Connecticut Mastery Test

Fourth Generation

Science Handbook

Connecticut State Department of Education
2008

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Introduction

The Connecticut Mastery Test (CMT) Science Handbook is designed to provide Connecticut's elementary and middle school teachers with a range of background materials, ideas, tasks and other resources to better align instruction and assessment with the expectations set for the CMT science assessment.

The underlying philosophy of the science framework and the CMT science assessment is that science is not only a body of knowledge, but also a way of thinking about the world around us. The philosophy and objectives closely parallel the National Science Education Standards developed in 1996 by the National Research Council and *Benchmarks for Scientific Literacy* published by the American Association for the Advancement of Science in 1993.

The handbook provides information about:

- test formats;
- tested content and skills;
- sample test items;
- scoring information; and
- science literacy terminology which all students should be familiar with to be successful in science.

Additionally, this handbook contains links to the curriculum-embedded performance tasks, both student materials and teacher manuals, and sample test items that can be used to inform classroom instruction and assessment. Teachers may use these materials in a variety of ways. For instance:

- Sample assessment items can be used to help teachers design instructional experiences that facilitate students' understanding of science concepts and inquiry processes.
- The CSDE-developed curriculum-embedded performance tasks may be used and/or modified in the normal course of instruction to provide students with opportunities to learn to use scientific inquiry processes proficiently to deepen their understanding of science concepts.
- Student work generated from curriculum embedded tasks and responses to open-ended questions can be used as catalysts for discussion on teaching and learning.

Overall, the science content of the CMT should be viewed as one component of a comprehensive, standards-based, science program designed to set and meet high expectations for all students. Classroom instruction should not be limited to preparation for the CMT. However, high-quality instruction should naturally reflect what is assessed and how it is assessed on the CMT.

It is hoped that the content of this handbook will provide teachers of science with information and ideas they need to continue to build and implement high-quality programs that significantly improve the scientific literacy of all Connecticut students.

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Position Statement on Science Education

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The Connecticut State Board of Education believes that every student needs and deserves a rich and challenging education in science. Such an education will promote essential understandings of the natural world and nurture student's abilities to apply scientific knowledge to make informed and logical judgments about personal and societal issues. Such an education requires that the fundamental approach to science is a creative process for investigating, reasoning, critiquing and communicating about ideas, not as a static body of facts to be memorized.

The Board believes that learning science is important for all students in order to prepare them to be informed individuals and citizens and to participate in a wide range of scientific and technological careers. Understanding the interconnections between science and technology, and their shared impact on environmental and societal issues, is essential in order to preserve and improve life on Earth.

Learning experiences in science should lead all students to:

- Understand and apply basic concepts, principles and theories of biology, chemistry, physics, earth and space sciences and their interrelationships;
- Recognize and participate in scientific endeavors which are evidence based and use inquiry skills that lead to a greater understanding of the world;
- Identify and solve problems through scientific exploration, including the formulation of hypotheses, design of experiments, use of technology, analysis of data and drawing of conclusions;
- Select and use properly appropriate laboratory technology, equipment and material, including measuring and sensing devices;
- Understand and use existing and emerging technologies which have an effect on society and the quality of life, including personal academic and work environments;
- Analyze the possibilities and limits of science and technology in order to make and defend decisions about societal issues; and
- Understand that the way in which scientific knowledge is formulated is crucial to the validity of that knowledge.

Quality education in science should, therefore, be an integral part of the core curriculum for all Connecticut students. The PreK-12 scientific program should enable students to achieve the learning goals and standards outlined in Connecticut's science framework. Improving students' participation and achievement in science is an important component of implementing the Board's educational agenda. Everyone has a role in providing all children education that includes rigorous scientific experiences.

The Department of Education plays an essential role in ensuring a quality educational program in science by:

- setting clear goals and core performance expectations for all students, and creating a science curriculum framework that provides a clear PreK-12 scope and sequence necessary to achieve these goals;

- establishing science teaching standards that set high expectations for science content knowledge and pedagogy;
- developing student assessment policies and practices for the state assessment that are aligned with the learning expectations described in the state curriculum framework;
- providing the field with standards-based professional development opportunities to enhance teachers' scientific knowledge and teaching skills; and
- developing statewide partnerships with business, industry and higher education that support scientific learning in schools.

School districts play an essential role in ensuring a quality educational program in science by:

- selecting and developing curriculum and courses of study that are guided by the state science framework;
- providing all students with coordinated, meaningful and engaging scientific experiences to support their development of scientific literacy;
- providing highly qualified teachers at all levels who are knowledgeable about the content, methods and pedagogy of the science they teach;
- applying standards for teaching science to the evaluation of science teachers;
- providing professional development opportunities to science teachers that will enhance the effectiveness of their instruction and improve student learning; and
- providing teachers and students with necessary science instructional resources, including lab space, equipment and materials, technology, textbooks and easy access to electronic sources of information.

Teachers play an essential role in ensuring a quality educational program in science by:

- planning units and lessons that contain current, accurate and meaningful content that is aligned with the district curriculum;
- keeping up-to-date with the latest scientific advances in their discipline;
- setting a context for scientific learning that is relevant to students in class;
- engaging students in extended, developmentally appropriate scientific investigations that motivate student effort and interest in scientific learning;
- providing students with a safe environment in which to participate in scientific investigations;
- providing students with resources needed to support their learning;
- assessing student understanding regularly and adjusting instruction to accommodate students with diverse needs, abilities and interests;
- communicating to students and parents the goals and importance of studying science; and
- encouraging students to pursue the study of advanced science and science-related careers.

Teacher preparation programs play an essential role in improving a quality educational program in science by:

- providing preservice teachers with a comprehensive program of challenging and meaningful science courses that develop understandings of scientific concepts, processes and ways of thinking;
- providing preservice teachers with knowledge about human cognition and learning theories;

- providing preservice teachers with instruction in science-specific classroom pedagogy, including the use of educational and scientific technology, aligned with state science teaching standards; and
- providing preservice teachers with opportunities to practice teaching in a safe and supportive environment.

Parents play an essential role in ensuring a quality educational program in science by:

- encouraging their children to participate in high-level science courses and activities, both in and out of school;
- talking to their children about science they learn at school and showing interest in scientific content, processes and ideas; and
- providing their children with access to science resources, such as museums, libraries and the Internet.

PART I

The Fourth Generation of the Connecticut Mastery Test

- **Overview of the CMT Program**
- **Format of the CMT Science Assessments**
- **Science Knowledge and Inquiry Practices Tested**
- **Curriculum-Embedded Performance Tasks**

Overview of the CMT Program

The Connecticut Mastery Test (CMT) has measured growth in achievement for Connecticut students since 1985, when it was first administered. New generations of the test have offered an opportunity to adjust content, re-establish standards and reflect changes in philosophy and technology that have occurred. The tests measure what students know and are able to do in relation to specific educational standards. Simply put, Connecticut's tests help assess how students are performing academically.

The CMT is administered in the spring to students in Grades 3–8 in mathematics and reading and writing across the disciplines. The science portion of the test will be administered for the first time in 2008 to students in Grades 5 and 8.

The CMT is part of a testing system that provides a logical progression from assessing foundational concepts and skills at the lower grades to focusing more on the integration and application of complex concepts and skills at the higher grades. These tests provide a challenging and accurate assessment of student achievement statewide. The CMT helps to:

- set high expectations and standards for student achievement;
- test a comprehensive range of academic skills;
- disseminate useful test achievement information about students, schools and districts;
- identify students in need of intervention;
- assess equitable educational opportunities; and
- continually monitor student progress.

The CMT is not like the traditional standardized achievement tests. Instead of being tested to see where each student ranks compared to others who took the test, students take criterion-referenced tests designed to measure how well they perform against established standards in a variety of essential and specific skills. Not only do they measure what students know, but Connecticut's tests also measure what students can do with what they know by asking them to respond in writing to questions in order to show or explain their work.

The CMT Science Assessment

The CMT science assessments measure what students have learned over several years about core science concepts and about how scientific inquiry is done. The assessments include questions related to concepts in life science, physical science and earth science and how those concepts apply to real world issues and technologies. The 2004 Core Science Curriculum Framework describes the conceptual focus of four Content Standards for each grade in the pK-8 span, as well as the Expected Performances assessed on the CMT.

The Elementary Science CMT is a cumulative test administered at Grade 5. It assesses science knowledge and abilities described in the framework expected performances for Grades 3, 4 and 5 (BINQ 1 to BINQ 10 and B.1 to B.25). Expected performances for Grades PK-2 are considered foundational, and, although not directly assessed on the Elementary Science CMT, they play an important role in supporting students' ongoing development of science understanding.

