Introduction to the performance standards for *Science*

There are two widely used and respected national documents in science which we have taken into account: the National Research Council (NRC) *National Science Education Standards* (1996) and the American Association for the Advancement of Science (AAAS) Project 2061 *Benchmarks for Science Literacy* (1993). We found the AAAS analysis of the Benchmarks and the NRC Draft to be helpful in seeing the substantial degree of agreement between the two documents. We also consulted New Standards partner statements about standards and international documents, including the work of the Third International Mathematics and Science Study and the Organisation for Economic Co-operation and Development. Many of these sources, like the *Benchmarks*, give greater emphasis to technology and the applications of science than does the NRC.

The framework for the Science performance standards reflects New Standards partner representatives' distillation of these several sources of guidance:

- S1 **Physical Sciences Concepts;**
- S2 **Life Sciences Concepts;**
- S3 **Earth and Space Sciences Concepts;**
- S4 **Scientific Connections and Applications;**
- S5 **Scientific Thinking;**
- S6 **Scientific Tools and Technologies;**
- S7 **Scientific Communication;**
- S8 **Scientific Investigation.**

As the amount of scientific knowledge explodes, the need for students to have deep understanding of fundamental concepts and ideas upon which to build increases; as technology makes information readily available, the need to memorize vocabulary and formulas decreases. There is general agreement among the science education community, in principle, that studying fewer things more deeply is the direction we would like to go. The choices about what to leave out and what to keep are hotly debated. There are 855 benchmarks and the content standards section of the NRC standards runs nearly 200 pages, so there are still choices to be made in crafting a reasonable set of performance standards.

When the goal is deep understanding, it is necessary to revisit concepts over time. Students show progressively deeper understanding as they use the concept in a range of familiar situations to explain observations and make predictions, then use the concept in unfamiliar situations; as they represent the concept in multiple ways (through words, diagrams, graphs, or charts), and explain the concept to another person. The conceptual understanding standards make explicit that students should be able to demonstrate understanding of a scientific concept "by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate)." Both aspects of understanding—explaining and representing—are required to meet these standards.

For most people and most concepts, there is a progression from phenomenological to empirical to theoretical, or from a qualitative to a quantitative understanding. We have chosen one important concept, density, to illustrate the progression. To do this we use "Flinkers" at the elementary school level (see page 136), "Discovering Density" at the middle school level (see Volume 2, page 101), and "The Density of Sand" at the high school level (see Volume 3, page 84). The expectation for any particular concept at any particular level can only be described with a satisfactory degree of precision and accuracy in the degree of detail adopted by AAAS and NRC; we strongly urge users of these performance standards to consult either or both of those documents for guidance on other concepts.

Complementing the conceptual understanding standards, S5 - S8 focus on areas of the science curriculum that need particular attention and a new or renewed emphasis:

- S5 **Scientific Thinking;**
- S6 **Scientific Tools and Technologies;**
- S7 **Scientific Communication;**
- S8 **Scientific Investigation.**

Establishing separate standards for these areas is a mechanism for highlighting the importance of these areas, but does not imply that they are independent of conceptual understanding. The NRC standards, by declaring that inquiry is not only a teaching method but also an object of study, should put the time-worn "content versus process" debate to rest, and focus effort on combining traditionally defined content with process. As the work samples that follow illustrate, good work usually provides evidence of both.

Resources

Reviewers of drafts of these performance standards have pointed out that our expectations are more demanding, both in terms of student time and access to resources, than they consider reasonable for all students. We acknowledge the distance between our goals and the status quo, and the fact that there is a tremendous disparity in opportunities between the most and least advantaged students. We think that there are at least two strategies that must be pursued to achieve our goals—making better use of existing, out-of-school resources and making explicit the connection between particular resources and particular standards.

Best practice in science has always included extensive inquiry and investigation, but it is frequently given less emphasis in the face of competing demands for student time and teacher resources. An elementary teacher faced with the unfamiliar territory of project work in science or a secondary teacher faced with the prospect of guiding 180 projects and investigations can legitimately throw up his or her hands and cry, "Help!" Youth and community-based organizations, such as the Boy Scouts of America, Girl Scouts of the U.S.A., and 4-H, have science education on their agenda. Thus, we have incorporated examples of projects and investigations that are done outside of school to make clear that help is available.

