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ABSTRACT

The Vermont Institute for Science, Math, and Technology (VISMT) and a team of Vermont educators have developed the Vermont Science Assessment in collaboration with CTB/McGraw-Hill. This assessment provides Vermont teachers and school officials with student performance data on scientific understanding as they implement Vermont's Framework of Standards and Learning Opportunities. This assessment is designed to provide schoolwide data on science programs as well as data on individual student performance on five of the content areas in the science, math, and technology section of the Framework. Although the assessment is administered at grades 6 and 11, it does not assess curricula exclusively at those grades but rather the students' accumulated knowledge and understanding of science. The items selected for inclusion sample the domain of science in elementary, middle, and secondary programs according to the Framework. The tasks are available through VISMT and the VISMT Teacher Associates. (ASK)

# Vermont Science Assessment Blueprint

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# Vermont Science Assessment

## Purpose

The Vermont Institute for Science, Math, and Technology (VISMT) and a team of Vermont educators have developed the Vermont Science Assessment in collaboration with CTB/McGraw-Hill. This assessment will provide Vermont teachers and school officials with student performance data on scientific understanding as they implement Vermont's Framework of Standards and Learning Opportunities. The assessment results used in conjunction with other local indicators will help educators make informed decisions on curriculum, instruction, and professional development to enhance the performance of ALL students in science.

This assessment is designed to provide school-wide data on science programs, as well as data on individual student performance on five of the content areas in the science, math, and technology section of the Framework. Although the assessment is being administered at grades 6 and 11, it does not assess curricula exclusively at those grades but rather the students' accumulated knowledge and understanding of science. The items selected for inclusion sample the domain of science in elementary, middle, and secondary programs according to the Framework.

As it samples the field of the Vermont SMT standards, this test will assess student understanding of those standards and WILL NOT evaluate the sum total of every student's scientific knowledge. Also, the integrated SMT performance tasks that were piloted in 1996 ("Terrific Timers" and "Breathing Easy") are not part of this assessment. Local districts are encouraged to consider these as part of their local assessment plans. These tasks are available through VISMT and the VISMT Teacher Associates.

# Vermont Science Assessment

## Assessment Format and Administration

Total number of items equals 20 to 30 multiple-choice items from the CAT 5 item bank and nine to 12 constructed response tasks developed and piloted locally. Each multiple-choice item contributes one point and each constructed response task contributes from three to seven points to the total score. The test is designed to take approximately 3 hours and is arranged in three one-hour sittings. (High school administrators may refer to *Producing Valid Results in Vermont High Schools Using Standardized Assessments: A Guide for Administering Large Scale Assessments in Vermont High Schools* [August 1997], published by the Department of Education and VISMT).

This is a closed book test. The tests should be administered in a quiet place where students can be seated apart from each other and without access to science materials. The only materials a student needs are sharpened pencils. Calculators are not needed, as there are no computations to perform. Students may use rulers to assist in the construction of diagrams, graphs, or tables if they wish.

## Assessment Domain:

The Science Assessment was developed based upon the Vermont Framework. On pages 8-15, you will find the **Standards** and **Evidence** from which the Science Assessment items were selected or developed. Since the Vermont Framework grade groupings do not correspond with a Grade 6 sampling, the domain for assessment for Grade 6 was derived using the Vermont Framework K-4, and 5-8 Standards. Decisions for inclusion of items at Grade 6 or Grade 11 were based upon national science standards (Benchmarks 2061 and the National Research Council Science Standards) and recommendations of CTB/McGraw-Hill.

### Content Areas tested include:

- Inquiry, Experimentation, and Theory — *Standard 7.1, 7.3-.5*
- Systems — *Standard 7.11*
- Physical Science (Space, Time, and Matter) — *Standard 7.12*
- The Living World — *Standard 7.13, 7.14*
- The Universe, Earth, and the Environment — *Standard 7.15*

*Note: The questions on the Design and Technology standards (7.16 – 7.19) are no longer included.*

### Vital Results tested include:

- Communication — *Standard 1.17*
- Problem Solving — *Standard 2.2*

*Note: The Vital Result Standards will be reported within the Inquiry, Experimentation, and Theory standard (7.1).*

For this assessment some of the science, mathematics, and technology (SMT) Standards are not assessed. Therefore, you will find these standards in the Vermont Framework but not in this Blueprint. These standards are either assessed in the mathematics portfolio assessment system or may be assessed via your local assessment plan.

### Content Areas of SMT Field of Knowledge NOT assessed:

- Inquiry, Experimentation, and Theory Standard 7.2
- Mathematical Understanding Standards 7.6, 7.7, 7.8, and 7.9
- Mathematical Problem Solving and Reasoning Standard 7.10
- Design and Technology Standards 7.16, 7.17, 7.18

## Scoring Information Available:

Three types of information both on the **school AND student level** will be available from this assessment. The combination of these three types of information will enable schools to evaluate their curricula and programs in light of the Framework, and at the same time consider a national reference.

1) **norm-referenced data** from a national sample reported as NCEs (normal curve equivalents) based on the CAT 5 items.

2) **total science scores** reported on the following rubric:
   - achieved the standard with honors
   - achieved the standard
   - nearly achieved the standard
   - below the standard
   - little or no evidence

   (see "Understanding the Total Science Score")

3) **criterion-referenced data** pertaining to five content areas in the Vermont Framework reported as scale scores based on the CAT 5 constructed response items.

# Understanding the "Total Science" Score of the Vermont Science Assessment

*The following statements describe what a student might know and be able to do at each of the performance levels for the "total science" score. These "descriptors" were developed by teams of elementary, middle, and high school teachers who participated in the standard - setting for the science assessment.*

## In the Sixth Grade:

**Achieved the standard with honors:** Students know and can apply the maximum body of specialized core elementary facts of science, can articulate abstract ideas, comparisons and relationships, can relate and apply an in-depth understanding of core concepts, models and systems, and use the inquiry process to analyze, evaluate, and design simple experiments.

**Achieved the standard:** Students know and can apply a large body of specialized core elementary facts of science, use appropriate scientific and mathematical vocabulary and representations to communicate ideas, and demonstrate the ability to apply and explain models and systems and can use the inquiry process to understand and design simple experiments.

**Nearly achieved the standard:** Students know and can apply a growing body of specialized core elementary facts of science, are beginning to use appropriate scientific and mathematical vocabulary and representations to communicate ideas, and demonstrate an understanding of some of the components of core concepts, models, systems, and of the inquiry process.

