Science
Module 6

Physical Science: Structure of Matter

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:

- Matter and Its Interactions (elementary)—Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter of any type can be subdivided into particles that are too small to see, even though the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (e.g., sugar in solution, evaporation in a closed container). Measurements of a variety of properties (e.g., hardness, reflectivity) can be used to identify particular materials. When two or more substances (a type of matter) are mixed, a new substance with different properties may occur.
- Matter and Its Interactions (middle)—Atoms form molecules that range in size from two to thousands of atoms. Pure substances are made from a single type of atom or molecule; each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. Many substances react chemically with other substances to form new substances with different properties. This change in properties results from the ways in which atoms from the original substances are combined and rearranged in the new substances. Even though the new substance has different properties from the reactants, the number of atoms remains the same. Solids, liquids, and gases have distinctive molecules, spacing, and motion. Temperature and pressure can result in a change in state of matter.

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

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

Academic Standards	Knowledge and Skills Statement (KSS)	Underlying Concept (UC) of the Academic Standard
Matter and Its Interactions (Elementary)		
3.PS1.1: Describe the properties of solids, liquids, and gases and identify that matter is made up of particles too small to be seen.	**3.PS1.1.a:** Ability to describe the different observable properties of solids, liquids, and gases	**3.PS1.1.UC:** Identify a material as a solid or liquid or gas.
	3.PS1.1.b: Ability to identify in a model (e.g., picture, diagram, drawing) that all matter can be broken down into smaller and smaller pieces until they are too small to be seen by human eyes	
3.PS1.3: Describe and compare the physical properties of matter including color, texture, shape, length, mass, temperature, volume, state, hardness, and flexibility.	**3.PS1.3.a:** Ability to describe materials by their observable properties	**3.PS1.3.UC:** Match materials with similar physical properties (e.g., color or shape).
	3.PS1.3.b: Ability to compare different kinds of materials by their observable properties	
5.PS1.1: Analyze and interpret data from observations and measurements of the physical properties of matter to explain phase changes between a solid, liquid, or gas.	**5.PS1.1.a:** Ability to identify the phase changes that occur between a solid, liquid, or gas using evidence provided from data	**5.PS1.1.UC:** Recognize that water may undergo a change in state from liquid to solid or from solid to liquid.
5.PS1.4: Evaluate the results of an experiment to determine whether the mixing of two or more substances result in a change of properties.	**5.PS1.4.a:** Ability to use evidence provided from data to identify the changes that occur when two or more substances are mixed	**5.PS1.4.UC:** Identify qualitative changes (e.g., color or clarity) which occur to water after being mixed with another substance.
Matter and Its Interactions (Middle)		
7.PS1.3: Classify matter as pure substances or mixtures based on composition.	**7.PS1.3.a:** Ability to identify models of pure substances or mixtures in situations with macroscopic objects (e.g., mixture of sand or rocks and pebbles, a container of one type of marbles)	**7.PS1.3.UC:** Identify members of a group of objects as all the same or different (e.g., a basket of produce being all apples versus a mixture of apples, bananas, and oranges).

7.PS1.4: Analyze and interpret chemical reactions to determine if the total number of atoms in the reactants and products support the Law of Conservation of Mass.	**7.PS1.4.a:** Ability to recognize that the total number of atoms in the reactants of a chemical reaction is equal to the total number of atoms in the product(s)	**7.PS1.4.UC:** Recognize that the total mass of a mixture is equal to the sum of the mass of the parts.
7.PS1.6: Create and interpret models of substances whose atoms represent the states of matter with respect to temperature and pressure.	**7.PS1.6.a:** Ability to use a particle representation in a rigid container to identify the effect of adding or removing thermal energy on particle motion and the state of a pure substance	**7.PS1.6.UC:** Recognize the arrangement or movement of particles in solids, liquids, and gases.
	7.PS1.6.b: Ability to use a particle representation in a rigid container to identify the effect of adding or removing pressure on particle motion and the state of a pure substance (i.e., gas)	