We acknowledge that some of the performance descriptions and examples presuppose resources that are not currently available to all students, even those who take advantage of the out-of-school opportunities available to them. Yet, New Standards partners have adopted a Social Compact, which says, in part, "Specifically, we pledge to do everything in our power to ensure all students a fair shot at reaching the new performance standards…This means that they will be taught a curriculum that will prepare them for the assessments, that their teachers will have the preparation to enable them to teach it well, and there will be an equitable distribution of the resources the students and their teachers need to succeed."

All of the district, state, and national documents in science make explicit the need for students to have hands-on experience and to use information tools. Thus, for example, S6 , Scientific Tools and Technologies, makes explicit reference to using telecommunications to acquire and share information. A recent National Center for Education Statistics survey recently reported that only 50% of schools and fewer than 9% of instructional rooms currently have access to the Internet. We know that this is an equity issue—that far more than 9% of the homes in the United States have access to the Internet and that schools must make sure that students' access to information and ideas does not depend on what they get at home—so we have crafted performance standards that would use the Internet so that people will make sure that all students have access to it. Since the New Standards partners have made a commitment to create the learning environments where students can develop the knowledge and skills that are delineated here, we hope that making these requirements explicit will help those who allocate resources to understand the consequences of their actions in terms of student performance.

Performance Descriptions *Science*

To see how these performance descriptions compare with the expectations for middle school and high school, turn to pages 232-239.

The Science standards are founded upon both the National Research Council's *National Science Education Standards* and the American Association for the Advancement of Science's Project 2061 *Benchmarks for Science Literacy*. These documents, each of which runs to several hundred pages, contain detail that amplifies the meaning of the terms used in the performance descriptions.

S1 Physical Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

S1 a Properties of objects and materials, such as similarities and differences in the size, weight, and color of objects; the ability of materials to react with other substances; and different states of materials.

S1 b Position and motion of objects, such as how the motion of an object can be described by tracing and measuring its position over time; and how sound is produced by vibrating objects.

S1 c Light, heat, electricity, and magnetism, such as the variation of heat and temperature; how light travels in a straight line until it strikes an object or how electrical circuits work.

Examples of activities through which students might demonstrate conceptual understanding of physical sciences include:

- Investigate the browning process of apple slices and the factors that slow or speed up the process. **1a**
- Use physical properties such as color, texture, or hardness to sort objects into two or more categories; change the categories to include a new object; and explain the rule to another student. **1a, 4a**
- Use diagrams to explain the characteristics of ice melting, water boiling, and steam condensing; and illustrate how these kinds of characteristics can affect environments and the organisms that live in them. **1a, 2a, 2b, 2c**
- Predict the bouncing pattern of a basketball under different throwing conditions using previous observations of force and motion. **1b**
- Make a musical instrument, explain the relationship between sound and shape, and compare this to a structure/function relationship in an organism. **1b, 2a**
- Investigate heat and friction by burning, rubbing, or mixing substances together; explain similarities and differences. **1c**
- Use knowledge of magnetism to predict what materials will be attracted, repelled, or unaffected by a magnet, then conduct an experiment to confirm or reject their predictions. **1c, 3a**

S2 Life Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

S2 a Characteristics of organisms, such as survival and environmental support; the relationship between structure and function; and variations in behavior.

S2 b Life cycles of organisms, such as how inheritance and environment determine the characteristics of an organism; and that all plants and animals have life cycles.

S2 c Organisms and environments, such as the interdependence of animals and plants in an ecosystem; and populations and their effects on the environment.

S2 d Change over time, such as evolution and fossil evidence depicting the great diversity of organisms developed over geologic history.

Examples of activities through which students might demonstrate conceptual understanding of life sciences include:

- Predict how long a plant will live planted in a closed glass jar located by a window; and explain what additional information regarding the plant and the surrounding environment would be needed to improve the prediction. **2a, 1a, 3a, 3b**
- Complete a 4-H animal care project; write a report explaining the growth and development of the animal and present the animal at the county-wide fair. **2a, 2b, 2c, 7a, 8b**
- Make drawings of observations showing the life cycle of a plant or animal. **2b**
- Explain the differences between inherited and environmental features of individuals such as flower colors or bike riding ability and describe the physical characteristics of the environment that could affect these features. **2a, 2b, 2c, 2d, 1a, 4a**
- Plan the supplies and equipment needed for a camping trip and explain their purposes. **2a, 2c, 4b, 4d, M8d, A1c**
- Explain how organisms, both human and other, cause changes in their environments and how some of these changes can be detrimental to other organisms. **2a, 2b, 2c, 2d, 1a, 4a, 4b**
- Use more than one medium such as models, text, drawings, or oral explanations to show how various organisms have changed over time to fill a variety of niches. **2c, 2d, 4a**
- Describe the similarities and differences between fossils and related contemporary organisms and explain how environmental factors contributed to these similarities and differences. **2a, 2c, 2d, 1a, 3a, 3c, 4a**