The Middle School Science CMT is a cumulative test administered at Grade 8. It includes science knowledge and abilities described in the Core Science Curriculum Framework for Grades 6, 7 and 8 (CINQ 1 to CINQ 10 and C.1 to C.30).

To assess students' understanding of inquiry and the nature of science, the CMT science assessments include some questions that assess inquiry within the CONTEXT of curriculum-embedded performance tasks developed by the State Department of Education. Students are not expected to recall the SPECIFIC DETAILS OR A SINGLE "RIGHT" ANSWER to any performance task. Rather, the test questions will assess students' general abilities to make scientific observations, pose testable questions, design "fair tests," make evidence-based conclusions and judge experimental quality. Students who have had numerous opportunities to make observations, design experiments, collect data and form evidence-based conclusions are likely to be able to answer the task-related CMT questions correctly, even if they have not done the state-developed performance tasks. However, familiarity with the context referred to in the test question may make it easier for students to answer the question correctly.

Results of the CMT are reported in various ways and are intended to help improve the performance of students, support modifications in curriculum and instructional practices, and stimulate higher expectations for student achievement. School districts receive sets of student reports that show how well individual students did on each section of the CMT. Score reports are given to students and parents in October and November.

Format of the Elementary Science CMT
Administered at Grade 5

Item Distribution

	Content Knowledge		Scientific Inquiry, Literacy and Numeracy	
	Selected Response*	Constructed Response*	Selected Response*	Total Points
Life Science	6	1	6	14
Physical Science	6	1	6	14
Earth Science	6	1	6	14
Total Points	24		18	42

* Each selected response item is worth 1 point. Each constructed response item is worth 2 points.

General Test Format

The Elementary Science CMT is a cumulative test administered at Grade 5. It includes science knowledge and inquiry skills described in the Core Science Curriculum Framework for Grades 3, 4 and 5. There are 39 test questions: 36 selected response items and three constructed response items. Of the 36 selected response items, 18 assess Content Knowledge and 18 assess processes of Scientific Inquiry, Literacy and Numeracy. The three constructed response items assess Content Knowledge.

Test Scoring

The selected response items are scored electronically as correct or incorrect. Constructed response items are hand-scored by trained readers using a three-point scale (0-2).

Curriculum-Embedded Performance Tasks

CSDE has developed curriculum-embedded performance tasks related to content standards in Grades 3, 4 and 5. These instructional materials are posted at www.ct.gov/sde at the science link from Curriculum and Instruction. Teachers are encouraged to incorporate these inquiry investigations into a learning unit that addresses the content standard related to each task. The Elementary Science CMT will include two to three multiple-choice items that assess expected performances in Scientific Inquiry, Literacy and Numeracy within the context of each embedded performance task.

Reporting

A total science score will be reported based on all 42 points. In addition, the following subscores will be reported:

- Life Science 14 points (33⅓ %)
- Physical Science 14 points (33⅓ %)
- Earth Science 14 points (33⅓ %)

- Content Knowledge 24 points (57%)
- Scientific Inquiry, Literacy and Numeracy 18 points (43%)

Testing Time - 65 minutes

Format of the Middle School Science CMT Administered at Grade 8

Item Distribution

	Content Knowledge	Scientific Inquiry, Literacy and Numeracy		
	Selected Response*	Selected Response*	Constructed Response*	Total Points
Life Science	10	5	1	17
Physical Science	10	5	1	17
Earth Science	10	5	1	17
Total Points	30	21		51

* Each selected response item is worth 1 point. Each constructed response item is worth 2 points.

General Test Format

The Middle School Science CMT is a cumulative test administered at Grade 8. It includes science knowledge and inquiry skills described in the Core Science Curriculum Framework for Grades 6, 7 and 8. There are 48 test questions: 45 selected response items and three constructed response items. Of the 45 selected response items, 30 assess Content Knowledge and 15 assess Scientific Inquiry, Literacy and Numeracy practices. The three constructed response items will assess Scientific Inquiry, Literacy and Numeracy in the context of the Grade 6, 7 and 8 Curriculum-Embedded Performance Tasks.

Test Scoring

The selected response items are scored electronically as correct or incorrect. Constructed response items are hand-scored by trained readers using a three-point scale (0-2).

Curriculum-Embedded Performance Tasks

CSDE has developed curriculum-embedded performance tasks related to content standards in Grades 6, 7 and 8. These instructional materials are posted at www.ct.gov/sde at the science link from Curriculum and Instruction. Teachers are encouraged to incorporate these inquiry investigations into a learning unit that addresses the content standard related to each task. The Middle School Science CMT will include constructed response items that assess expected performances in Scientific Inquiry, Literacy and Numeracy within the context of each of the three embedded performance tasks.

Reporting

A total science score will be reported based on all 51 points. In addition, the following subscores will be reported:

- Life Science — 17 points (33⅓ %)
- Physical Science — 17 points (33⅓ %)
- Earth Science — 17 points (33⅓ %)

- Content Knowledge — 30 points (59 %)
- Scientific Inquiry, Literacy and Numeracy — 21 points (41 %)

Testing Time - 70 minutes

ELEMENTARY SCIENCE CMT
INQUIRY PRACTICES AND SCIENCE KNOWLEDGE ASSESSED*

THE STANDARDS FOR SCIENTIFIC INQUIRY, LITERACY AND NUMERACY ARE INTEGRAL PARTS OF THE CONTENT STANDARDS FOR EACH GRADE LEVEL IN THIS CLUSTER.

Grades 3-5 Core Scientific Inquiry, Literacy and Numeracy *How is scientific knowledge created and communicated?*	
Content Standards	**Expected Performances**
SCIENTIFIC INQUIRY ♦ Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena. **SCIENTIFIC LITERACY** ♦ Scientific literacy includes speaking, listening, presenting, interpreting, reading and writing about science. **SCIENTIFIC NUMERACY** ♦ Mathematics provides useful tools for the description, analysis and presentation of scientific data and ideas.	**B INQ.1** Make observations and ask questions about objects, organisms and the environment. **B INQ.2** Seek relevant information in books, magazines and electronic media. **B INQ.3** Design and conduct simple investigations. **B INQ.4** Employ simple equipment and measuring tools to gather data and extend the senses. **B INQ.5** Use data to construct reasonable explanations. **B INQ.6** Analyze, critique and communicate investigations using words, graphs and drawings. **B INQ.7** Read and write a variety of science-related fiction and nonfiction texts. **B INQ.8** Search the Web and locate relevant science information. **B INQ.9** Use measurement tools and standard units (e.g., centimeters, meters, grams, kilograms) to describe objects and materials. **B INQ.10** Use mathematics to analyze, interpret and present data.

* Excerpted from the 2004 Core Science Curriculum Framework

Grade 3
Core Themes, Content Standards and Expected Performances

Content Standards	Expected Performances
Properties of Matter – How does the structure of matter affect the properties and uses of materials? **3.1 - Materials have properties that can be identified and described through the use of simple tests.** ♦ Heating and cooling cause changes in some of the properties of materials.	**B 1.** Sort and classify materials based on properties such as dissolving in water, sinking and floating, conducting heat, and attracting to magnets. **B 2.** Describe the effect of heating on the melting, evaporation, condensation and freezing of water.
Heredity and Evolution – What processes are responsible for life's unity and diversity? **3.2 - Organisms can survive and reproduce only in environments that meet their basic needs.** ♦ Plants and animals have structures and behaviors that help them survive in different environments.	**B 3.** Describe how different plants and animals are adapted to obtain air, water, food and protection in specific land habitats. **B 4.** Describe how different plants and animals are adapted to obtain air, water, food and protection in water habitats.
The Changing Earth – How do materials cycle through the Earth's systems? **3.3 - Earth materials have different physical and chemical properties.** ♦ Rocks and minerals have properties that may be identified through observation and testing; these properties determine how earth materials are used.	**B 5.** Describe the physical properties of rocks and relate them to their potential uses. **B 6.** Relate the properties of rocks to the possible environmental conditions during their formation.
Science and Technology in Society – How do science and technology affect the quality of our lives? **3.4 - Earth materials provide resources for all living things, but these resources are limited and should be conserved.** ♦ Decisions made by individuals can impact the global supply of many resources.	**B 7.** Describe how earth materials can be conserved by reducing the quantities used, and by reusing and recycling materials rather than discarding them.