[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: What can we learn about the properties of matter through observation? How does temperature affect matter? What happens to water when it evaporates? The class needs to find a way to separate the water and the rocks in the classroom aquarium in order to clean it. Students generate questions such as, "Does matter still exist if you cannot see it?" At what temperature may the following change from liquid to solid (or other change)?
- Developing and using models.
  Examples: Use a model to build an understanding of matter at the particle level, evaporate salt water, dissolve sugar in water, and add air to expand a balloon. Develop a model showing effective means to filter sediment out of water. Use models to identify invisible forms of matter. Use the patterns observed in models to predict the behavior of particles whenever the pressure or temperature is increased or decreased.
- Planning and carrying out investigations.
  Examples: Conduct an investigation on a phenomenon such as mixing salt and water compared with mixing sand and water. Conduct an investigation to find a way to separate water and salt. Collect data during an investigation to determine if the weight of reactants before a chemical reaction is the same as the resulting product when in a closed system. Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility.
- Analyzing and interpreting data.
  Examples: Analyze data on properties before and after a chemical change. Analyze the data showing the mass of the reactants and the mass of the product created during a chemical change to determine if the mass is conserved or lost. Make macroscopic observations of matter or analyze data taken directly from samples of matter. Collect data by individual/small groups, and then compare to class results in histograms to answer scientific problems. Analyze data before and after a phase change.
- Using mathematics and computational thinking.

Examples: Measure the change in temperature when a chemical reaction has occurred (e.g., vinegar as it reacts to baking soda). (Emphasis should be on building student ability to make and compare measurements.) Examine the composition of the atmosphere as an example. Explore the question, "Does a balloon gain weight as you fill it?"

- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Explain how a chemical reaction activates a heat or cold pack. Using information from reliable sources, design a safe water filter. Make and use measurements to construct an explanation.
- Engaging in argument from evidence.
  Examples: Organize information about a variety of materials to categorize them by their physical properties. Use reasoning to connect the relevant and appropriate evidence and construct an argument that includes the idea that mixtures can be separated because the physical properties of the constituent parts remain unaltered. Present an argument based on using the mass of the individual reactants prior to the reaction and the mass of the final product as evidence for the argument that mass is conserved during chemical reactions. The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. Examples of transitions may include measuring the mass of a set amount of salt and a set amount of water, and then measuring the mass of the salt dissolved in the water.
- Obtaining, evaluating, and communicating information.
  Examples: Communicate the idea that while matter undergoing a physical change looks different, it is still the same (e.g., ice is still water). Express the understanding that a chemical change produces a new substance. Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.

Science Practices Resources[2]

- Safety in the Elementary Science Classroom provides safety information for teachers and students. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/safetypractices/safety-in-the-elementary-school-science-classroom.pdf
- This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. Each type provides a wide range of example lessons grouped by elementary and middle school. http://www.justsciencenow.com/inquiry/
- This site provides an animated model of states of matter. http://www.abpischools.org.uk/page/modules/solids-liquids-gases/slg2.cfm?coSiteNavigation_allTopic=1
- This site provides hands-on activities regarding chemical reactions. https://owlcation.com/stem/hands-on-experiments-to-learn-about-chemistry)
- This site has an interactive model showing changes in states of matter given changes in temperature. http://www.bbc.co.uk/schools/scienceclips/ages/9_10/changing_state_fs.shtml
- Glencoe provides a virtual lab to observe physical changes and record online data. http://www.glencoe.com/sites/common_assets/science/virtual_labs/E03/E03.html
- This site has a variety of experiments regarding chemical reactions (For safety concerns, DO NOT attempt the "Starting a fire with water experiment." http://reekoscience.com/category/science-experiments/chemical-reactions

- 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. Physical science focuses on physical and chemical principles that can be observed and applied to new systems and processes. For example, understanding that cause and effect relationships may be used to predict phenomena in natural or designed systems is a Crosscutting Concept that applies to predicting the outcome of such questions such as, "When matter changes, does its weight change?" "What effects do open and closed systems have on matter and the changes that occur?" Crosscutting Concepts may apply across multiple content areas and instructional emphases (e.g., Cause and effect of conflicts in social studies instruction.).