**Below the standard:** Students can identify/ name core scientific facts given a list of word choices or a representation, and show a beginning understanding of core concepts, models, systems, and the inquiry process.

**Little or no evidence:** Students show little or none of the above.

## In the Eleventh Grade:

**Achieved the standard with honors:** Students exhibit exceptional recall spanning a broad knowledge base, use scientific language, notation, and representation effectively to document and explain connections between scientific concepts, understand science concepts at an advanced level, analyze data for use in evaluation, prediction, and exptrapolation, and use understanding of science data and concepts to infer, generalize, and exptrapolate.

**Achieved the standard:** Students exhibit excellent recall of all fundamental facts necessary to conceptual understanding, use scientific language, notation, and representation to communicate solid understanding of scientific concepts,consistently demonstrate understanding of scientific concepts and processes and interpret information for application and problem solving, predict by recognizing data trends, and use understanding of science concepts and data to synthesize, apply, evaluate, explain, and make predictions.

**Nearly achieved the standard:** Students exhibit good recall of basic scientific facts and terminology, use some scientific language, notation, and representation to demonstrate understanding of science concepts, analyze and interpret some data to demonstrate understanding of science concepts and processes, and synthesize, evaluate, and explain some science concepts.

**Below the standard:** Students exhibit significant gaps in the content standards, can identify some scientific language, notation and representation but are unable to use it to demonstrate understanding, cannot use data to demonstrate understanding of science concepts, demonstrate some understanding of science concepts by identifying but cannot synthesize, apply, evaluate, or explain.

**Little or no evidence:** Students show little or none of the above.

# Types of Science Assessment Items

## Types of Science Assessment Items:

**1) Multiple choice**: The multiple choice-questions were carefully selected from the CTB/McGraw-Hill CAT/5 bank of items. Criterion for inclusion on the assessment was based upon alignment with the Vermont Framework. Some multiple-choice items were specifically included to yield the norm-referenced data.

**2) Constructed Response**: These items were developed by a team of exemplary Vermont teachers in partnership with VISMT and CTB/Mc Graw-Hill. Constructed response items require the student to respond to the questions with written text and/or diagrams. The constructed response items were designed to assess scientific understanding and are specifically aligned in their content and structure with the Vermont Framework.

The following sample questions indicate the styles of constructed response questions and demonstrate their alignment with the standards:

## Sample Question Type 1— Experimental Design

*Students are presented with a scientific problem and then asked to explain materials they would need, and procedures they would use to investigate the problem.*

**Standard 7.1: Students use scientific method to describe, investigate and explain phenomena.**

*Evidence:*
c-cc. Create hypotheses for problem, design a "fair test" of their hypothesis, and analyze data to draw conclusions.

### Grade 6 Example

Ellen and Tom decided to make cinnamon rolls. Their recipe instructed them to mix and bake sugar, water, flour, yeast, cinnamon, and butter. As they made the rolls, they observed several physical and chemical changes. They were curious which ingredient/ ingredients produced the gas that made the rolls rise.

A. Design a fair test that Ellen and Tom could use to investigate their question "Which cinnamon roll ingredient/ingredients cause the rolls to rise?"

### Grade 11 Example

British scientists have warned that the massive Larsen B ice sheet is breaking up in Antarctica because of rapid rises in temperature associated with global warming.

A. State a hypothesis that links the effects of global warming to the Larsen B ice sheet.

B. If you were asked to design an experiment to test this hypothesis, list two variables that would be difficult to control and explain why.

## Sample Question Type 2 — Flawed Experiment

*Students are given the procedure, data and conclusion of a flawed experiment, and then are asked analytical questions about the design of the experiment.*

**Standard 7.1: Students use scientific methods to describe, investigate and explain phenomena.**

*Evidence:*
c-cc. Create hypotheses for problem, design a "fair test" of their hypothesis, and analyze data to draw conclusions.

h-hh. Identify problems, purpose implement solutions, and evaluate products and designs.

### Grade 6 example

Ellen and Tom decided to make cinnamon rolls. Their recipe instructed them to mix and bake sugar, water, flour, yeast, cinnamon, and butter. As they mixed the ingredients, they noticed that the rolls started out much smaller than the picture on the package, then grew larger after a period of time. They were curious which ingredient/ingredients made their rolls rise. They designed the following test to investigate their question "which cinnamon roll ingredient/ingredients cause the rolls to rise?"

Step 1: Follow the recipe directions, but leave out the butter and the sugar.

Step 2: Follow the recipe directions, but leave out the water and the yeast.

Step 3: Compare the size of the rolls from step one and step two.

A. This experiment will not allow them to conclude which ingredient caused the dough to rise. Why not?

B. How would you fix the experimental design so that the conclusion they are looking for can be found?

### Grade 11 example

British scientists have warned that the massive Larson B ice sheet breaking up in Antarctica might be breaking up because of rapid rises in temperature associated with global warming. They plan to test the hypothesis that a rapid rise in temperature due to global warming is causing the break up of Larson B ice sheets by implementing the following experimental design:

1) Measure atmospheric carbon dioxide over Larson B ice sheet for a period of one month during the Antarctic summer.
2) Use satellite imaging to measure the area of the Larson B ice sheet, once during the Antarctic winter and once during the Antarctic summer.
3) Repeat steps 1 and 2 over a five year period.
4) Analyze the data to determine of a correlation exists between the amount of carbon dioxide in the atmosphere and the area of the Larson B ice sheet.

A. Using the information presented and the design proposed for this research, state the purpose of this experiment.

B. Give at least two reasons that the recommended procedure may *not* provide sufficient information to draw a valid conclusion for this investigation.

## Sample Question Type 3—Conceptual Understanding

*Students are asked to provide explanations of scientific processes or phenomena in written text and/or diagrams.*

### Grade 6 example

**Standard 7.12: Students understand forces, motion,the properties and composition of matter, energy sources and transformations.**

*Evidence:*
b. Observe and describe changes of states of matter.

AND (from 5-8)
Use the knowledge of behavior and structure of molecules to explain changes in states of matter and differentiate between a chemical and a physical change.

Ellen and Tom decide to make cinnamon rolls. Their recipe instructed them to make and bake sugar, water, flour, yeast, cinnamon, and butter. As they made the rolls, they observed several physical and chemical changes.