Grade 4 Core Themes, Content Standards and Expected Performances	
Content Standards	**Expected Performances**
Forces and Motion – What makes objects move the way they do? **4.1 - The position and motion of objects can be changed by pushing or pulling**. ♦ The size of the change in an object's motion is related to the strength of the push or pull. ♦ The more massive an object is, the less effect a given force will have on its motion.	**B 8.** Describe the effects of the strengths of pushes and pulls on the motion of objects. **B 9.** Describe the effect of the mass of an object on its motion.
Matter and Energy in Ecosystems – How do matter and energy flow through ecosystems? **4.2 - All organisms depend on the living and non-living features of the environment for survival.** ♦ When the environment changes, some organisms survive and reproduce, and others die or move to new locations.	**B 10.** Describe how animals, directly or indirectly, depend on plants to provide the food and energy they need in order to grow and survive. **B 11.** Describe how natural phenomena and some human activities may cause changes to habitats and their inhabitants.
Energy in the Earth's Systems – How do external and internal sources of energy affect the Earth's systems? **4.3 - Water has a major role in shaping the Earth's surface.** ♦ Water circulates through the Earth's crust, oceans and atmosphere.	**B 12.** Describe how the sun's energy impacts the water cycle. **B 13.** Describe the role of water in erosion and river formation.
Energy Transfer and Transformations – What is the role of energy in our world? **4.4 - Electrical and magnetic energy can be transferred and transformed.** ♦ Electricity in circuits can be transformed into light, heat, sound and magnetic effects. ♦ Magnets can make objects move without direct contact between the object and the magnet.	**B 14.** Describe how batteries and wires can transfer energy to light a light bulb. **B 15.** Explain how simple electrical circuits can be used to determine which materials conduct electricity. **B 16.** Describe the properties of magnets, and how they can be used to identify and separate mixtures of solid materials.

Grade 5 Core Themes, Content Standards and Expected Performances	
Content Standards	**Expected Performances**
Energy Transfer and Transformations – What is the role of energy in our world? **5.1 - Sound and light are forms of energy.** ♦ Sound is a form of energy that is produced by the vibration of objects and is transmitted by the vibration of air and objects. ♦ Light is a form of energy that travels in a straight line and can be reflected by a mirror, refracted by a lens, or absorbed by objects.	**B 17.** Describe the factors that affect the pitch and loudness of sound produced by vibrating objects. **B 18.** Describe how sound is transmitted, reflected and/or absorbed by different materials. **B 19.** Describe how light is absorbed and/or reflected by different surfaces.
Structure and Function – How are organisms structured to ensure efficiency and survival? **5.2 - Perceiving and responding to information about the environment is critical to the survival of organisms.** ♦ The sense organs perceive stimuli from the environment and send signals to the brain through the nervous system.	**B 20.** Describe how light absorption and reflection allow one to see the shapes and colors of objects. **B 21.** Describe the structure and function of the human senses and the signals they perceive.
Earth in the Solar System – How does the position of Earth in the solar system affect conditions on our planet? **5.3 - Most objects in the solar system are in a regular and predictable motion.** ♦ The positions of the Earth and moon relative to the sun explain the cycles of day and night, and the monthly moon phases.	**B 22.** Explain the cause of day and night based on the rotation of Earth on its axis. **B 23.** Describe the monthly changes in the appearance of the moon, based on the moon's orbit around the Earth.
Science and Technology in Society – How do science and technology affect the quality of our lives? **5.4 - Humans have the capacity to build and use tools to advance the quality of their lives.** ♦ Advances in technology allow individuals to acquire new information about the world.	**B 24.** Compare and contrast the structures of the human eye with those of the camera. **B 25.** Describe the uses of different instruments, such as eye glasses, magnifiers, periscopes and telescopes, to enhance our vision.

MIDDLE SCHOOL SCIENCE CMT
INQUIRY PRACTICES AND SCIENCE KNOWLEDGE ASSESSED*

Grades 6-8 Core Scientific Inquiry, Literacy and Numeracy *How is scientific knowledge created and communicated?*	
Content Standards	**Expected Performances**
SCIENTIFIC INQUIRY ♦ Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena. ♦ Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation. ♦ Scientific inquiry requires the sharing of findings and ideas for critical review by colleagues and other scientists. **SCIENTIFIC LITERACY** ♦ Scientific literacy includes speaking, listening, presenting, interpreting, reading and writing about science. ♦ Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media. **SCIENTIFIC NUMERACY** ♦ Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas.	**C INQ.1** Identify questions that can be answered through scientific investigation. **C INQ.2** Read, interpret and examine the credibility of scientific claims in different sources of information. **C INQ.3** Design and conduct appropriate types of scientific investigations to answer different questions. **C INQ.4** Identify independent and dependent variables, and those variables that are kept constant, when designing an experiment. **C INQ.5** Use appropriate tools and techniques to make observations and gather data. **C INQ.6** Use mathematical operations to analyze and interpret data. **C INQ.7** Identify and present relationships between variables in appropriate graphs. **C INQ.8** Draw conclusions and identify sources of error. **C INQ.9** Provide explanations to investigated problems or questions. **C INQ.10** Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.

* Excerpted from the 2004 Core Science Curriculum Framework

Grade 6
Core Themes, Content Standards and Expected Performances

Content Standards	Expected Performances
Properties of Matter – How does the structure of matter affect the properties and uses of materials? **6.1 - Materials can be classified as pure substances or mixtures, depending on their chemical and physical properties.** ♦ Mixtures are made of combinations of elements and/or compounds, and they can be separated by using a variety of physical means. ♦ Pure substances can be either elements or compounds, and they cannot be broken down by physical means.	**C 1.** Describe the properties of common elements, such as oxygen, hydrogen, carbon, iron and aluminum. **C 2.** Describe how the properties of simple compounds, such as water and table salt, are different from the properties of the elements of which they are made. **C 3.** Explain how mixtures can be separated by using the properties of the substances from which they are made, such as particle size, density, solubility and boiling point.
Matter and Energy in Ecosystems – How do matter and energy flow through ecosystems? **6.2 - An ecosystem is composed of all the populations that are living in a certain space and the physical factors with which they interact.** ♦ Populations in ecosystems are affected by biotic factors, such as other populations, and abiotic factors, such as soil and water supply. ♦ Populations in ecosystems can be categorized as producers, consumers and decomposers of organic matter.	**C 4.** Describe how abiotic factors, such as temperature, water and sunlight, affect the ability of plants to create their own food through photosynthesis. **C 5.** Explain how populations are affected by predator-prey relationships. **C 6.** Describe common food webs in different Connecticut ecosystems.
Energy in the Earth's Systems – How do external and internal sources of energy affect the Earth's systems? **6.3 - Variations in the amount of the sun's energy hitting the Earth's surface affect daily and seasonal weather patterns.** ♦ Local and regional weather are affected by the amount of solar energy these areas receive and by their proximity to a large body of water.	**C 7.** Describe the effect of heating on the movement of molecules in solids, liquids and gases. **C 8.** Explain how local weather conditions are related to the temperature, pressure and water content of the atmosphere and the proximity to a large body of water. **C 9.** Explain how the uneven heating of the Earth's surface causes winds.
Science and Technology in Society – How do science and technology affect the quality of our lives? **6.4 - Water moving across and through earth materials carries with it the products of human activities.** Most precipitation that falls on Connecticut eventually reaches Long Island Sound.	**C 10.** Explain the role of septic and sewage systems on the quality of surface and ground water. **C 11.** Explain how human activity may impact water resources in Connecticut, such as ponds, rivers and the Long Island Sound ecosystem.