This content module, Physical Science: Structure of Matter, addresses how to identify particular materials by measuring a variety of observable properties. It addresses the fact that matter is composed of atoms and molecules and how that fact can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of mass. A critical concept is the unifying principle that understanding the types of atoms and their interactions provide information about matter.

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 the important features.),
- big ideas (e.g., Present and reinforce the "big ideas" that students should take and apply throughout their 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—Physical Science: Structure of Matter. 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

- Patterns in the natural and human-designed world can be observed. (e.g., Different materials may have similar properties such as hardness and texture).

Causality

Cause and Effect

- Cause and effect relationships are routinely identified and used to explain change (e.g., Mixing two or more materials together may create a new material with different properties.).
- Cause and effect relationships may be used to predict phenomena in natural or designed systems (e.g., The addition or removal of thermal energy results in the arrangement, motion, and interaction of particles in matter.).

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their functions depend on the shapes, composition, and relationships among their parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function (e.g., The total number of atoms do not change when a substance changes shape or composition.).

Systems

Scale, Proportion, and Quantity

- Natural objects exist from the very small to the immensely large (e.g., As water evaporates, it breaks down into smaller and smaller particles until it is too small to be seen.).
- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume (e.g., The weight of matter before and after it has had a change in its properties can be evidence for the conservation of mass.).
- Time, space, and energy phenomena can be observed at various scales using models to study systems too large or too small (e.g., Use models to describe substances that are pure and substances that are mixtures.).

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes (e.g., The total number of atoms in the reactant is equal to the total number of atoms in the product(s).).
- The transfer of energy can be tracked as energy flows through a designed or natural system (e.g., Chemical reactions can cause substances to either release or absorb thermal energy.).

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 10 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., physical properties) and in the context of the specific content (e.g., Teach the terms "properties," "size," "shape," "texture," and "color" in the context of describing observable physical properties.).

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 "substance" helps students to understand related terms (e.g., pure, mixture, solution, etc.). The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. For example, the specific phrase "states of matter" connects to the general words "solid," "liquid," and "gas" to help students understand water freezing or evaporating. 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, five, and seven. Refer to the Tennessee Academic Standards for Science for grade specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Texture is the way things feel—smooth, rough, fuzzy, etc.) and an example of the word (e.g., The texture of sand paper is rough.). Teach the specific content vocabulary using a student-friendly description of the word or phrase meaning (e.g., Three states of matter are solid, liquid, or gas.) and a possible connection to a general vocabulary word (e.g., Ice is the solid state of water.).

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 identify a physical property rather than defining the term.

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., A liquid takes the shape of the container it is in and keeps the same volume. *Example: Water is a liquid and takes the shape of the glass it is in.).*		
• absorb	• mass	• release
• atom	• matter	• shape
• clarity	• melt	• size
• color	• mixture	• solid
• energy	• motion	• solubility
• evaporate	• observe	• solution
• freeze	• particles	• substance
• gas	• pieces	• texture
• heat	• pressure	• water
• liquid	• properties	• volume
• magnetism	• pure	

Table 3. Specific Content Words

Specific Content Words—words that specify a particular thing (e.g., states of matter) or phenomena (e.g., effects of pressure on states of matter). Describe the word and when possible make the connection to a Crosscutting Concept (e.g., States of matter are solid, liquid, and gas. Thermal energy can change ice from a solid to water, which is a liquid.)		
• chemical change	• particle motion	• products
• electrical conductivity	• phase change	• reactants
• hardness	• physical change	• states of matter
• law of conservation of mass	• physical mixture	• thermal energy
• molecules	• physical properties	