A. What is the differences between a physical and a chemical change of matter.

B. Label each of the following changes as chemical or physical:
butter melted
carbon dioxide gas formed in the dough
sugar dissolved in the water
the edge of the rolls burned in the oven

C. Ellen and Tom also noticed some water vapor rising from the rolls. Compare the motion of molecules in the water and the water vapor.

## Grade 11 example

**Standard 7.15: Students demonstrate understanding of the earth and its environment, the solar system, and the universe in terms of the systems that characterize them, the forces that affect and shape them over time, and the theories that currently explain their evolution.**

*Evidence:*
ccc. Identify, model, explain, and analyze the interrelated parts and connections between earth systems (e.g., sun, radioactive decay, and gravitational energy; weather and climate).

British scientists have warned that the massive Larsen B ice sheet is breaking up in Antarctica because of rapid rises in temperature associated with global warming.

A. Explain what is meant by the theory of global warming and mention at least one possible cause of the phenomenon.

The British Antarctic Survey says that the 8,000-square-mile ice sheet is critically unstable and may collapse during the next two years. The survey predicts that such an event could affect the climate as far away as Northern Europe.

B. Explain how a widespread increase or decrease in water temperature in one part of the world could affect the weather in another part of the world.

## Sample Question Type 4 — Data Interpretation

*Students are given experimental data in either narrative form or in a graph or table and are asked to apply that data to a scientific explanation. Alternately, students are given a situation and are asked to create a graph, chart or table to represent that data and then draw conclusions.*

**Standard 1.17: Students interpret and communicate using mathematical, scientific, and technological notation and representation.**

*Evidence:*
a-aa. appropriately represent data and results in multiple ways (e.g. numbers and statistics, charts, tables, models).

Ellen and Tom decided to make cinnamon rolls. Their recipe instructed them to mix and bake sugar, water, flour, yeast, cinnamon, and butter. They knew that yeast produced the gas that would cause the rolls to rise. However, Tom and Ellen wonder if the amount of yeast in a recipe would affect how high the dough will rise. They designed a fair test to investigate their question and recorded the following data.

**Roll Height Data**

| Amount of Yeast(mg) | Height of the Rolls (cm) |
|---|---|
| 0 | 2 |
| 5 | 3 |
| 10 | 6 |
| 15 | 8 |
| 20 | 8 |
| 25 | 8 |

A. Use the data in the table to construct a line graph.

B. According to the data represented in your line graph, does the amount of yeast affect the height of the cinnamon rolls? Explain your answer.

**Text Criticism:** These items consist of text in which a scientific claim is made. The students analyze the validity of the data used to support the claim, and then suggest an experimental design or other kinds of data that may be used to support or refute the claim. (Grade 11 design only).

## Grade 11 example

**Mars Pathfinder Weather Data**

This graph presents a preliminary evaluation of the atmospheric temperature structure encountered by the Mars Pathfinder module during its descent through the Martian atmosphere on July 4, 1997. The temperature profile measured by Viking 1 during its descent to the surface of Mars on July 20, 1976 is shown for comparison.

A key debate in the Martian atmospheric sciences community has been over whether Martian climate has changed significantly since the era of Viking missions. The issue has been whether the lower and middle atmosphere of Mars (altitudes less than 50 km) are "cold" relative to Viking data or whether they are as "warm" as at the time of the Viking.

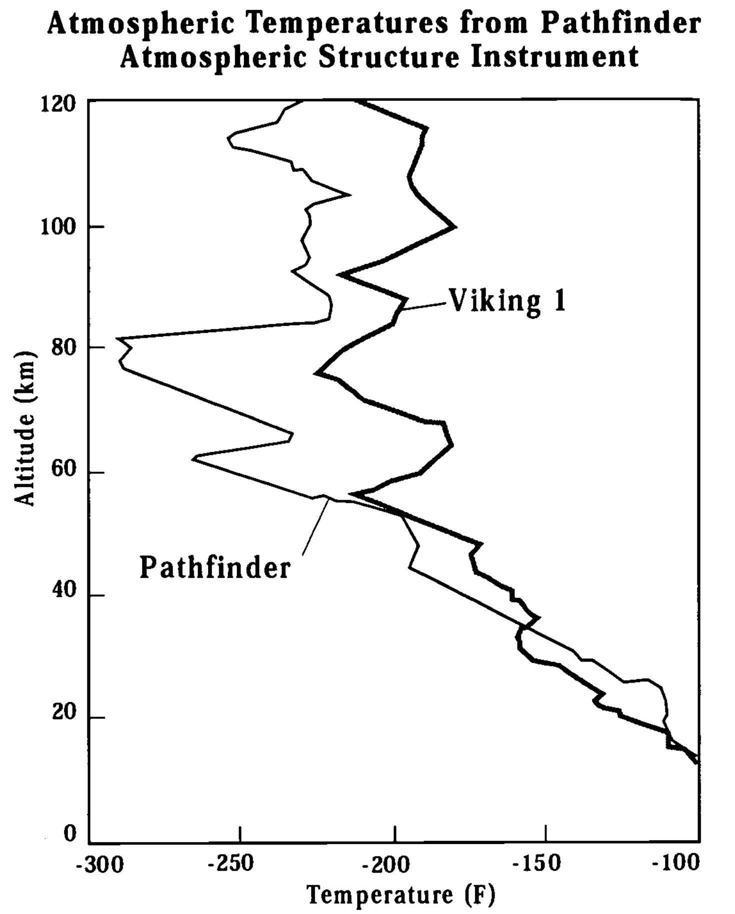
The temperature profile in this figure shows the upper atmosphere of Mars to be quite cold relative to Viking. In fact, at about 80 km altitude, the temperature is the lowest ever measured on Mars – a brisk

-275 degrees Farenheit. The cold temperatures in this region are surprising since Pathfinder entered the atmosphere at 3AM Mars Local Time when the upper atmosphere is cold due to the lack of solar heating. Below 60 km altitude, the temperatures measured by Pathfinder are quite close to those measured by Viking. Therefore, the Pathfinder measurements, which represent one slice through the atmosphere at one location and time, show that the atmosphere is "warm" as it was at the time of the Viking.

A. The temperature profiles for Mars Pathfinder and Viking 1 indicate identical temperatures at several altitudes. List two altitudes that recorded the same temperature for both spacecrafts.

B. The author claims that the atmosphere of Mars today is as warm as it was at the time of Viking 1. Use the graph to explain the evidence that the author uses to make this claim.