S3 Earth and Space Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

S3 a Properties of Earth materials, such as water and gases; and the properties of rocks and soils, such as texture, color, and ability to retain water.

S3 b Objects in the sky, such as Sun, Moon, planets, and other objects that can be observed and described; and the importance of the Sun to provide the light and heat necessary for survival.

S3 c Changes in Earth and sky, such as changes caused by weathering, volcanism, and earthquakes; and the patterns of movement of objects in the sky.

Examples of activities through which students might demonstrate conceptual understanding of Earth and space sciences include:

Investigate how the properties of soil can affect the growth of a plant. **3a, 1a, 2a, 2b, 2c, 4a**

Predict what kinds of materials would be useful for different purposes, such as in buildings or as sources of fuel, because of their physical and chemical properties. **3a, 1a**

Observe and keep a record of the shape of the Moon for several months; and then make drawings predicting what will happen during the next week. **3b, 3c**

Make observations of the changes in an object's shadow during the course of a day and investigate the source of the variation. **3b, 3c**

Write a story that describes what happens to a drop of water and the physical environment through which it flows as it travels from a lake to a river via the Earth's atmosphere. **3a, 3b, 1a, 4a**

Collect information from a weather station and use the information to explain the patterns of change from fall to winter in terms of weather and the position and movement of objects in the sky. **3b, 3c, 4a, M1a, M1c, M1f, A1a**

S4 Scientific Connections and Applications

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

S4 a Big ideas and unifying concepts, such as order and organization; models, form and function; change and constancy; and cause and effect.

S4 b The designed world, such as development of agricultural techniques; and the viability of technological designs.

S4 c Personal health, such as nutrition, substance abuse, and exercise; germs and toxic substances; personal and environmental safety.

S4 d Science as a human endeavor, such as communication, cooperation, and diverse input in scientific research; and the importance of reason, intellectual honesty, and skepticism.

Examples of activities through which students might demonstrate conceptual understanding of scientific connections and applications include:

Conduct an experiment to determine which brand of paper towel is the best in terms of form and function, cause and effect, cost and personal preference, and write an advertisement for the brand highlighting findings of the experiment. **4a, 4b, 1a, 3a**

Earn the Webelos Engineer Badge (Boy Scouts of America) or the Brownie Building Art Try-It (Girl Scouts of the U.S.A.) and explain the design of the model. **4b, 4d, 1a, 1b, 1c**

Explain why people should wash their hands when preparing food. **4c, 3c**

Make recommendations to improve the selection of food in the school vending machines so that students can make healthier choices. **4c, 2b, M8a, A1b**

Build a solar cooker and explain what foods can or cannot be cooked safely within the temperature range achieved. **4b, 4c, 2a**

Interview a person who has a job that interests you and write a report explaining how studying science helped the person prepare for the job. **4d**

Samples of student work that illustrate standard-setting performances for these standards can be found on pages 136-158.

The examples that follow the performance descriptions for each standard are examples of the work students might do to demonstrate their achievement. The examples also indicate the nature and complexity of activities that are appropriate to expect of students at the elementary level.

The cross-references that follow the examples highlight examples for which the same activity, and possibly even the same piece of work, may enable students to demonstrate their achievement in relation to more than one standard. In some cases, the cross-references highlight examples of activities through which students might demonstrate their achievement in relation to standards for more than one subject matter.

Performance Descriptions *Science*

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S5 Scientific Thinking

The student demonstrates scientific inquiry and problem solving by using thoughtful questioning and reasoning strategies, common sense and conceptual understanding from Science Standards 1 to 4, and appropriate methods to investigate the natural world; that is, the student:

S5 a Asks questions about natural phenomena; objects and organisms; and events and discoveries.

S5 b Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

S5 c Uses evidence from reliable sources to construct explanations.