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 matter, (e.g., "Matter is anything that takes up space and has mass. I am made of matter."). [Individualization idea: Present a variety of objects to students as examples of matter.]
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 what a mixture is and an example (e.g., A mixture is a material made by mixing two different substances that can be separated. An example of a mixture is sand and seashells mixed together.) [Individualization ideas: Place necessary vocabulary on the students' alternative and augmentative communication (AAC) system. Provide a choice of several mixtures for the student to use as examples.]
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	Have students complete a graphic organizer by categorizing materials as solids, liquids, or gases. [Individualization idea: Use pictures and/or objects for the graphic organizer.] Have students create a word mural by pasting examples of the three states of matter (see Figure 1. Example States of Matter Wall Mural).
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.	Incorporate vocabulary into daily activities such as determining if baking cookies, mixing sugar into tea, boiling water, shredding paper, etc., result in chemical or physical changes. [Individualization idea: Provide students with the terms "chemical change" and "physical change" on their AAC system and have them use as discussed in daily activities.] Read books or watch videos related to the vocabulary and concepts. • Watch a video that defines terms such as mixture (e.g., https://www.youtube.com/watch?v=jA0PzblYPUM or https://www.youtube.com/watch?v=Vt7lN4QPU0k). • Read an online book on the states of matter (e.g., http://www.storyjumper.com/book/index/14684442/States-Of-Matter#).

Ideas	Examples
	[Individualization idea: Have students use a screen reader.] View vocabulary word definitions of matter and atoms online that are paired with pictures and read to the student (e.g., https://quizlet.com/141262578/atoms-and-matter-flash-cards/).
Ask students to discuss the vocabulary words with each other.	Have students work with a partner or in groups of three to describe a vocabulary word and provide an example. Then have each student share the description and example with a student from a different group or with the entire class. [Individualization idea: Put the definition of the word on a voice output switch for the student to share.] Have students share examples of solids, liquids, and gases. [Individualization idea: Provide pictures of materials showing the three states of matter in the students' science notebooks for the students to refer to.]
Play vocabulary word games with students.	Play a phase change card game (e.g., https://www4.esc13.net/uploads/science/docs/manipulatives/phasechangecardgame.pdf). [Individualization idea: Create a model for students to follow when matching the correct cards.] Have students play an online vocabulary review game (e.g., https://www.eduplace.com/kids/hmsc/activities/ewordgame/index.html?grade=3&unit=e&chapter=11).
Have students watch a dramatization or have them act out the vocabulary term.	Have students act as a scientist explaining one of the science concepts to classmates or younger students.