Grade 7 Core Themes, Content Standards and Expected Performances	
Content Standards	**Expected Performances**
Energy Transfer and Transformations – What is the role of energy in our world? **7.1 - Energy provides the ability to do work and can exist in many forms.** ♦ Work is the process of making objects move through the application of force. ♦ Energy can be stored in many forms and can be transformed into the energy of motion.	**C 12.** Explain the relationship among force, distance and work, and use the relationship ($W = F$ x D) to calculate work done in lifting heavy objects. **C 13.** Explain how simple machines, such as inclined planes, pulleys and levers, are used to create mechanical advantage. **C 14.** Describe how different types of stored (potential) energy can be used to make objects move.
Structure and Function – How are organisms structured to ensure efficiency and survival? **7.2 - Many organisms, including humans, have specialized organ systems that interact with each other to maintain dynamic internal balance.** ♦ All organisms are composed of one or more cells; each cell carries on life-sustaining functions. ♦ Multicellular organisms need specialized structures and systems to perform basic life functions.	**C 15.** Describe the basic structures of an animal cell, including nucleus, cytoplasm, mitochondria and cell membrane, and how they function to support life. **C 16.** Describe the structures of the human digestive, respiratory and circulatory systems, and explain how they function to bring oxygen and nutrients to the cells and expel waste materials. **C 17.** Explain how the human musculoskeletal system supports the body and allows movement.
Energy in the Earth's Systems – How do external and internal sources of energy affect the Earth's systems? **7.3 - Landforms are the result of the interaction of constructive and destructive forces over time.** ♦ Volcanic activity and the folding and faulting of rock layers during the shifting of the Earth's crust affect the formation of mountains, ridges and valleys. ♦ Glaciation, weathering and erosion change the Earth's surface by moving earth materials from place to place.	**C 18.** Describe how folded and faulted rock layers provide evidence of the gradual up and down motion of the Earth's crust. **C 19.** Explain how glaciation, weathering and erosion create and shape valleys and floodplains. **C 20.** Explain how the boundaries of tectonic plates can be inferred from the location of earthquakes and volcanoes.
Science and Technology in Society – How do science and technology affect the quality of our lives? **7.4 - Technology allows us to improve food production and preservation, thus improving our ability to meet the nutritional needs of growing populations.** ♦ Various microbes compete with humans for the same sources of food.	**C 21.** Describe how freezing, dehydration, pickling and irradiation prevent food spoilage caused by microbes.

Grade 8 Core Themes, Content Standards and Expected Performances	
Content Standards	**Expected Performances**
Forces and Motion – What makes objects move the way they do? **8.1 - An object's inertia causes it to continue moving the way it is moving unless it is acted upon by a force to change its motion.** ♦ The motion of an object can be described by its position, direction of motion and speed. ♦ An unbalanced force acting on an object changes its speed and/or direction of motion. ♦ Objects moving in circles must experience force acting toward the center.	**C 22.** Calculate the average speed of a moving object and illustrate the motion of objects in graphs of distance over time. **C 23.** Describe the qualitative relationships among force, mass and changes in motion. **C 24.** Describe the forces acting on an object moving in a circular path.
Heredity and Evolution – What processes are responsible for life's unity and diversity? **8.2 - Reproduction is a characteristic of living systems and it is essential for the continuation of every species.** ♦ Heredity is the passage of genetic information from one generation to another. ♦ Some of the characteristics of an organism are inherited and some result from interactions with the environment.	**C 25.** Explain the similarities and differences in cell division in somatic and germ cells. **C 26.** Describe the structure and function of the male and female human reproductive systems, including the process of egg and sperm production. **C 27.** Describe how genetic information is organized in genes on chromosomes, and explain sex determination in humans.
Earth in the Solar System – How does the position of Earth in the solar system affect conditions on our planet? **8.3 - The solar system is composed of planets and other objects that orbit the sun.** ♦ Gravity is the force that governs the motions of objects in the solar system. ♦ The motion of the Earth and moon relative to the sun causes daily, monthly and yearly cycles on Earth.	**C 28.** Explain the effect of gravity on the orbital movement of planets in the solar system. **C 29.** Explain how the regular motion and relative position of the sun, Earth and moon affect the seasons, phases of the moon and eclipses.
Science and Technology in Society – How do science and technology affect the quality of our lives? **8.4 - In the design of structures there is a need to consider factors such as function, materials, safety, cost and appearance.** ♦ Bridges can be designed in different ways to withstand certain loads and potentially destructive forces.	**C 30.** Explain how beam, truss and suspension bridges are designed to withstand the forces that act on them.

Curriculum-Embedded Performance Tasks and the Science CMTs

To assess students' understanding of inquiry and the nature of science, the CMT science assessment includes some questions framed within the CONTEXT of the curriculum-embedded performance tasks developed by the Connecticut State Department of Education (see links that follow). By embedding an extended scientific investigation within the context of the school curriculum, the Department hopes to influence science teaching and learning throughout the school year. With this goal in mind, there is no "hands-on" task administered on the day of the science CMT.

The embedded tasks engage students in focused explorations of science concepts using all the inquiry practices described in the science framework. Each embedded task is designed to be part of a larger learning unit described in the science framework, and teachers decide when and how to incorporate them into the curriculum. These inquiry investigations demonstrate how students use science inquiry practices to deepen understanding of a science concept.

Some of the CMT questions that assess scientific inquiry will relate to the scenarios featured in the curriculum-embedded performance tasks. To answer these questions successfully, students DO NOT have to recall the SPECIFIC DETAILS or a single "RIGHT" ANSWER to any performance task. In fact, the embedded tasks are open-ended investigations designed to support students' development of scientific thinking skills, and therefore have no single "correct" outcome. Students who have had NUMEROUS opportunities to make observations, design "fair tests," collect data and form evidence-based conclusions are likely to be able to answer the task-related CMT questions correctly, even if they have not done the state-developed performance tasks. However, familiarity with the context referred to in the test question may make it easier for students to answer the questions correctly.

Below are links to the elementary and middle school Curriculum Embedded Performance Tasks and Teacher Manuals:

- Grade 3 – Soggy Paper

  Student Materials [English 153KB, DOC] | [Spanish 162 KB, DOC]

  Teacher Manual [English 225KB, DOC]

- Grade 4 – Go With The Flow

  Student Materials [English 66KB, DOC] | [Spanish 72KB, DOC]

  Teacher Manual [345KB, DOC]

- Grade 5 – Catch It

  Student Materials [English 410KB, DOC]| [Spanish 423KB, DOC]

  Teacher Manual [523KB, DOC]

- Grade 6 – Dig In

  Student Materials [127KB, DOC]

  Teacher Manual [DOC]

- Grade 7 – Feel The Beat

  Student Materials [128KB, DOC]

  Teacher Manual [177KB, DOC]

- Grade 8 – Shipping And Sliding

  Student Materials [184KB, DOC]

  Teacher Manual [250KB, DOC]

PART II

EFFECTIVE INSTRUCTIONAL STRATEGIES

PRACTICAL INSTRUCTIONAL STRATEGIES TO IMPROVE STUDENT ACHIEVEMENT IN SCIENCE

The Connecticut Mastery Test (CMT) in science is designed to assess students' understanding of fundamental science ideas and practices. Grasping key science concepts, such as natural selection or Newton's laws of motion, happens as a result of many carefully selected experiences focused on component ideas over a prolonged period of time. Hence, strong performance on the CMT Science Assessment relies on students' science education beginning in kindergarten and continuing each year to engage them in exploring concepts in life, physical and earth/space science at progressively deeper levels of complexity.

A sound science program requires a district science curriculum aligned with state standards, ample instructional time, high-quality instructional materials and science equipment, appropriate lab space and teachers who can confidently and safely implement various instructional and assessment strategies for different students, different purposes and at different times.

Strategy 1: FOCUS ON ESSENTIAL KNOWLEDGE AND INQUIRY PROCESSES. Imagine the futility of trying to cover everything that is included in a science textbook and expect students to make sense of, retain and build on all that information. Because the study of science can include a vast array of fascinating topics, from astronomy to zoology, it is important to allocate ample learning time and resources for in-depth exploration of the key concepts that are most important for students to learn. One way to ensure success on the science CMT is by focusing instruction on the concepts and abilities described in Connecticut's science framework and standards. Aligning science curriculum to the learning progressions defined in the state science standards will help teachers to use instructional time efficiently, avoid redundancy, improve consistency in what is taught throughout the district, and focus on developmentally appropriate concepts. Work with colleagues to trim a "mile-wide, inch-deep" curriculum that may result in incomplete coverage of many topics rather than mastery of key concepts.

Strategy 2: CHOOSE "MEANINGFUL" LEARNING ACTIVITIES. It is often said that students learn science best when it is a "hands-on" experience. Although students clearly enjoy these opportunities to "do" science, hands-on activities alone do not necessarily lead to "minds-on" understanding of science concepts, what science is, or how scientists work. Meaningful learning activities help students make sense of science ideas and techniques. To prepare students to respond to a range of CMT questions that assess basic factual knowledge, conceptual understanding and application of knowledge, teachers should purposefully select each learning activity based on its potential to help students acquire basic factual knowledge (e.g., identifying structures of plant cells), conceptual understanding (e.g., understanding how the cell membrane regulates materials entering and leaving the cell), or to apply knowledge to solve problems (e.g., how does acid rain affect plant growth). Activities that focus solely on cultivating "process skills" in isolation from science knowledge should be avoided. Instead, use scientific investigation as the vehicle for refining students' abilities to use inquiry science practices to build understanding of a targeted science concept. This approach will prepare students to respond to CMT questions that require students to explain or apply science concepts or inquiry processes.