S5 d Evaluates different points of view using relevant experiences, observations, and knowledge; and distinguishes between fact and opinion.

S5 e Identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

S5 f Works individually and in teams to collect and share information and ideas.

Examples of activities through which students might demonstrate scientific thinking include:

Evaluate the claims of a new product: describe the questions and evidence required to substantiate the claims; conduct an investigation to test ideas; and evaluate the accuracy of the conclusions. **5a, 5b, 5c, 5e**

Work with others to examine the changes in the flora, fauna, and environment in a one square meter plot, caused by recent construction, explain the observations, and make predictions about the future of this microsystem. **5a, 5b, 5c, 5d, 5f, 2a, 2b, 2c**

Use data from one investigation to generate a prediction and conduct a new investigation. **5a, 5b, 5c, 5e**

Summarize a series of newspaper and magazine articles on a current topic, e.g., El Niño; use multiple sources to evaluate accuracy in the articles; and write a revised article putting all the relevant ideas together. **5a, 5b, 5c, 5d, 3a**

S6 Scientific Tools and Technologies

The student demonstrates competence with the tools and technologies of science by using them to collect data, make observations, analyze results, and accomplish tasks effectively; that is, the student:

S6 a Uses technology and tools (such as rulers, computers, balances, thermometers, watches, magnifiers, and microscopes) to gather data and extend the senses.

S6 b Collects and analyzes data using concepts and techniques in Mathematics Standard 4, such as average, data displays, graphing, variability, and sampling.

S6 c Acquires information from multiple sources, such as experimentation and print and non-print sources.

Examples of activities through which students might demonstrate competence with the tools and technologies of science include:

Collect information from the United States Geological Survey and use the information to identify trends in geologic movement in your hometown or state. **6c, 3a, 3c, 5c**

Conduct a survey of students' electricity and gas use at home, compare the data to that of other students, and select an appropriate way to display the comparative data. **6b, 2c, 4b**

Use telecommunications to compare data on similar investigations with students in another school. **6c**

Use electronic data bases to find out about the nutritional value of food available in the cafeteria and compare with alternative selections or snack foods. **6c, 4c**

S7 Scientific Communication

The student demonstrates effective scientific communication by clearly describing aspects of the natural world using accurate data, graphs, or other appropriate media to convey depth of conceptual understanding in science; that is, the student:

S7 a Represents data and results in multiple ways, such as numbers, tables, and graphs; drawings, diagrams, and artwork; and technical and creative writing.

S7 b Uses facts to support conclusions.

S7 c Communicates in a form suited to the purpose and the audience, such as writing instructions that others can follow.

S7 d Critiques written and oral explanations, and uses data to resolve disagreements.

Examples of activities through which students might demonstrate competence in scientific communication include:

Write and illustrate a creative story to explain the food chain to a younger brother or sister. **7a, 7c, 2c**

Make a poster of charts and graphs to communicate effective nutrition and health habits. **7a, 2a, 4b**

Work with other students to create a skit depicting the sequence of events and the characters in an important scientific discovery. **7c, 4d**

Prepare a report, with graphs, charts, and diagrams, on the optimal number and placement of recycling containers, based on trash disposal data from the classroom and the entire school. **7a, 4b, 6b, M7, A1b**

S8 Scientific Investigation

The student demonstrates scientific competence by completing projects drawn from the following kinds of investigations, including at least one full investigation each year and, over the course of elementary school, investigations that integrate several aspects of Science Standards 1 to 7 and represent all four of the kinds of investigation:

S8 a An experiment, such as conducting a fair test.

S8 b A systematic observation, such as a field study.

S8 c A design, such as building a model or scientific apparatus.

S8 d Non-experimental research using print and electronic information, such as journals, video, or computers.

A single project may draw on more than one kind of investigation. A full investigation includes:

- Questions that can be studied using the resources available.
- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.
- Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify and analyze using skills expected at this grade level (see also Mathematics Standard 4).
- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.
- Recommendations, decisions, and conclusions based on evidence.
- Acknowledgment of references and contributions of others.
- Results that are communicated appropriately to audiences.
- Reflection and defense of conclusions and recommendations from other sources and peer review.