C. Give three reasons why the research presented in this article is not sufficient to prove the author's claim.



# Vermont Elementary Science Assessment Domain – Standards and Evidence:

*(Drawn from the Vermont Framework evidence Pre-K-4 and portions of grades 5-8 and tested at the grade 6 level)*

* **Note:** *This is not a sixth grade curriculum. It represents the accumulation of science knowledge and skills from grades PreK-6 as a result of a comprehensive articulated curriculum as outlined in the Vermont Framework of Standards and Learning Opportunities.*

## Scientific Method

**7.1 Students use scientific methods to describe, investigate, and explain phenomena:**

Raise questions;

- Generate alternative explanations — hypotheses — based on observations and prior knowledge;
- Design inquiry that allows these explanations to be tested;
- Deduce the expected results;
- Gather and analyze data to compare the actual results to the expected outcomes; and
- Make and communicate conclusions, generating new questions raised by observations and readings.

*This is evident when students:*

**(PreK-4)**

a. Ask questions about objects, organisms, and events in the world around them

AND **(from 5-8)**

Frame questions in a way that distinguishes causes and effects; identify variables that influence the situation and can be controlled.

b. Use reliable information obtained from scientific knowledge, observation, and exploration

AND **(from 5-8)**

Record and use reliable information obtained from scientific knowledge and observation.

c. Create hypotheses for problems, design a "fair test" of their hypothesis, collect data through observation and instrumentation, and analyze data to draw conclusions; use conclusions to clarify understanding and generate new questions to be explored

AND **(from 5-8)**

Create hypotheses for problems, design a "fair test" of their hypothesis, and analyze data to draw conclusions.

d. Use evidence to construct an explanation, including scientific principles they already know and observations they make

AND **(from 5-8)**

Use and explain evidence to construct an explanation, including scientific principles they already know and observations they make.

e. Explain a variety of observations and phenomena using concepts that have been learned

AND **(from 5-8)**

Explain a variety of observations and phenomena using concepts that have been learned.

f. Use either deductive or inductive reasoning to explain observations and phenomena, or to predict answers to questions

AND **(from 5-8)**

Use either deductive or inductive reasoning to explain observations and phenomena, or to predict answers to questions.

g. Recognize other points of view, and check their own and others' explanations against experiences, observations, and knowledge;

h. Identify problems, propose and implement solutions, and evaluate products and designs

AND **(from 5-8)**

Identify problems, propose and implement solutions, and evaluate products and designs.

## Theory

7.3 Students understand the nature of mathematical, scientific, and technological theory.

*This is evident when students:*
**(PreK-4)**
a. Show understanding that concepts form the foundation for theories

AND **(from 5-8)**

Identify and describe theories that form the basis for scientific concepts.

b. Look for evidence that explains why things happen

AND **(from 5-8)**

Question theories that explain why things happen.

c. Modify explanations when new observations are made or new knowledge is gained

AND **(from 5-8)**

Explain how new theories replace old theories when new knowledge is gained.

## History of Science, Mathematics, and Technology

**7.4 Students understand the history of science, mathematics, and technology.**

*This is evident when students:*
**(PreK-4)**
a. Investigate contributions made to science, technology, and mathematics by many different kinds of people, and explain their importance

AND **(from 5-8)**

Investigate contributions made to science, math, and technology by many different kinds of people, and identify and explain their importance in the development of understanding.

## Systems

**7.11 Students analyze and understand living and non-living systems (e.g., biological, chemical, electrical, mechanical, optical) as collections of interrelated parts and interconnected systems.**

*This is evident when students:*
**(PreK-4)**
a. Demonstrate understanding that systems are made of interrelated parts that influence one another

AND **(from 5-8)**

Demonstrate an understanding that systems are made of interrelated parts, can be connected to other systems, and that one system can affect how others work.

b. Demonstrate understanding that systems include inputs, processes and outputs;

c. Use physical and mathematical models to show how, in a system, inputs affect outputs

AND **(from 5-8)**

Explain understanding, using physical and mathematical models, that systems include inputs, processes, and outputs, and how when one part off the system changes, it changes the other parts.

## Physical Science (Space, Time, and Matter)
### *Matter, Motion, Forces, and Energy*

**7.12 Students understand forces and motion, the properties and composition of matter, and energy sources and transformations.**

*This is evident when students:*
**(PreK-4)**
a. Sort objects and materials according to observations of similarities and differences of properties (e.g., size, weight, color, shape, temperature)

AND **(from 5-8)**

Observe and measure properties of matter (boiling point, melting point) and categorize according to those properties. Observe simple chemical reactions.

b. Observe and describe changes of states of matter (e.g., in water)

AND **(from 5-8)**

Use the knowledge of the behavior and structure of molecules to explain changes in states of matter and differentiate between a chemical and a physical change.

c. Observe and describe the behavior of gases in containers (e.g. , pumps, balloons)

AND **(from 5-8)**

Use the concept of air pressure to explain the behavior of gases in containers.

d. Apply forces to objects (e.g., inertia, gravity, friction, push and pull), and observe the objects in motion

AND **(from 5-8)**

Understand how forces (gravity, inertia, friction, push, pull) act on objects and demonstrate a qualitative understanding of the relationship beween mass, force, and speed.

e. Identify and describe several common forms of energy (e.g., light, heat, and sound) and provide examples of sources, as well as some characteristics of the transmission (e.g., light travels in straight lines until it is reflected, refracted, or absorbed)

AND **(from 5-8)**

Identify several common forms of energy (light, heat, sound, electricity) and describe their characteristics and how they are transmitted (conduction, convection).

f. Observe and record the effects of electric charge (e.g., charges repel, batteries); investigate magnetic and non-magnetic materials, and materials that are conductors and non-conductors of electricity

AND **(from 5-8)**

Understand and explain the components of an electrical circuit and the relationship between electricity and magnetism.

## The Living World: Organisms, Evolution, and Interdependence

**7.13 Students understand the characteristics of organisms, see patterns of similarity and differences among living organisms, understand the role of evolution, and recognize the interdependence of all systems that support life.**

*This is evident when students:*

**(PreK-4)**

a. Identify characteristics of organisms (e.g., needs, environments that meet them; structures, especially senses; variation and behaviors, inherited and learned)

AND **(from 5-8)**

Describe characteristics of organisms (cells, tissues, organs, systems) and identify the relationship between structure and function.

b. Categorize living organisms (e.g., plants; fruits, vegetables)

AND **(from 5-8)**

Classify plants and animals according to common structural characteristics.

c. Describe and show examples of the interdependence of all systems that support life (e.g., family, community, food chains, populations, life cycles, effects on the environment), and apply them to local systems

AND **(from 5-8)**

Describe, model, and explain the principles of the interdependence of all systems that support life (e.g. ecosystems, populations, food chains, life cycles).

d. Provide examples of change over time (e.g., extinction, changes in organisms)

AND **(from 5-8)**

Describe changes over time (e.g. adaptation, variation, extinction) and identify some causes of those changes.