Strategy 3: MAKE LEARNING RELEVANT AND INTERESTING. In a textbook-driven curriculum, students often ask, "Why do we have to learn this?" When students cannot see a purpose for learning science, knowledge retention can quickly fade after the end-of-chapter test (or even sooner!) Among the best ways to prepare students for cumulative tests like the CMT is through learning experiences that place Framework science concepts in a context of questions, problems and social issues that are interesting and relevant to students' lives. The immediate school or neighborhood surroundings, sports, music, art, national news or family health and nutrition all provide motivating contexts that draw students into their learning. For example, consider the contrast between an ecosystems learning unit in which students read a textbook page that defines terms such as food chain, producer and consumer, compared to a contextualized unit during which students inventory living and nonliving things on the school playground, explore the impact of an invasive weed on the biodiversity of the area over time, and develop strategies to intervene.

Strategy 4: FOLLOW AN INQUIRY-ORIENTED INSTRUCTIONAL SEQUENCE. The traditional instructional approach has been to pre-teach content and then have students follow a prescribed procedure to confirm the pre-taught content. Among the limitations of this approach are that (1) it fails to get students thinking about a possible explanation to a problem, (2) it promotes the misunderstanding that science is the act of memorizing facts, and (3) it sends the message that experiments are done simply to confirm predetermined outcomes. An effective strategy for activating student thinking is to sequence instruction so that students first explore their own ideas about a science phenomenon and then compare their findings with peers and with established science at strategic points throughout the investigation. For instance, begin the study of electric circuits by having students explore different ways they can light a bulb using batteries and wires. After sharing and comparing their findings, students can learn more about batteries and bulbs using books and websites. What they learn from reading will then raise new questions that can be turned into further experiments and research.

Strategy 5: PROBE PRE-EXISTING IDEAS, PLAN ACCORDINGLY, ASSESS FREQUENTLY. Students come to school with their own ideas about the natural world based on everyday experiences. Some parts of these ideas may be scientifically accurate, but some may not. For example, young children may think that shadows are alive and move willfully on their own. Even though these ideas may be nonscientific, learners cling to them because they are reasonable based on the child's own experiences. To prepare students for the science CMT — a cumulative assessment that requires students to internalize their learning so they can apply it to new situations — teachers need to provide learning experiences that bring students' current thinking to the surface and cause them to refine their initial beliefs, or "change their minds." One strategy many teachers use at the beginning and end of a learning unit is a "K-W-L" chart that lists what students KNOW about a topic, what they WANT to find out, and what they LEARNED. In science, the K-W-L can be modified to: What I NOTICE, what I WONDER, and what I THINK. In this way, it teaches students to observe, question and theorize rather than to state facts that may be inaccurate or not truly understood. Pictures can also be used to track concept development throughout a learning unit. For instance, at several points during a unit about plant life cycles, ask students to draw pictures showing the sequence of plant development and monitor the changes in what is included in their drawings. Another formative assessment strategy involves using a checklist, such as "Listed below are examples of living and nonliving things. Put an X next to the things that could be considered living and explain the 'rule' you used to make your decision."

Strategy 6: USE CURRICULUM-EMBEDDED PERFORMANCE TASKS AND OTHER EXTENDED INQUIRIES. Questions and evidence are at the heart of scientific inquiry. In contrast with traditional school experiments in which students follow instructions that lead to a single "correct" outcome, the CSDE-developed curriculum-embedded performance tasks engage students in authentic scientific investigation. Students examine their assumptions about a scientific phenomenon and learn systematic ways to collect data to test their theories using the inquiry skills spelled out in the science framework for Grades 3-5 (BINQ 1 to BINQ 10) and Grades 6-8 (CINQ 1 to CINQ 10). The performance tasks can be most effective if students are allowed to work collaboratively to make observations, pose testable questions, and design procedures to collect, record and interpret data, even if their methods are not entirely scientific at first. During a post-lab class discussion in which students compare their experimental results, ask them what might explain their different outcomes. Even young students will quickly realize that everyone has to use the same measures and methods in order for their experiments to be "fair tests" and for results to be similar. Ask students "What could we do differently to get our results to be more alike?" Students will want to repeat the experiment, but this time they will be more aware of controlling variables, and they will have learned why this practice is important in order to get reliable data. Incorporate the state-developed curriculum-embedded performance tasks into learning units to prepare students to respond to questions on the science CMT that assess BINQ or CINQ inquiry practices by referring to the contexts of the embedded tasks. Reinforce students' proficiency using BINQ or CINQ skills by weaving them individually into daily science learning and collectively into other full inquiry investigations.

Strategy 7: PROMOTE CLASSROOM DISCOURSE THAT SUPPORTS SCIENTIFIC THINKING. Scientific inquiry begins with questions. But the kinds of questions scientists ask are more like puzzles than the kind of single-answer questions often used in classrooms or on tests. A single-answer question such as "What are the three states of matter" may be good for reviewing factual knowledge, but it does not work well to support the development of complex reasoning, supporting claims with evidence, or generating novel interpretations. Consider the difference in what is revealed about student thinking if the question were to be stated as "What do you know about the different states of matter?" Teachers' probing questions can train students to explore their own thinking and to elaborate their responses. For example, prior to beginning an experiment, ask "What outcome do you predict?" and follow up the initial question with comments such as, "Say more about that" or "What makes you think that?" Encourage active listening among all the students in the class by asking "Does anyone agree or disagree with what Carlos just said?" or "Does anyone want to add or build onto the idea Christina is developing?" By expecting students to support their claims with well-developed evidence, you teach them to expect this of each other. When working collaboratively, students should ask each other, "How do you know that?" or "What evidence do you have?" Foster students' self-reliance by responding to their questions with "How can we find out?" Guide students to elaborate their observations by comparing, for example, different leaves and asking "How are these alike? How are they different?" Help students consider cause and effect relationships by asking "What would happen if…" This kind of discourse leads to deeper engagement with the content being studied, brings to light students' thinking, and helps students to learn the norms followed by a scientific community.

Strategy 8: USE LANGUAGE ARTS AND MATHEMATICS SKILLS TO LEARN SCIENCE. There is no doubt that reading, writing, speaking and listening are integral elements of actively doing science. One useful tool for developing communication and thinking skills is a scientist's notebook that students use to:

- record preliminary ideas;
- make sketches of observations;
- note perplexing phenomena or questions of interest;
- document data collection procedures;
- display data in graphs, charts, etc.;
- explain concepts and findings; or
- identify questions for further study.

On the science CMT, students will respond to some questions by writing brief explanations of phenomena, such as magnetic attraction, electric circuits or moon phases. Teachers should include similar writing assignments in which students describe, explain, analyze, synthesize or evaluate information to continually monitor students' understanding of ideas. In addition, students want to discuss their observations, explain their conclusions and compare their findings with those of others. Specialized science vocabulary will help them to communicate their thoughts and actions effectively. Instead of pre-teaching a list of vocabulary words in isolation from student experiences, introduce technical vocabulary as a "gift" for students to use once they have observations, theories and dilemmas to discuss and debate. It is often said that mathematics is the "language" of science; yet many students believe that mathematics is only done during "math time." Measurement, estimation, finding patterns, representing data in graphs and tables, and analyzing data can all be learned and practiced within the exciting context of a scientific study of butterfly metamorphosis, for example. Have students measure their caterpillars on Day 1 and then again on Day 5. How much has the caterpillar grown? What do you predict its length will be on Day 10? What story do the numbers tell?

Strategy 9: CREATE A SAFE, SUPPORTIVE SCIENCE LEARNING COMMUNITY. Establish a classroom environment in which ALL students are expected to learn and "smartness" is manifested in different ways. Students regularly collaborate in teams and communicate respectfully with each other as well as with the teacher. In a science learning community, students present their findings and hold each other accountable for making precise observations, controlling experiments, and for making logical, evidence-based conclusions. Students express their ideas openly and are encouraged to explore scientifically without fear of failure; students learn even more when studies don't turn out as expected. Students learn critical thinking by focusing on experimental "errors" rather than on an individual being "wrong". During class discussions or when working with partners, students should engage in critiquing and improving others' investigations. On the science CMT, some questions require students to identify scientific questions, differentiate observations from opinions, evaluate the design of a procedure (were variables controlled?), or decide whether a conclusion logically follows from the evidence. Safe and productive science classrooms include appropriate lab space with necessary resources, e.g., water, flat work space, storage. In a well-managed science classroom, teachers teach and consistently enforce rules and procedures for the safe handling of scientific equipment, substances and organisms. Students wear protective goggles, gloves and aprons when necessary and know that their behavior earns them the privilege of doing science.