Examples of projects through which students might demonstrate competence in scientific investigation include:

Design, make, and fly kites; modifying the kites so they fly higher, maneuver more easily, or achieve some other goal. **8a, 8c**

Investigate why different plants live in the cracks of the sidewalk in different areas around the school. **8b, 2a**

Design and build a Rube Goldberg device and explain how changing aspects of the design made it work better. **8c, 4b**

Research a particular disease; compare local with national risk factors; and produce an information pamphlet that communicates the characteristics and risk associated with the disease. **8d, 4c**

Make a series of drawings and explain the seasonal succession of plants in a field near the school. **8d, 2b**

With a partner, select an endangered plant or animal in your area; collect information from reference books, magazines, video; debate whether the plant or animal should be saved or allowed to disappear, and why. **8d, 2c, 6c**

Samples of student work that illustrate standard-setting performances for these standards can be found on pages 136-158.

The examples that follow the performance descriptions for each standard are examples of the work students might do to demonstrate their achievement. The examples also indicate the nature and complexity of activities that are appropriate to expect of students at the elementary level.

The cross-references that follow the examples highlight examples for which the same activity, and possibly even the same piece of work, may enable students to demonstrate their achievement in relation to more than one standard. In some cases, the cross-references highlight examples of activities through which students might demonstrate their achievement in relation to standards for more than one subject matter.

Work Sample & Commentary: *Flinkers*

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

The task

Students were instructed to complete a laboratory activity in which they adjusted the mass and/or the volume of an object so that the object would not float on top of water or sink…it would "flink."

The task calls for the student to explore the range of available floating and sinking objects. In order to accomplish the task, it is necessary to combine floating and sinking objects to construct one of the correct density.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision

What the work shows

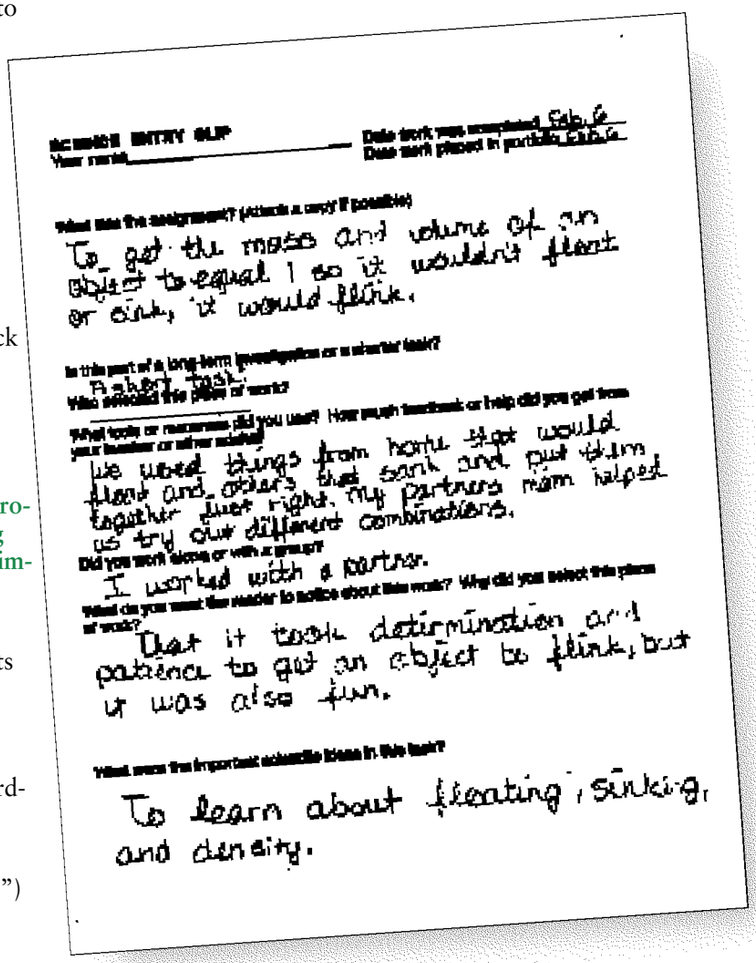
S1 a Physical Sciences Concepts: The student produces evidence that demonstrates understanding of properties of objects and materials, such as similarities and differences in the size, weight, and color of objects….

The drawings provide evidence of sorting objects by observable properties and representing the findings.

A The students sorted common objects into those that floated and those that sank and recorded their findings.

B They used trial and error to find combinations that were neutrally buoyant (that "flinked") and drew the results.

The written summary provides evidence of conceptual understanding of density, an observable and measurable property of objects and materials.