## The Living World: The Human Body

**7.14 Students demonstrate understanding of the human body — heredity, body systems, and individual development — and understand the impact of the environment on the human body.**

*This is evident when students:*

**(PreK-4)**

a. Recognize that there are many similarities between parents and their children, some inherited and some learned

AND **(from 5-8)**

Understand how genetic information is passed through reproduction and identify the systems and structures (cells, nucleus, chromosomes, genes) which are responsible for passing on traits from one generation to the next.

b. Identify the parts of the human body, and demonstrate understanding of how the parts work together to perform functions that satisfy common needs

AND **(from 5-8)**

Demonstrate an understanding of the human body systems for obtaining and providing energy, and defense and protection.

c. Identify and describe environmental factors that can influence human health (e.g., exposure to microbes, pollution)

AND **(from 5-8)**

Understand the processes by which the body develops disease (e.g. exposure to microbes, environmental factors) and how human choices can affect health.

d. Identify the pattern of human development

AND **(from 5-8)**

Identify and explain the pattern of human development.

## The Universe, Earth, and the Environment
### *Theories, Systems, and Forces*

**7.15 Students demonstrate understanding of the earth and its environment, the solar system, and the universe in terms of the systems that characterize them, the forces that affect and shape them over time, and the theories that currently explain their evolution.**

*This is evident when students:*

**(PreK-4)**

a. Identify and record evidence of change over time (e.g., erosion, weathering, fossilization)

AND **(from 5-8)**

Identify and explain evidence of change over time (e.g. erosion, weathering, fossilization, geological formations).

b. Identify and record patterns and forces that shape the earth (e.g., geological, atmospheric)

AND **(from 5-8)**

Identify and explain patterns and forces that shape the earth (e.g. geological, atmospheric).

c. Identify and record the interrelated parts of earth systems (seasons, time, weather, etc.)

AND **(from 5-8)**

Identify and explain the interrelated parts of earth systems ( e.g. seasons, weather patterns, water cycle, crustal plates and land forms).

d. Identify and record characteristics of our solar system (e.g., nine planets, order from sun, and movement of planets in relationship to the sun and moon; calendar

AND **(from 5-8)**

Identify, record, and model the relationship of earth to the other parts of the solar system and to the universe (day/night, year, sun, stars, galaxies).

e. Analyze and explain natural resource management (e.g., properties and uses of earth materials: rocks, soils, water, fish, wildlife, plants, trees, and gases)

AND **(from 5-8)**

Analyze and explain natural resource management and how human activity impacts on the environment (e.g. pollution, recycling, energy use).

AND **(from 5-8)**

f. Identify modern theories of how the universe emerged.

# Vermont Secondary Science Assessment Domain - Standards and Evidence

*(Drawn from the Vermont Framework evidence 5-8 and 9-12 and tested at the grade 11 level)*

* ***Note:*** *This represents the accumulation of science knowledge and skills from grades 7-12 as a result of a comprehensive articulated curriculum as outlined in the Vermont Framework of Standards and Learning Opportunities.*

## Scientific Method

**7.1 Students use scientific methods to describe, investigate, and explain phenomena:**

### Raise questions;

- Generate alternative explanations — hypotheses — based on observations and prior knowledge;
- Design inquiry that allows these explanations to be tested;
- Deduce the expected results;
- Gather and analyze data to compare the actual results to the expected outcomes; and
- Make and communicate conclusions, generating new questions raised by observations and readings.

*This is evident when students:*

**(5-8... evidence PreK - 4 applies plus ...)**

aa. Frame questions in a way that distinguishes causes and effects; identify variables that influence the situation and can be controlled;

bb. Seek, record, and use information from reliable sources, including scientific knowledge, observation, and experimentation;

cc. Create hypotheses to problems, design their own experiments to test their hypothesis, collect data through observation and instrumentation, and analyze data to draw conclusions; use conclusions to clarify understanding and generate new questions to be explored;

dd. Describe, explain, and model, using evidence that includes scientific principles and observations;

gg. Propose, recognize, and analyze alternative explanations.

**(9-12 ...evidence 5 - 8 applies plus ...)**

aaa. Frame questions that can be investigated using scientific methods and knowledge, including manipulating variables, and predicting outcomes for untested hypotheses using scientific principles;

bbb. Critically evaluate the validity and significance of sources and interpretations, including scientific knowledge, observation, and experimentation;

ddd. Formulate and revise explanations and models based on evidence, logical argument, and scientific principles;

ggg. Propose, recognize, analyze, synthesize, and evaluate alternative explanations; and

hh. Identify problems and opportunities, propose designs and choose among the alternatives.

## Theory

**7.3 Students understand the nature of mathematical, scientific, and technological theory.**

*This is evident when students:*

**(5-8 )**

aa. Explain theories based upon observations, concepts, principles, and historical perspective;

bb. Determine the validity of a theory by examining the principles on which it was founded, the constraints that apply to its application, and the body of physical evidence that supports it; and

cc. Show understanding that new theories develop when phenomena are observed that are not fully explained by old theories.

(9-12...evidence 5-8 applies plus ...)

aaa. Use principles and observations to formulate theory and to explain or predict phenomena.

## History of Science, Mathematics, and Technology

**7.4 Students understand the history of science, mathematics, and technology.**

*This is evident when students:*

**(5-12)**

aa. Examine important contributions made to the advancement of science, technology, and mathematics, and respond to their impact on past, present, and future understanding.

## Systems

**7.11 Students analyze and understand living and non-living systems (e.g., biological, chemical, electrical, mechanical, optical) as collections of interrelated parts and interconnected systems.**

*This is evident when students:*

**(5-8)**

aa. Demonstrate understanding that systems are connected to other systems, and that one system affects how others work;

bb. Demonstrate understanding that systems are effectively designed when specifications and constraints are understood; and

cc. Use physical and mathematical models to express how systems behave given a set of inputs or outputs.

**(9-12...evidence PreK-8 applies plus ...)**

aaa. Demonstrate understanding that analysis of systems is important to define and control inputs and outputs; and

bbb. Demonstrate understanding that systems are effectively designed when specifications and constraints are understood; systems are optimized when efficiencies are maximized; and a system is never 100 percent efficient (entropy).