Strategy 10: COUPLE CURRICULUM PROGRESS WITH ONGOING REVIEW. Be sure to provide numerous opportunities for students to explore and revisit concepts and skills that are included on the science CMT. Make conceptual connections across science topics studied throughout the year and in previous years. Create opportunities to explore a complex concept with numerous experiences and from different perspectives. Embed ongoing review and reinforcement of key concepts from earlier learning units by finding new applications in the current unit. For example, over the course of the school year, elementary students learn about the physics of light, how it travels in straight lines and how its path is changed as it is reflected or refracted by objects. In a life science unit, students build on previous learning as they explore the way light travels through the human eye and is focused, or refracted, to form images. The way in which the sun's light is reflected by the moon and viewed from Earth is the focus of an earth science unit, and students explore how the lenses and mirrors used in telescopes make distant moon features appear larger and closer. To promote understanding and retention of major science ideas, teachers should make frequent connections to prior learning and to real-world applications.

In summary, the best preparation for the science CMT is a coherent, well-supported pK–8 science program that naturally and continually develops scientifically literate students who are prepared to become critical thinkers, creative problem-solvers and informed decision-makers.

A System of Informative Assessments

A statewide standardized assessment like the CMT only tells part of the story about what students know and are able to do in science. It can provide general information about how well students are learning life, physical and earth science, as well as scientific inquiry. In addition, a statewide assessment can be used to compare student performance across schools and districts. To know explicitly what life science concepts students struggle with, however, district and classroom assessments should be used in tandem with CMT results to build a more complete picture of student achievement.

Regular classroom assessments yield information that can be used to inform and pace instruction. Ongoing monitoring of student learning helps teachers know when students have grasped a particular concept and when there is a need to provide additional learning experiences to solidify understanding. Summative assessments at the end of learning units inform students and teachers about how the concepts and skills studied are understood and applied.

Periodic common assessments administered to an entire grade-level can provide valuable information about the effectiveness of curriculum and instruction districtwide. Results can be used to reveal gaps in curriculum or specific content or skills on which to focus intensive instruction.

To get a complete picture of student learning, it is important to extract information from numerous sources, one of which is the Science CMT.

RESOURCES

Designing Effective Science Lessons, McRel, 2006.

How Students Learn Science in the Classroom, National Academies Press, 2005.

Inquiry and the National Science Education Standards, National Academy Press, 2000.

National Science Education Standards, National Academy Press, 1996.

Texas Science Initiative Meta-Analysis of Research on Science Teaching, Texas Education Agency, 2005.

Ready, Set, Science!: Putting Research to Work in K-8 Science Classrooms, National Academies Press, 2008.

Uncovering Student Ideas in Science, NSTA Press, 2005.

PART III

SAMPLE ASSESSMENT ITEMS

INTRODUCTION TO CMT ITEMS

On the science CMT, students will respond to multiple choice questions as well as questions that require short written responses.

The science CMT includes questions that assess science content as well as scientific inquiry. All questions are derived from Expected Performances described in the 2004 Core Science Curriculum Framework. Questions represent a range of difficulty, and are designed to probe different levels of knowledge:

- basic factual knowledge;
- conceptual understanding; and
- ability to apply knowledge to a real-world situation

The level of knowledge measured by an item is independent of its difficulty; that is, a basic factual knowledge question can be difficult, based on the percentage of students who answered it correctly in field tests. Conversely, an application of knowledge question can be considered easy if a large proportion of students answered it correctly in field tests.

This section provides detailed information about:

1. Multiple choice items.
2. Constructed response items.
3. Sample questions.
4. Sample scored student responses with commentary.

MULTIPLE CHOICE ITEMS

Multiple choice items assess what students know about science (content) as well as how science is done (scientific inquiry). On the Elementary Science CMT, some of the multiple choice items assess inquiry using the familiar contexts of the curriculum-embedded performance tasks developed by the Connecticut State Department of Education. On the Middle School Science CMT, inquiry is assessed through a combination of multiple choice items and constructed response items that assess inquiry using the contexts of the curriculum-embedded performance tasks.

Multiple choice questions, also called "selected response" items, have a brief question stem and four answer choices, one of which is the best answer. Students will bubble in their selected response directly in the test booklet.

Sample 1 is an example of an **elementary** multiple choice <u>content</u> item that assesses basic factual knowledge. It is related to Expected Performance B.24:

Sample 1

The opening of a camera controls the amount of light allowed in. Which part of the eye does the same job?

○ The lens

○ The iris*

○ The retina

○ The cornea

Sample 2 is an example of an **elementary** multiple choice content item that assesses conceptual understanding. It is related to Expected Performance B.6:

Sample 2

A volcanic rock is black, glossy, and smooth. How did this rock **most likely** form?

- ○ Rapidly, on the Earth's surface*
- ○ Rapidly, beneath the Earth's surface
- ○ Slowly, on the Earth's surface
- ○ Slowly, beneath the Earth's surface

Sample 3 is an example of an **elementary** multiple choice content item that assesses application of knowledge. It is related to Expected Performance B.1:

Sample 3

A student found a piece of metal. What could the student do to quickly determine if the metal might contain iron?

- ○ Heat the metal
- ○ Place the metal in water
- ○ Place the metal near a magnet*
- ○ Weigh the metal

Sample 4 is an example of an **elementary** multiple choice item that assesses inquiry. It is related to Expected Performance BINQ.3:

Sample 4

A student thinks that birds eat the same food as squirrels. Which of the following would give her data to answer the question?

- ○ She counts the numbers of birds and squirrels in a park.
- ○ She feeds sugar water to each and records how much they drink.
- ○ She observes squirrels and birds and writes down everything they eat.*
- ○ She puts a squirrel and a bird together in a cage for a week and observes them.

Sample 5 is an example of an **elementary** multiple choice item that assesses inquiry in the context of a curriculum-embedded performance task. It is related to Expected Performance BINQ.10:

Sample 5

Some students did an experiment to find out which type of paper holds the most water. They repeated the experiment 3 times, counting the number of squares used. Their data are shown in the table below.

Number of Squares Needed to Absorb 25 Milliliters of Water

Type of Paper	Test 1	Test 2	Test 3
Paper Napkin	12 squares	13 squares	11 squares
Paper Towel	6 squares	5 squares	7 squares
Toilet Paper	10 squares	8 squares	6 squares
Tissue	10 squares	8 squares	9 squares

What should the students do next to answer their question?

- ○ Show all the numbers in a bar graph
- ○ Show all the numbers in a pie chart
- ○ Find the average number of squares for each paper type*
- ○ Find the highest number of squares used in Test 1, 2, or 3

Sample 6 is an example of a **middle school** multiple choice content item that assesses basic factual knowledge. It is related to Expected Performance C.15:

Sample 6

Which structure is responsible for allowing materials into and out of an animal cell?

- ○ Nucleus
- ○ Cell wall
- ○ Mitochondrion
- ○ Cell membrane*

Sample 7 is an example of a **middle school** multiple choice content item that assesses conceptual understanding. It is related to Expected Performance C.7:

Sample 7

Solids have a definite shape and volume. This is because

- ○ the molecules in solids move past each other easily.
- ○ the molecules in solids stay in a definite location and vibrate.*
- ○ the molecules in solids move freely in all directions.
- ○ the molecules in solids do not move at all.

Sample 8 is an example of a **middle school** multiple choice content item that assesses application of knowledge. It is related to Expected Performance C.1:

Sample 8.

A student dipped a strip of aluminum and a strip of iron into water. The student then exposed the strips to air for one week. What was **most likely** observed one week later?

- ○ The iron strip formed rust.*
- ○ The aluminum strip formed rust.
- ○ Both of the metal strips formed rust.
- ○ Neither of the metal strips formed rust.