Your name _____ Date work was completed Sept 6
Date work placed in portfolio Sept 6

What was the assignment? (attach a copy if possible)

To get the mass and volume of an object to equal 1 so it wouldn't float or sink, it would flink.

Is this part of a long-term investigation or a shorter task?

A short task

What tools or resources did you use? How much feedback or help did you get from your teacher or other students?

We used things from home that would float and others that sank and put them together just right. My partners mom helped us try out different combinations.

Did you work alone or with a group?

I worked with a partner.

What do you want the reader to notice about this work? Why did you select this piece of work?

That it took determination and patience to get an object to flink, but it was also fun.

What were the important scientific ideas in this task?

To learn about floating, sinking, and density.

C The statement, "To make something flink, the mass and volume had to equal one," is acceptable for the elementary school level. At the middle school level, one would expect the student to discuss density in terms of a ratio; for example, "To make something flink, the ratio of the mass and the volume had to equal one," or "To make something flink, the mass divided by the volume had to equal one." Further, and although this is perhaps taken for granted, an adequate middle school response would make explicit the density of water, which equals one.

D Additional evidence of understanding the concept of density is provided in this sentence which

This work sample illustrates a standard-setting performance for the following part of the standards:

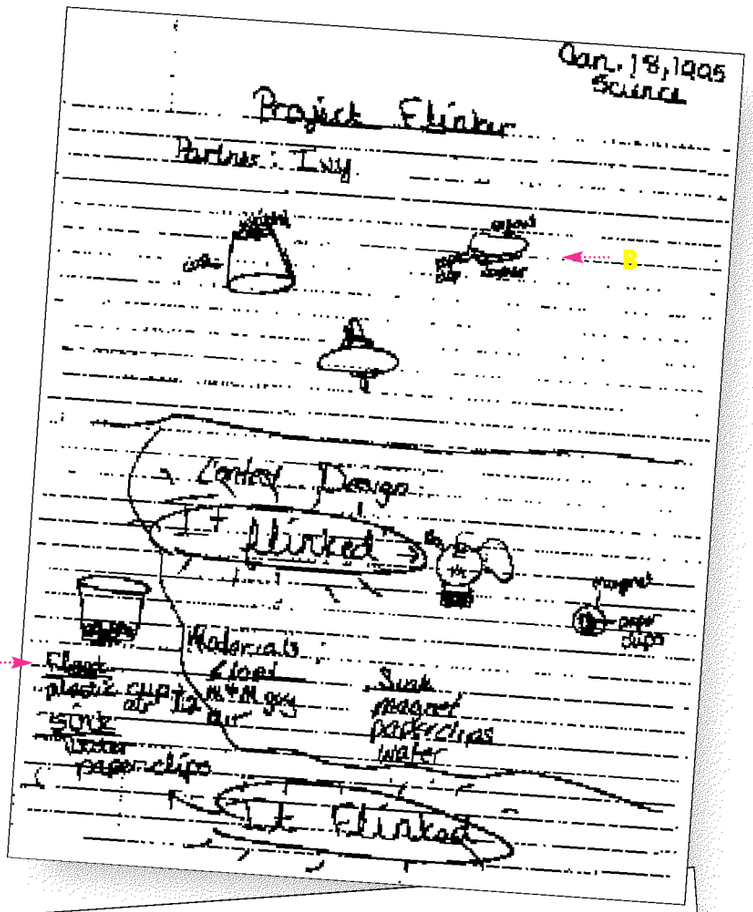
S1 a Physical Sciences Concepts: Properties of objects and materials.