## Physical Science (Space, Time, and Matter)

***Matter, Motion, Forces, and Energy***

**7.12 Students understand forces and motion, the properties and composition of matter, and energy sources and transformations.**

*This is evident when students:*

**(5-8)**

aa. Observe and measure characteristic properties of matter (e.g., boiling point, melting point, density, buoyancy, simple chemical reactions), and use them to distinguish one substance from another;

bb. Provide examples of substances reacting chemically to form new substances with different characteristics, and describe and model the phenomenon with reference to elements and compounds;

cc. Explain the relationships between pressure, volume, and the amount of gas (e.g., soda bottles, auto tires);

dd. Observe and demonstrate a qualitative understanding of the relationship between mass, the magnitude of an applied net force, and the resulting change in speed and direction;

ee. Identify and describe commons forms of energy (e.g., light, heat, sound, electricity, electromagnetic waves) and their attributes, sources, and transmission characteristics (e.g., radiation, convection, conduction of heat); and

ff. Investigate the relationship between electricity and magnetism (e.g., in electric motors).

**(9-12 )**

aaa. Observe and measure characteristic properties of, and chemical reactions between, one substance and another to distinguish between them; explain the structure of matter using the periodic properties of elements;

bbb. Demonstrate an understanding of the atomic structure of matter in relationship to the periodic table, bonding, elements and compounds; demonstrate an understanding of the conservation of matter; understand how radioactive elements decay (e.g., half life, alpha and beta emissions);

ccc. Quantitatively apply ideal gas laws; understand the concept of gas density;

ddd. Use Newton's laws to explain quantitatively the effects of applied forces; observe, explain, and model object motion in a plane; qualitatively investigate conservation of momentum as it relates to collisions, and investigate the mechanics of rolling motion;

eee. Provide examples of transformations of energy from one form to another; provide examples of conservation of energy; and understand that light and some particles have wave and particle properties (diffraction); and fff. Understand that alternating magnetic fields generate electric fields, and vice versa (e.g. generators); discuss electromagnetic waves (e.g. radio waves, x-rays).

## The Living World: Organisms, Evolution, and Interdependence

**7.13 Students understand the characteristics of organisms, see patterns of similarity and differences among living organisms, understand the role of evolution, and recognize the interdependence of all systems that support life.**

*This is evident when students:*
**(5-8)**

aa. Identify, model, and explain the structure and function (e.g., cells, tissues, organs, systems) of organisms (e.g. plants, animals, microbes), both as individual entities and as components of larger systems;

bb. Identify and use anatomical structures to classify organisms (e.g., plants, animals, fungi);

cc. Describe, model, and explain the principles of the interdependence of all systems that support life (e.g., food chains, webs, life cycles, energy levels, populations, oxygen-carbon dioxide cycles), and apply them to local, regional, and global systems; and

dd. Describe evolution in terms of diversity and adaptation, variation, extinction, and natural selection.

**(9-12 )**

aaa. Demonstrate understanding of the uniqueness of the cell in different organisms (plants, animals, microorganisms) and the structures and functions of the cell (e.g., chemical reactions, diffusion of materials, direction by DNA of the synthesis of proteins, regulation, differentiation);

bbb. Demonstrate understanding of how biological organisms are classified into a hierarchy of groups and subgroups based upon similarities that reflect their evolutionary relationships (e.g., plants, animals, microorganisms);

ccc. Describe, model, and explain the principles of the interdependence of all systems that support life (e.g., flow of energy, ecosystems, life cycles, cooperation and competition, human population impacts on the world ecological system), and apply them to local, regional, and global systems; and

ddd. Explain and justify how natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms.

## The Living World: The Human Body

**7.14 Students demonstrate understanding of the human body — heredity, body systems, and individual development — and understand the impact of the environment on the human body.**

*This is evident when students:*
**(5-8)**

aa. Describe how genetic information is passed through reproduction (e.g., genes, traits, chromosomes);

bb. Demonstrate an understanding of the human body systems for obtaining and providing energy, defense, reproduction, hormones, immunity, and coordination of physical functions;

cc. Provide examples of how the health of human beings is affected by their genetic makeup and environmental factors (e.g., exposure to microbes, pollution); and

dd. Identify and explain the human body's pattern of development.

**(9-12)**

aaa. Explain and model how information passed from parents to offspring is coded in DNA molecules (e.g., gene mutations, gene combinations);

bbb Demonstrate an understanding that human beings have complex biochemical systems that enable them to function and reproduce (e.g., immunity);

cc.c Analyze and describe how the health of human beings is affected by diseases passed through DNA, environmental factors, and activities that deliberately or inadvertently alter the equilibrium in ecosystems; and

ddd. Identify, explain, and analyze the pattern of human development.

## The Universe, Earth, and the Environment

*Theories, Systems, and Forces*

**7.15 Students demonstrate understanding of the earth and its environment, the solar system, and the universe in terms of the systems that characterize them, the forces that affect and shape them over time, and the theories that currently explain their evolution.**

*This is evident when students:*

**(5-8)**

aa. Identify, record, and model evidence of change over time (e.g., earth's history: biological, geological);

bb. Identify evidence of, model, and explain the patterns and forces that shape the earth (e.g., atmospheric, geological);

cc. Identify, record, model, and explain the interrelated parts and connections between earth systems (e.g., crustal plates and land forms; atmosphere, water cycle, weather, and oceans);

dd. Identify, record, model, and explain the relationship of our solar system to the universe (day, year, season; sun, stars, galaxies; gravity, energy, orbits; planet characteristics);

ee. Analyze and explain natural resource management and demonstrate an understanding of the ecological interactions and interdependence between humans and their resource demands on environmental systems (e.g., waste disposal, energy resources, recycling, pollution reduction); and

f. Explain how modern views of the universe emerged (e.g., scientific theories, improved instrumentation).