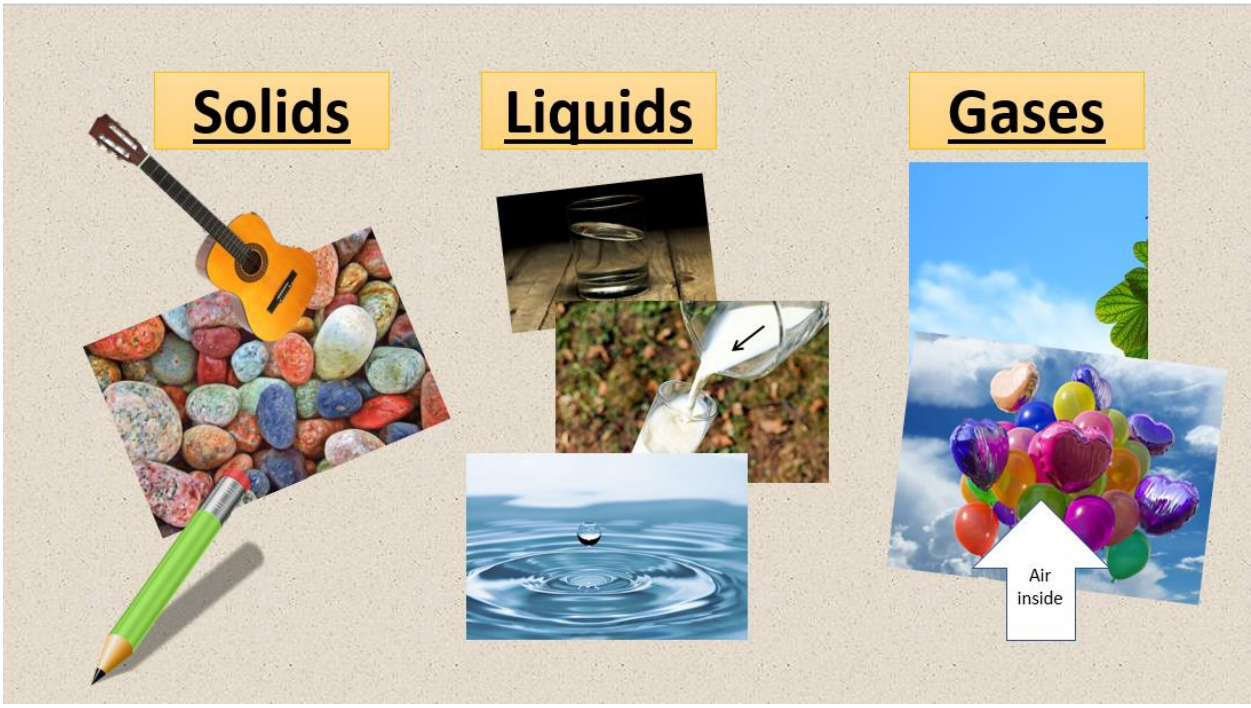
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students create a wall mural by taping pictures of solids, liquids, and gases under the appropriate heading. Educators may need to support, modify, or adapt steps as needed for individual students. [Individualization idea: Have students use an adapted keyboard to copy and paste online pictures to print and use for the mural.] 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 States of Matter Wall Mural



Vocabulary Resources

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

Section V

Overview of Units' Content

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

Matter and Its Interactions (elementary)

Content

- Matter is anything that takes up space and has mass, even if it is too small to see.
- Materials can be compared and categorized by physical properties (e.g., texture, size, shape, color).
- Materials can be described by solubility, mass, magnetism, and electrical conductivity.
- All matter can be broken into smaller and smaller particles too small to be seen by human eyes.
- Models can be used to illustrate particles of matter that are too small to be seen by the human eye.
- Matter exists in three states or phases: solid, liquid, and gas.
- When matter absorbs thermal energy (i.e., when heated) a phase change can occur (e.g., solid to a liquid; liquid to a gas).
- When matter releases thermal energy (i.e., when cooled) a phase change can occur (e.g., gas to a liquid; liquid to a solid).
- Mixing two or more substances may result in a physical change.
- Physical changes can be observed as qualitative changes (e.g., color, clarity, state of matter) and/or quantitative changes (e.g., weight).
- Mixing two or more substances together may result in a chemical change (i.e., new substance).

Matter and Its Interactions (middle)

Content

- A pure substance (e.g., diamond, sugar, water) has only one type of element or molecule.
- A mixture is a combination of two or more substances that are physically combined (e.g., sand and water, sugar and salt, salt and pepper).
- Mixtures can be physically separated.
- All matter is made of tiny particles called atoms.
- Atoms cannot be created or destroyed (law of conservation of mass).
- In chemical reactions, atoms are combined, separated, or rearranged.
- The total number of atoms of the reactants is equal to the total number of atoms of the products.
- Solids, liquids, and gases have different types of particle motion.
- Particles of solid matter are packed closely together and can only vibrate, resulting in matter that has a fixed shape.
- Particles in liquid matter have more room to move around than in a solid state, resulting in matter that takes the shape of its container and keeps the same volume.

- Particles in gas matter have a great amount of space to move around very quickly and spread out, resulting in matter that has no fixed shape or volume.
- A phase change does not change the particles but does change the way they are arranged.
- The addition or removal of thermal energy results in changes of state.
- Pressure can cause gases to expand or compress.