Sample 9 is an example of a **middle school** multiple choice item that assesses inquiry. It is related to Expected Performance CINQ.7:

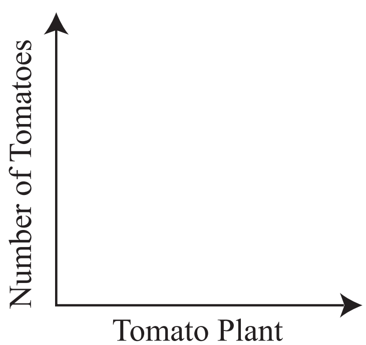
Sample 9

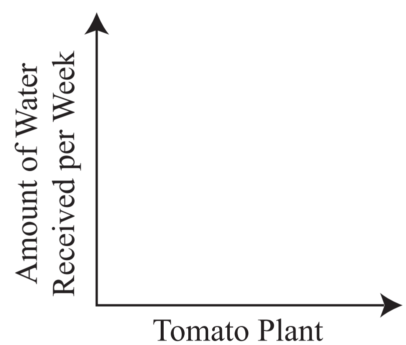
A student planted three tomato plants and gave them different amounts of water each week. She wanted to see how this would affect the number of tomatoes each plant produced. Her data are shown in the table below.

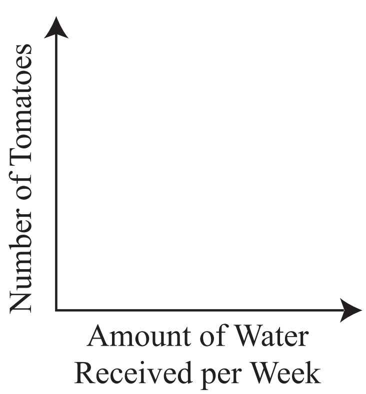
Tomato Plant Data

Tomato Plant	Water Received per Week (mL)	Number of Tomatoes
1	1,000	8
2	800	6
3	600	4

The student needs to make a graph to show her data. Which graph shows correctly labeled axes for these data?







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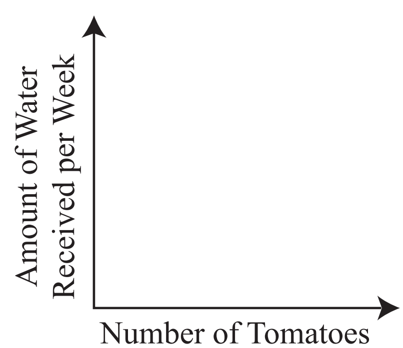


CONSTRUCTED RESPONSE ITEMS

Open-ended questions, also called "constructed response" items, have a question stem that requires a brief written response; generally, two to four sentences. Constructed response items are designed to probe students' understanding of complex ideas. As such, these questions include at least two components and there is no single correct answer; rather, they can be answered fully and correctly in a variety of ways.

Responses to constructed response items are holistically scored. A score of 2 is awarded for a response that fully and accurately answers the question, a score of 1 is awarded for a response that partially answers the question, and a score of 0 is awarded for a response that does not answer the question or is fundamentally inaccurate.

Generic Scoring Rubric for CMT Science Open-Ended Items

Score Point 2

The response is correct, complete and appropriate. The student has demonstrated a strong understanding of scientific concepts and inquiry skills. The response may contain minor errors that will not necessarily lower the score.

Score Point 1

The response is partially correct and appropriate although minor inaccuracies or misconceptions may occur. The student has demonstrated limited evidence of an understanding of scientific concepts and inquiry skills.

Score Point 0

The response is an unsatisfactory answer to the question. The student has failed to address the question or does so in a very limited way. The student shows no evidence for understanding scientific concepts and inquiry skills. Serious misconceptions may exist.

An item-specific scoring rubric is developed for each constructed response item. The item-specific rubric describes the content expected in a complete and accurate response, as well as the content that would be missing from a partial response. Scorers look for evidence of student understanding of the concepts or processes described in the item-specific scoring rubric. A score point is assigned based on the level of understanding demonstrated and the clarity and directness of the response.

On the science CMT, written responses are not penalized for incorrect grammar, spelling, punctuation, sentence structure or overall organization. Most important is that the student writes a clear and understandable response to the question that is asked.

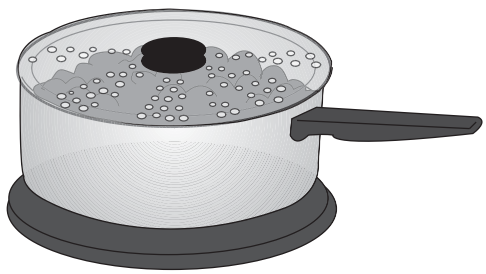
Where appropriate, responses may be in the form of bulleted lists, and students may insert labeled diagrams or tables in order to clarify their thinking. Length of response is not a factor in determining the score; concise responses can provide as much evidence of understanding as lengthy treatises. No scoring advantage is gained by including extraneous details or by rewriting parts of the question in the response. Using technical vocabulary is not required in order to attain a 2 score.

Examples of constructed response items and item-specific rubrics are included in the following section. For each score point, two examples are provided to illustrate the range of student responses that fit within that performance level.

Sample 10 is an example of an **elementary** constructed response item that assesses students' ability to apply science content knowledge to a real-world situation. The science content assessed here is related to Expected Performance B.2. Constructed response items that require a multipart answer, as the one shown below, often provide a "scaffolded" structure that guides students to answer all parts of the question:

Sample 10

Hot water is poured into a pot and covered with a lid. Over time, water droplets begin to form on the inside of the pot lid.



What two processes caused the water droplets to form? Explain how each process occurs.

Process 1: ______________________________

Explanation: ______________________________

____

____

Process 2: ______________________________

Explanation: ______________________________

____

____

SAMPLE 10: ITEM-SPECIFIC SCORING RUBRIC

Possible Response:

Heat causes the water to evaporate, change into steam, or become a gas. Warm steam (water vapor or gas) hits the cool lid. Steam (water vapor or gas) cools and changes (condenses) from a gas back to water droplets.

2-Point Rubric:

Score 2	Explains that heat causes water to change to a gas and cooling causes the gas to change back to a liquid (may use terms "evaporate" and "condense" but not essential)
Score 1	Explains either evaporation <u>or</u> condensation; OR
	Mentions terms "evaporate" and "condense" with no explanation
Score 0	Incorrect explanation or does not answer the question

Sample 10 - Score 2 – Example 1:

Process 1: Evaporation occurs.

Explanation: When water is heated it starts to evaporate, and since the steam can't escape it sticks to the lid.

Process 2: Conuensation occurs.

Explanation: The out side air cools off the steam on the lid and brings the molecules together to form water.

Scorer Commentary: This response explains both evaporation and condensation, and relates both to heating and cooling. Terms are used correctly.

Sample 10 - Score 2 – Example 2:

What two processes caused the water droplets to form? Explain how each process occurs.

Process 1: The heat bellow the water.

Explanation: That's because when you put fire under a metal container the water heats up and evaporates.

Process 2: Heat evaporates the water.

Explanation: That is because when there's a lid over evaporating water it forms back to water.

Scorer Commentary: The response meets the minimum requirements for a 2. It has some extraneous information and incompletely describes condensation.

Sample 10 - Score 1 – Example 1:

Process 1: evaperation.

Explanation: Evaperation happens becauce it's hot and water is just staying there so it turns into air and gets out of the pot.

Process 2: It's very hot.

Explanation: This pot can't hold in all that hot air and water anymore so it lets it out.

Scorer Commentary: The response correctly explains that heat causes water to change to a gas. It does not explain correctly what causes the vapor to change back to a liquid.

Sample 10 - Score 1 – Example 2:

Process 1: Humidity

Explanation: Water evaporates on to the Top.

Process 2: Water Vapor

Explanation: Condinsates in the pot.

Scorer Commentary: The response mentions the terms "evaporates" and "condinsates" [sic], but provides no evidence of understanding either process or the role of heating and cooling.

Sample 10– Score 0 – Example 1:

Process 1: Maybe the lid has holes so air gets onto the food.

Explanation: the holes make air come into the food.

Process 2: The hot processes by the air.

Explanation: If there is fire, the air blows it then there would be some evaporation goin on.

Scorer Commentary: The response has misconceptions about holes in the lid and air getting in. The explanation is not clearly written.

Sample 10 – Score 0 – Example 2:

Process 1: humid

Explanation: Because since it is baikng in there it is humid.

Process 2: Warm

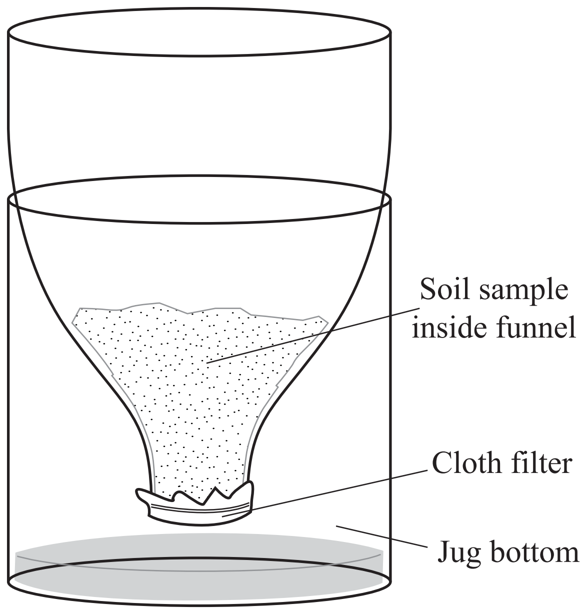
Explanation: Becaus the lid is cover and it's like ~~the~~ it can't breathe.