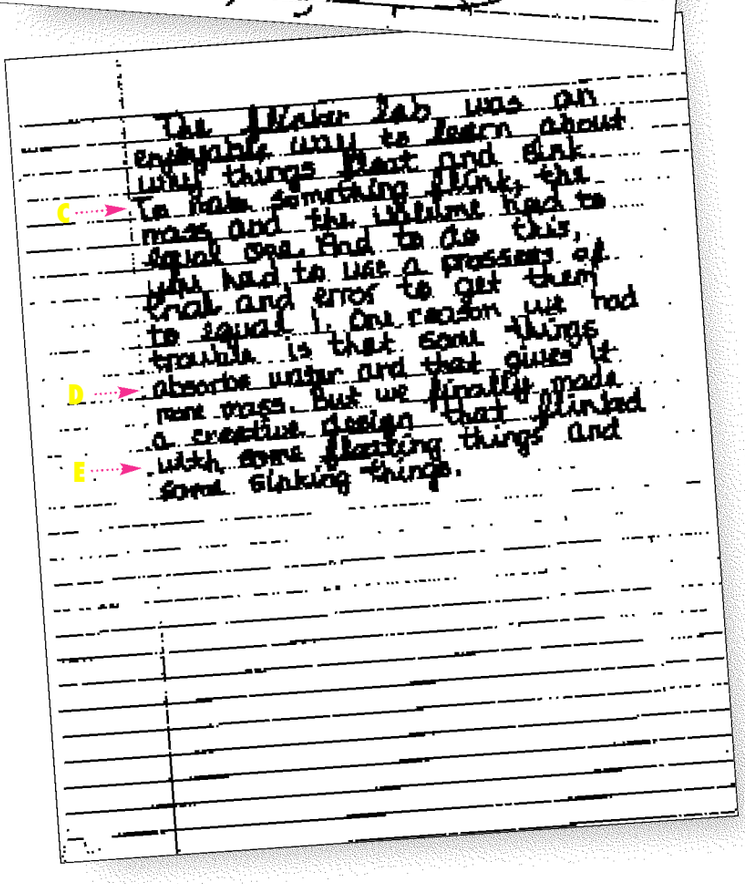
Flinkers

says that the addition of mass changes the buoyancy of the object.

E The final sentence completes the summary with reference to observable properties.

This work is an unrevised piece of homework. There are three spelling errors ("prosess," "absorbe," and "detirmination") and a missing apostrophe.





Work Sample & Commentary: *The Growing Tree*

The task

A small tree is planted in a meadow. After 20 years it has grown into a big tree, weighing 250 kg more than when it was planted. Where do the extra 250 kg come from? Explain your answer as fully as you can.

Circumstances of performance

These samples of student work were produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed (20 minutes)	opportunity for revision

The task was part of a state assessment program and unrelated to the curriculum that the students were studying.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

What the work shows

S2 a Life Sciences Concepts: The student produces evidence that demonstrates understanding of characteristics of organisms, such as survival and environmental support....

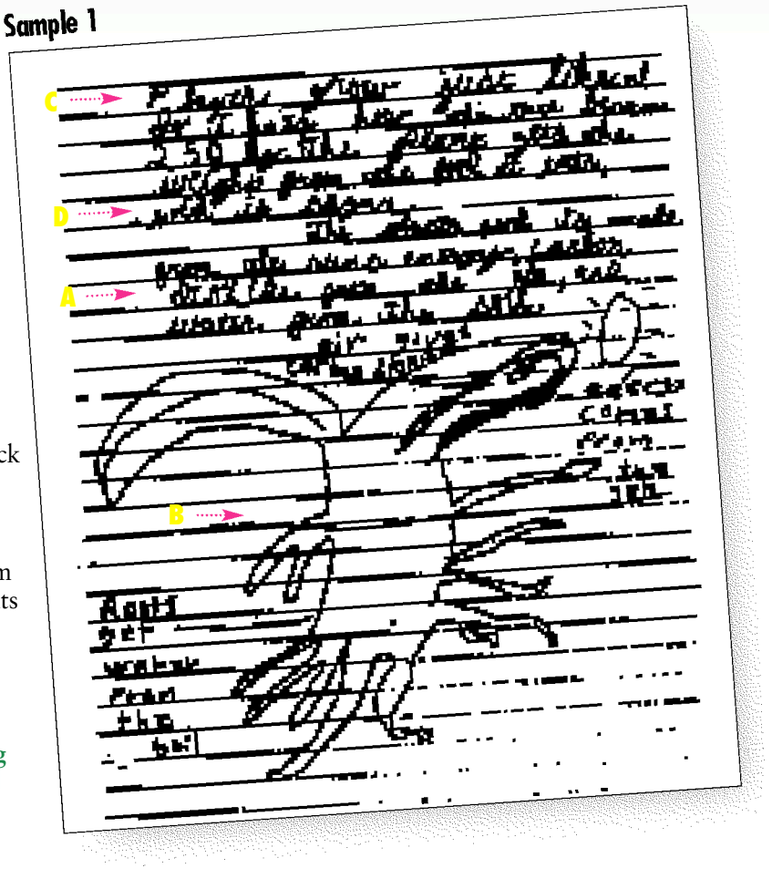
These samples effectively explain and represent the key components of photosynthesis at an appropriate level using simple text.