Unit Content Resources

States of Matter

- Inquiry in Action has numerous investigative activities and background information for teachers on matter. http://www.inquiryinaction.org/classroomactivities/
- This site provides a video on physical properties of the states of matter. https://www.youtube.com/watch?annotation_id=annotation_4109161969&feature=iv&src_vid=bMbmQzV-Ezs&v=21CR01rlmv4
- Soft Schools provides a description and examples of physical properties. http://www.softschools.com/examples/science/physical_properties_examples/30/
- Chem4Kids has information on matter, states of matter, and chemical and physical changes of matter. http://www.chem4kids.com/files/matter_intro.html
- This site has science projects for kids on the states of matter. https://lifestyle.howstuffworks.com/crafts/science-projects/science-projects-for-kids-states-of-matter.htm

Particles in Matter

- BetterLesson provides a lesson plan on visual models of particles in each state of matter, https://betterlesson.com/lesson/636178/states-of-matter, and one on creating 3-D models of the particles in each matter, https://betterlesson.com/lesson/629401/matter-foldable-and-modeling-matter#
- This YouTube video has information on particles. https://www.youtube.com/watch?v=npv74D2MO6Q
- CPALMS has a hands-on activity lesson plan regarding the absorbing or releasing of thermal energy. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/129588
- Chem4Kids has information on changing states of matter. http://www.chem4kids.com/files/matter_states.html
- The American Association of Chemistry Teachers provides a lesson plan on energy changes and transfer during a phase change. https://www.acs.org/content/dam/AACT/high-school/states-of-matter/molecular%20motion/lesson-modelingicemelting.pdf
- ACS Chemistry for Life provides activity-based lessons on how temperature affects matter. http://www.inquiryinaction.org/classroomactivities/topic.php?topic=Temperature%20Affects%20Matter
- Science NetLinks has a lesson on the effect of temperature on the motion of particles. http://sciencenetlinks.com/lessons/temperature-changes-everything/

Physical and Chemical Changes

- Chem4Kids has information on chemical changes versus physical changes. http://www.chem4kids.com/files/matter_chemphys.html
- This site explains physical properties and physical changes. http://chemistry.elmhurst.edu/vchembook/104Aphysprop.html
- Soft Schools provides examples of physical changes. http://www.softschools.com/examples/science/physical_changes_examples/170/
- This site has an activity-based lesson plan on physical and chemical changes. https://www.acs.org/content/dam/AACT/elementary-school/states-of-matter/physical-change/secure/Lesson_Alien.doc
- Utah Education Network has a variety of activities to help students understand chemical and physical changes in matter. https://www.uen.org/core/displayLessonPlans.do?courseNumber=3050&standardId=1223&objectiveId=1225

Mixtures and Substances

- CPALMS has a lesson plan on pure substances, mixtures, and solutions. http://www.cpalms.org/Public/PreviewResourceLesson/Preview/125968
- Soft Schools provides information and examples of pure substances. http://www.softschools.com/examples/science/pure_substances_examples/476/
- This YouTube video provides an explanation of how to evaluate pure substances and mixtures. https://www.youtube.com/watch?v=88MBCyiaPSM

Conservation of Mass

- CK-12 provides a lesson plan on changes in matter and includes the law of conservation of mass. http://www.ck12.org/section/Changes-in-Matter-::of::-Introduction-to-Matter-::of::-CK-12-Physical-Science-For-Middle-School/
- This site provides a video demonstrating the conservation of mass. https://www.youtube.com/watch?v=774TbEUUM-A
- This site provides an explanation of the law of conservation of mass. https://www.etutorworld.com/science/7th-grade-science-tutoring/law-of-conservation-of-mass.html
- This site has a lab exercise to demonstrate the law of conservation of mass. http://www.nclark.net/conservation_of_matter_lab.pdf

Section VI

Universal Design for Learning (UDL) Suggestions

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

Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**: providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding.