**(9-12)**

aaa. Identify, record, model, and explain evidence of change over time (e.g., origin and evolution of the earth's biological, ecological, geological systems);

bbb. Identify evidence of, model, and explain the patterns and forces that shape the earth (e.g., geological and meteorological processes);

ccc. Identify, model, explain, and analyze the interrelated parts and connections between earth systems (e.g., sun, radioactive decay, and gravitational energy; weather and climate);

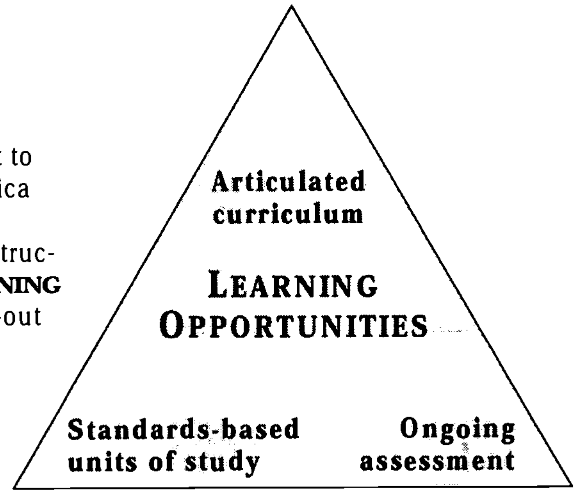
ddd. Identify, model, and explain the position of our solar system in the universe relative to distance and time (stars and star systems, fusion, instrumentation, and simulations; the universe as a hierarchy of interrelated systems);

eee. Analyze and explain natural resource management and demonstrate an understanding of the ecological interactions and interdependence between humans and their resource demands on environmental systems (e.g., production, consumption); and

ff. Explain the emergence of modern views of the universe (past, present, and future scientific theories).

# Preparing for the Science Assessment

In preparing for the Science Assessment, it is most important to remember that the focus of this test is the gaining and application of scientific understanding. Therefore, the best way to prepare is to engage the students in high-quality science instruction and inquiry. Best practice leads us to incorporate the **LEARNING OPPORTUNITIES** of the Vermont Framework into a well-thought-out program of science study that progresses from K-12, that aligns with the Framework, and builds a solid base of knowledge and experience through the **integration of the following:**




## I. Articulated curriculum

Although the tests are being administered at Grades 6 and 11, the knowledge in the frameworks spans pre K-4, 5-8, and 9-12. In order to ensure that ALL students have the opportunity to learn about all the content areas, it is critical that the curriculum of a school or district be coordinated so that the experiences gained in the progression of grades lead to the knowledge contained in the standards.

VISMT is developing a guide to creating a working standards-based curriculum that incorporates the Learning Opportunities.

## II. Use of standards-based units or adoption of materials with the Learning Opportunities

On the classroom level, decisions are made constantly about learning experiences. Learning activities should be chosen carefully in the context of a carefully crafted standards-based curriculum. VISMT has information on programs that align well with the Vermont Frameworks.

## III. Assess student learning

Classroom activities are an important first part of the process. But the critical issue that must always be addressed is, "Does the student understand the scientific concepts underlying the activity?" Assessment of student learning of the standard is an integral part of the learning process. While assessment may be used at the end to evaluate student progress, assessment should also be on-going and embedded in classroom activities, and be designed to determine to what extent the standard has been achieved. Some examples of standards-based classroom assessment are:

- Students keep a lab notebook and record observations, using the data gathered to answer the question, "Why do you think this is happening?"
- Students do a "free-write" to pose and/or answer questions.
- Students generate some general principles based on their observations.
- Students complete constructed response tasks that assess content knowledge as well as understanding of the scientific process.
- Students design and conduct an independent investigation AND
- Develop a rubric that measures their understanding of the concept including criteria for their hypotheses, approaches to the problem, and explanations.
- Students do active inquiry tasks, such as "Terrific Timers" and "Breathing Easy" (see page 1), which assess conceptual understanding as well as inquiry and experimentation.

# Improving Student Results

*The following are* ***suggestions*** *for possible actions to take to improve student performance on the science assessment.*

**If a large percentage of students are below the standard on the Vermont Science Assessment, you might want to consider the following actions:**

- Develop an articulated K-12 science curriculum if none exists
- Seek curriculum expertise in science to help in the development one.
- Look for developmentally appropriate standards-based science resources (ie: textbooks, standards-based units, supporting materials, supplies, library and technology resources, community sources)?
- Ask if the resources support inquiry in science.
- Make sure **every** teacher K-6 teaches science.
- Make sure **every** student K-12 has the opportunity to take science courses that address the full range of standards.
- Make sure **every** teacher K-12 has the content expertise to deliver the standards.
- Make sure **every** teacher integrates the Learning Opportunities ("best practice" pedagogy) into classroom instruction.
- Make sure standards-based assessment used in **every** classroom for frequent student feedback and for making instructional decisions along the way.
- Allocate professional development resources to support improved science knowledge and pedagogy.
- Consider the full range of professional development models from large informational conferences to on-site demonstration of content and pedagogy and make sure **all** teachers have access to the professional development in science.

**If your results show a large percentage of students in the "achieved the standard" and "honors" categories, but there are still students in the "below" or "little evidence" categories, you may want to consider:**

- Disaggregating your data to see who the students in the below the standard categories are. (Are they female, minority, LEP, lower SES, etc.?)
- Check course taking patterns to see if ALL students have the opportunity to access the full range of standards K-12. What courses have they taken? What opportunities have those courses offered?
- Collect any other data that will help determine what is in the way of their achievement? How do they differ from the groups nearly, meeting, and achieving honors?

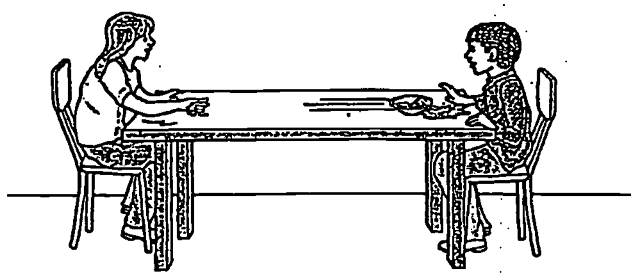
**If your results show an averge percentage of students in the "achieved the standard" and "honors" categories, but more than half are only nearly or below meeting the standard, you may want to consider asking:**

- Is our science program of a high quality, offering access of the full range of the standards to ALL students?
- Are ALL teachers equipped with the content and the pedagogy to not just "cover" the standards, but to enable students to master them?
- Who are the students in the "nearly" category? What courses have they taken? Have they had the same curriculum and opportunities as those meeting the standard?
- How do our results compare to other schools like us? If their results are different, how does their science program differ from ours?

# Grade 6 Released Task

**Standard 7.12**
**Physical science (space, time, matter)**
d. Apply forces to objects (eg. inertia, gravity, friction, push & pull) and observe the objects in motion.

