the Tennessee Department of Education.

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