Table 7 provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

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

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

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

Multiple Means of Representation	
Strategies	**Examples**
Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Present models of particle arrangement and motion in solids, liquids, and gases (e.g., https://www.youtube.com/watch?v=EZHmUTmJtF8). [Individualization idea: Create 3-D particles for the model using plastic beads, polystyrene foam balls, gum drops, etc., and have students feel how the particles change arrangement.] **V** Conduct experiments about: • chemical changes (e.g., Perkins School for the Blind has a hands-on lesson plan for observing chemical changes. http://www.perkinselearning.org/accessible-science/chemical-or-physical-change) **V** and • conservation of matter (e.g., http://www.troup.org/userfiles/929/My%20Files/Science/MS%20Science/8th%20Science/Matter/conservation_matter/conservation_mass_lab2.pdf?id=8053).
Model content through pictures, dramatization, videos, etc.	Present a variety of solids (e.g., ice, pencils, books) and liquids (e.g., water, oil, juice). Describe the physical properties (e.g., size, shape, mass, texture, color) and discuss gases (e.g., air, helium in a balloon, etc.) and the associated physical properties. [Individualization idea: Have students feel the objects and pour liquids into containers.] **V** Show videos on: • states of matter (e.g., https://www.youtube.com/watch?v=RKimVuvCXiA), • relationship between states of matter and particle motion (e.g., https://www.brainpop.com/science/matterandchemistry/statesofmatter/), and • mixtures and solutions (e.g., https://www.youtube.com/watch?v=nqc9ASP0tq0). [Individualization idea: Sign the narration for students.] **H**
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: http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** Help students complete 3-D models of the particles in each state of matter (e.g., https://betterlesson.com/lesson/629401/matter-foldable-and-modeling-matter).

Multiple Means of Representation	
Strategies	**Examples**
	Provide and complete as a class or small group a research graphic organizer (e.g., http://sassafrasscience.com/what-are-lapbooks/ or https://www.livinglifeandlearning.com/use-lapbooks-science.html). Individualization ideas: Have students use a bingo dauber to complete graphs in the lapbook. Help them copy and print facts from online sources to paste into research notes. Have students take a photograph before and after the investigation.] Have students complete a graphic organizer as they conduct an investigation on mixtures (e.g., http://mrascienceclass.weebly.com/mixtures-and-solutions.html). [Individualization idea: Provide students with picture choices and reduced number of properties to observe.]
Provide appropriate and accessible text on the content for students to listen to or read.	Read online text about: • matter (e.g., https://www.scoe.org/files/ngss-particle-model.pdf), • states of matter (e.g., page 3 of http://www.lexington1.net/images/continuous-improvement/standard-3/Indicator-1/Grade2_DWW_2_Informative_Prompt_15-16.pdf). • physical changes (e.g., http://www.ck12.org/physical-science/Physical-Change-in-Physical-Science/lesson/Physical-Change-MS-PS/?referrer=featured_content), or • phase changes (e.g., https://www.storyjumper.com/book/index/16609792/Phase-Changes#). [Individualization idea: Have students use a screen reader.] **V**
Teach information using songs.	• Teach states of matter through songs (e.g., https://www.youtube.com/watch?v=pag2zq-gE0E).