Scorer Commentary: The response has misconceptions and does not answer the question.

Sample 11 is an example of a **middle school** constructed response item that assesses inquiry in the context of a curriculum-embedded performance task. The inquiry practice assessed here is related to Expected Performance CINQ.8:

Sample 11

A group of students tested different soils to compare how much water they each can hold water. They used the following setup:



They used the following procedure:

1. Put some sand, clay or garden soil into a funnel.
2. Pour water into the funnel and measure how much drips through.
3. Repeat for all 3 soil types.

Describe two improvements that could be made to their procedure. Explain how each improvement would make their data and conclusion more reliable.

SAMPLE 11: ITEM-SPECIFIC SCORING RUBRIC

Possible Response may include any two of the following improvements with an appropriate explanation of its impact:

- Amount of soil should be specified and should be equal (students may use the word weight).
- Should measure soil before and after.
- Volume of water poured through samples should be specified and should be equal.
- Volume of water should be enough so that some will exit and be collected.
- How the water is added to the samples should be specified (all at once, gradually, or over a specified period of time).
- Type of cloth filter should be specified and kept the same in size and type for all samples.
- Amount of filtered water could be subtracted from the starting amount. This gives a more accurate measure of how much water is held in the soil.
- Multiple trials should be done; results should be averaged.

Possible Explanations:

- Enables experiment to be replicated (repeated, confirmed)
- Makes it a more fair comparison of the soils
- Reduces variability in data
- Multiple trials increases confidence in data derived
- Multiple trials reduces the effect of outlying data
- Averaging enables raw data to be processed and conclusion to be drawn
- Any other reasonable explanation

2-Point Rubric:

Score 2 = Two improvements and an explanation for each or one explanation that covers both

Score 1 = Two improvements without an explanation, or one improvement with an explanation

Score 0 = No scientifically valid improvements described

Sample 11– Score 2 – Example 1:

I would have measured the mass of each substance to make sure you have the same amount of everything. I would recommend to do the experiment over about 3 times to see if there were any different results.

Scorer Commentary: *The response correctly states two improvements with brief explanations: soil and water amounts should be specified so they can be kept the same; and multiple trials to see consistent results.*

Sample 11– Score 2 – Example 2:

If they were to do this experiment again, I would make sure to mention to them that they had to use the same amount of water for each soil type. For example, if too much water was put into one type, and too little in the other, it wouldn't be accurate. They also should make sure to put in the same amount of soil in each one for consistency.

Scorer Commentary: The response meets the minimum requirements for a 2. It correctly states that the soil and water amounts should kept the same. The explanation vaguely describes improved consistency and accuracy.

Sample 11– Score 1 – Example 1:

They should measure the amount of soil and water.

Scorer Commentary: *The response states one improvement with no explanation.*

Sample 11– Score 1 – Example 2:

The first reccommendation I have is to use a container with measuring line on it all ready. The I wauld put the san into a strainter and put a cloth on the bottom, the water will drip intr your jug. Your measurements will be more acurate.

Scorer Commentary: The response offers some evidence of understanding of the need to measure substances in the container. There is extraneous information, and no explanation of how measuring would improve the experiment.

Sample 11– Score 0 – Example 1:

I wouldn't use a funnel. I would use a bottle because you would have to put the sand, clay, or garden soil in it first and then the water. With a funnel you aren't able to do that because the soil would fall out before you put the water.

Scorer Commentary: *The response does not answer the question. It describes an alternative procedure, but does not address improvements to its scientific reliability.*

Sample 11– Score 0 – Example 2:

I would tell them to do all different soils at once but in different set-ups so that they can get it done faster and to see wich holds the most water.

Scorer Commentary: The response shows no evidence that the student understands how to control experimental variables.

PART IV

SCIENTIFIC LITERACY TERMINOLOGY
For Classroom Discourse

SCIENTIFIC LITERACY TERMINOLOGY: ELEMENTARY

This list is intended as a guide for teachers. While not exhaustive, it includes vocabulary that should be used, as appropriate, by teachers and students during everyday classroom discourse. It is not intended for student memorization.

absorb
adaptation (adapt)
aluminum
amphibian
analyze
atmosphere
attract
average
balance
battery
beaker
binoculars
boulder
breathe
butterfly
cactus
camouflage
Celsius
centimeter
characteristic
circuit
classify
clay
climate
collect data
compare
conclusion
conclusion based on data
condense
condensation
conduct (an experiment)
conduct (electricity)
conserve
cork
critique
crystal
cycle
data
decrease
describe
determine
diagram
dissolve
draw a conclusion
droplets
drought
ecosystem
environment
erode, erosion
evaluate
evaporate
evaporation
evidence
experiment
explain your reasoning
explain, explanation
explore
extinct
Fahrenheit
fair test
findings
flexible
float
force
freeze
gas
germinate
gills
graduated cylinder
gram
gravity
guitar string
habitat
hand lens
hibernate, hibernation
humid, humidity
hypothesis
identify
increase
insect
insulate, insulator
investigate
kilogram
layer
length
lens
life cycle
liquid
liter
lungs
magnet, magnetic
magnifier
magnifying glass
mammal
mass
materials
melt
metal
metamorphosis
meter, meter stick
migrate
migration
milliliters
mineral
mirror
mixture
motion
natural resources
nutrients
object
observe, observation
offspring
opinion
orbit
organism
oxygen
particles
pattern
pebble
perform an experiment
periscope
photosynthesis
pitch (sound)
planet
pluck (a string)
position
precipitation
predict, prediction
pressure
procedure
process
property
range
record (data)
recycle
reflect
repel
reproduce
reptile
result
reuse
revolve, revolution
rotate, rotation
sand
scale
scientific observation
season
seed dispersal
separate
sequence
shadow
silt
sink (float)
soil
solid
sort
speed
state of matter
stopwatch
strum (a string)
surface
survive
telescope
temperature
tension
testable
texture
thermometer
thorns
transparent
vibrate, vibration
water cycle
weigh, weight

SCIENTIFIC LITERACY TERMINOLOGY: MIDDLE SCHOOL

This list is intended as a guide for teachers. While not exhaustive, it includes vocabulary that should be used, as appropriate, by teachers and students during everyday classroom discourse. It is not intended for student memorization.

adaptation (adapt)
analyze
assumption
atmosphere
average
axis
balance
beaker
boiling point
camouflage
categorize
Celsius
centimeter (cm)
characteristic property
classify
climate
collect data
compare
composition
compound
conclusion
conclusion based on data
condense, condensation
conduct (an experiment)
conserve, conservation
constant
contrast
control
controlled experiment
credibility
critique
cycle
data
decrease
demonstrate
density, dense
dependent variable
describe, description
design
determine
develop
diagram
differentiate
dissolve
draw a conclusion
distinguish
droplets
ecosystem
element
energy transformation
environment
erode, erosion
evaluate
evaporate, evaporation
evaluate
evidence
examine
experiment
experimental design
explain your reasoning
explain, explanation
explore
extinct
Fahrenheit
fair test
findings
force
formulate
friction
function
graduated cylinder
gram
gravity
habitat
hemisphere
hypothesis
identify
increase
independent variable
infer
interact
interpret
investigate
joules
kilogram
life cycle
liter
mass
materials
metal
meter, meter stick
microscopic
milliliter (mL)
mixture
model
moisture
molecule
motion
natural resources
newtons
nonmetal
nutrients
object
observe, observation
offspring
orbit
organism
organize
oxygen
particles
pattern
perform an experiment
photosynthesis
position
precipitation
predict, prediction
pressure
procedure
process
property
range
record (data)
reliability (data)
reproduce
resources
result
revolve, revolution
rotate, rotation
scale
scientific observation
separate
sequence
soluble
solution
speed
state of matter
structure
substance
surface
support with data
survive
synthesize
technique
temperature
tension
tentative
testable question
theory
trials
valid
variable
volume
water cycle
weather, weathering
weigh, weight
work