**The laws of force and motion can be used to understand the motions of the planets and stars. They can also be used to understand something as simple as sliding a bowl of soup across a table.**



**In the school cafeteria, your friend slides a bowl of soup quickly across the table to you. The soup sloshes onto her hand as she slides it toward you and then the soup sloshes out in front of you when the bowl comes to a stop.**

---

**Response #1**

This response does not receive credit because, although the student understands that a force is responsible, there is confusion about which force applies in this situation (inertia not mentioned or described).

**Explain why the soup sloshes onto the hand of the student who is pushing the bowl.**

It does this because when it is pushed, it is forced to move because of gravity and it moves a different. It does this because of the force of the person.

**Explain why the soup sloshes out towards you when the bowl comes to a stop.**

It does this because, the soup is pushed then when it stops, the soup is at an angle and the gravity forces the soup to splash to help regain its normal level.

---

**Response #2**

This response receives full credit because, although the word "inertia" is not used, the student clearly understands the concept and knows that it is the force that is operating in this situation.

**Explain why the soup sloshes onto the hand of the student who is pushing the bowl.**

Because you are pushing the bowl not the soup so the bowl goes and the soup stays or wants to stay while the bowl brings it or carries it with the other side.

**Explain why the soup sloshes out towards you when the bowl comes to a stop.**

Because all of a sudden you are stopping the bowl and the soup wants to keep going cause its in motion, like when you are going fast in a car and suddenly you stop unless you have a seatbelt on you keep going but the soup doesn't have a seatbelt.

---

**Key elements for scoring**

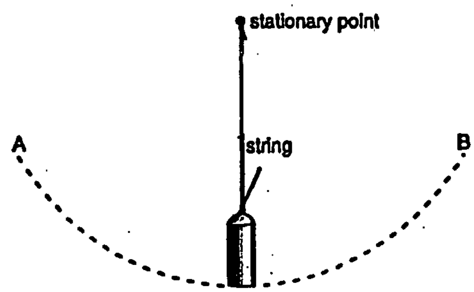
1 pt.: Force is applied to the bowl (push > go; friction > stop)
1 pt. : Soup either stays where it is or keeps on going (inertia)

# Grade 11 Released Task

**Standard 7.12 Physical science (space, time, matter)**

dd. Observe and demonstrate ta qualitative understanding of the relationship between mass, the magnitude of an applied net force, and the resulting chande in speed and direction.

**A pendulum, consisting of a string fixed at one end with a weight (mass) tied to the other end, will swing with a constant period (the period is the time it takes for the weight to go through one complete cycle of swinging motion, from point A to point B in the diagram, and back again).**




**It is well known that if the length of the string is increased, the period will increase, and if the length of the string is shortened, the period will decrease. If the mass is changed, the period does not change.**

---

**Response #1**

This response receives no credit because the incorrect prediction and faulty procedures indicate no understanding of the effect of the length of a pendulum on its period.

**A** **Suppose that, instead of a string and a weight, the pendulum consists of a solid metal bar pivoting from a fixed point at one end of the bar. If the bar is shortened without changing the mass (the bar is made shorter *and* thicker), the period of the pendulum will decrease. Predict what will happen if the mass of the original bar is increased with no change in length.**

The bar will move quicker.

**B** **Describe the steps in a procedure you could use to test your prediction.**

Take a string and bar of the same mass, but in the shapes above and suspend them and let them swing and measure the acceleration of both.

---

**Response #1**

This response receives full credit because the correct prediction and an appropriate test of that prediction indicate understanding of the period of a pendulum.

**A** **Suppose that, instead of a string and a weight, the pendulum consists of a solid metal bar pivoting from a fixed point at one end of the bar. If the bar is shortened without changing the mass (the bar is made shorter *and* thicker), the period of the pendulum will decrease. Predict what will happen if the mass of the original bar is increased with no change in length.**

The Straight Bar will act the same as the String (have the same results)

**B** **Describe the steps in a procedure you could use to test your prediction.**

Get a piece of String the same length of the bar use the Same weight on both String and Bar, then increase both masses on the String and Bar. Both the String and the bar will have the same result in not having the period Change.

---

**Key elements for scoring**

**Part A** 1 pt.: The period will not change

**Part B** 1 pt.: Construct two pendulums of same length, different mass
1 pt.: Compare the two periods

# Questions and Answers
## about the
## Vermont Science Assessment

### Why has VISMT developed a customized science assessment with CTB/McGraw Hill?

CTB/McGraw-Hill is a nationally recognized assessment developer that has worked with other states in developing customized science assessments. Working in partnership with CTB provides the Vermont working group with the necessary technical assistance. While we have used some of the CTB/ McGraw items, we have developed all new constructed response items that align with the Vermont Framework.

### Will the assessment provide student-level results?

**Yes**. The assessment was expanded after the 1996 administration and is now designed to provide school-level AND student-level data relative to five content areas in the Vermont Framework.

### Why assess science at Grades 6 and 11?

Grade 6 was selected because it is a time when students are completing their elementary experience and starting middle school. This information will be useful for elementary schools in reflecting on their programs. Assessing science at Grade 11 provides schools with data on student performance at a time when most students have completed their requirements for high school science. Obtaining data on student performance at this juncture will provide one piece of the information needed to evaluate high school science programs. Science can and should be assessed more often and at various junctures. This should be considered when districts draw up their local assessment plans.

### Are we assessing just the Grade 6 and Grade 11 curricula?

**No.** Although the assessment is being administered at Grades 6 and 11, it is not about the curricula exclusively at those grades. Rather, it is designed to assess students' accumulated understanding of science. The items selected for inclusion, therefore, sample the domain of science expected to be in elementary and secondary programs according to the Framework. For this reason, this assessment can **NOT** be used to draw conclusions about a particular teacher, but **CAN** yield valuable information about a school's science program.

### Will this science assessment provide all the information a school will need to evaluate the effectiveness of its science programs?

**No.** Other forms of assessment and data collection are necessary. Strongly recommended in order to assess active scientific inquiry is the Integrated SMT Performance Task piloted in 1996. Although this task is not part of the mandated state portion of the comprehensive assessment plan, it is available through VISMT along with training and consultation for its use. In addition, since student performance is just one important measure of the effectiveness of science programs, VISMT is committed to helping schools use the student performance data along with other measures of effectiveness to make decisions about programs (i.e., course-taking patterns, curriculum alignment with the Vermont Framework, facilities, teacher preparation).

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