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 explore an interactive site demonstrating phase change (e.g., http://www.bbc.co.uk/schools/scienceclips/ages/9_10/changing_state_fs.shtml or http://www.harcourtschool.com/activity/states_of_matter/molecules.swf). [Individualization idea: Have students use an adapted mouse to click on buttons.] **P** Have students record data online. [Individualization idea: Have students use an adaptive keyboard to enter data.] **P** Use a blender to complete investigation on mixtures. [Individualization idea: Have students use an adapted switch to activate the blender.] **P**
Allow for instructional materials that can be modified to provide access.	Place material on a slant board for improved fine and visual motor skills (e.g., https://nspt4kids.com/parenting/benefits-of-a-slant-board/). [Individualization idea: Provide adapted page turners (e.g., add large paper clips to each page, pencil with eraser placed in an adapted holder.] **V/P** Provide a talking calculator, scale, thermometer, etc., for investigations. **V** Use wax sticks or glue to raise lines on graphs created or used in investigations. **V** Use American Sign Language for scientific terms (e.g., https://www.youtube.com/watch?v=sTQeWOc-h_Q). **H** Have students work collaboratively with a peer to complete research on conservation of mass by supplying a claim, evidence, or reasoning. [Individualization idea: Provide choices of claims, evidence, and reasoning for students to choose to add to the research.]
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**
Provide simulation activities.	Have students observe a simulation of states of matter (e.g., https://phet.colorado.edu/en/simulation/states-of-matter-basics). Have students observe a demonstration that shows that the pressure from atoms can inflate a balloon using an interactive model (e.g., https://concord.org/stem-resources/what-pressure). Have students role play phase changes and act out molecules (e.g., http://www.nsta.org/publications/news/story.aspx?id=51497).
Provide graphic organizers and templates.	Have students use a graphic organizer with prompting questions to describe materials in different states of matter (e.g., https://www.worksheetplace.com/index.php?function=DisplaySheet&sheet=States-of-matter-worksheet-01&links=2&id=6158&link1=241&link2=379).

Multiple Means of Action and Expression	
Strategies	**Examples**
	[Individualization idea: Provide drawings or photographs to show what the material looks like and answer options to choose for the questions.]

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 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 personal schedule that is engaging for individual students (e.g., photos of the student in the various settings or activities; modify a planner used by peers, object schedule (e.g., https://www.autismclassroomresources.com/visual-schedule-series-object-schedules_25/ and (http://www.perkinselearning.org/videos/teachable-moment/object-schedule-systems) in a backpack, etc.)
Vary the challenge and amount of information presented at a time.	Begin with having students identify water, ice, and gas (in the form of steam). Then have students identify the states of matter. Finally, introduce factors that influence the change in states of matter.
Make connections to topics or activities that are motivating.	Create a book with photos showing the class investigating physical properties of matter, states of matter, and particle motion. [Individualization idea: Create a tactile book by adding raised lines on drawings and placing items in sandwich baggies attached to the pages, etc.]. Make connections to familiar and pleasing activities when teaching phase changes (e.g., bubble freezing, https://www.youtube.com/watch?v=OXfbYzPV5Bc, or boiling water freezing in midair, https://www.youtube.com/watch?v=jKMNSvpB9dY).
Allow choices as possible.	Allow students to choose whether to read/listen to an article (e.g., https://www.ducksters.com/science/chemistry/chemical_mixtures.php) or watch a video (e.g., https://www.youtube.com/watch?v=LCIeS5Cwke0&t=73s) during independent work time.
Provide opportunities to work collaboratively with peers.	Partner with the general education science teacher to plan and teach the units. Have students work in collaborative groups with accessible tasks assigned to the students.
Teach student self-regulation skills.	Help students set a timer and a goal for part of a task to work on before taking a break when the timer ends. Provide students with stress balls, finger fidgets, etc. Provide seating that offers sensory feedback (e.g., inflatable seat cushion, bean bag cushion, etc.).

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 obtaining, evaluating, and communicating information in science to doing the same in daily life (e.g., communicating with the doctor).	Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems. Work with students in following directions during science investigations.
Reading and Listening Comprehension	Provide information through reading books and articles on science concepts (e.g., states of matter, phase changes, conservation of matter) while working on reading comprehension.	Practice site words in the reading material. Work on fine motor skills while turning pages or range of motion by pointing to pictures.
Mathematics	Teach measurement and data skills (e.g., attributes of objects such as height, weight, and temperature).	Provide practice on number identification and qualitative measurement of temperature.
Age-Appropriate Social Skills	Make connections between the Crosscutting Concepts and real-life experiences showing the cause and effect relationships of their behaviors and how those can be used to predict outcomes.	Provide opportunities to work with 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 this time to help students set goals and self-evaluate.
Skills in Accessing Support Systems	Encourage students to ask appropriately for accommodation needs (e.g., interpreter, large print, preferential seating, etc.).	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

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