Sample 1

A Most of the components of photosynthesis are mentioned in the text: energy from the sun, carbon dioxide from the air, and water from the soil; though minerals are omitted.

B The drawing elaborates the text.

Sample 1



C This statement shows an understanding of the comparable ways that plants and animals grow. A more refined understanding would include the mechanism of adding cells, which is not mentioned in this work, and clarify the differences between plant and animal growth, i.e., that plants can and do make their own food while animals cannot. On the latter point, the idea that plants "eat" sugar is a common statement at the elementary level. The significance of the statement depends on what is meant by "eat." If, for example, the student means "take into their cells and use for growth and other life processes," this would be an accurate understanding.

D By recognizing that the plant makes sugar, this statement shows a high level of conceptualization for an elementary student.

These work samples illustrate standard-setting performances for the following parts of the standards:

S2 a **Life Sciences Concepts: Characteristics of organisms.**

S7 a **Scientific Communication: Represent data and results in multiple ways.**

The Growing Tree

S7 a Scientific Communication: The student represents data and results in multiple ways, such as…drawings, diagrams, and artwork….

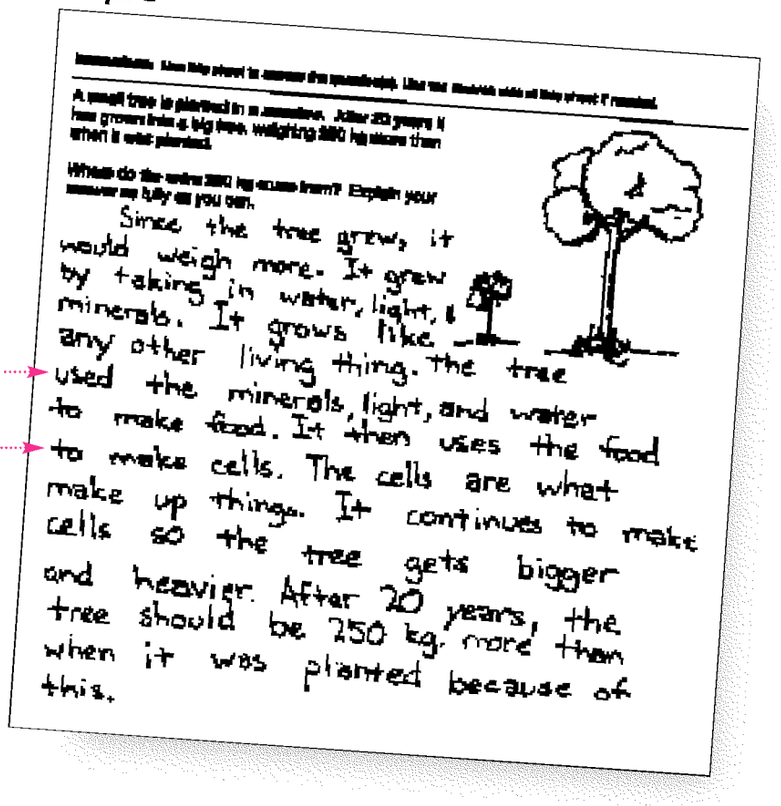
Sample 1 was produced by a student in a special education reading program. Despite the punctuation, capitalization, and spelling errors, this sample effectively uses drawing to strengthen the written response.

Sample 2

E This work also includes three of the four major ingredients of photosynthesis—minerals, water, and light. Mentioning the fourth ingredient and the necessity for the presence of chlorophyll would be required in a middle school response. (See also the high school work sample entitled "Photosynthesis" in Volume 3 of these Performance Standards.)

F The elaboration, that the food is used to make cells and that the plant is made up of cells, shows progress from the elementary level, anticipating the middle school level, where structure and function are more extensively explored.

Sample 2



Since the tree grew, it would weigh more. It grew by taking in water, light, & minerals. It grows like any other living thing. the tree used the minerals, light, and water to make food. It then uses the food to make cells. The cells are what make up things. It continues to make cells so the tree gets bigger and heavier. After 20 years, the tree should be 250 kg. more than when it was planted because of this.

Work Sample & Commentary: *Inside the Rain Forest*

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

The task

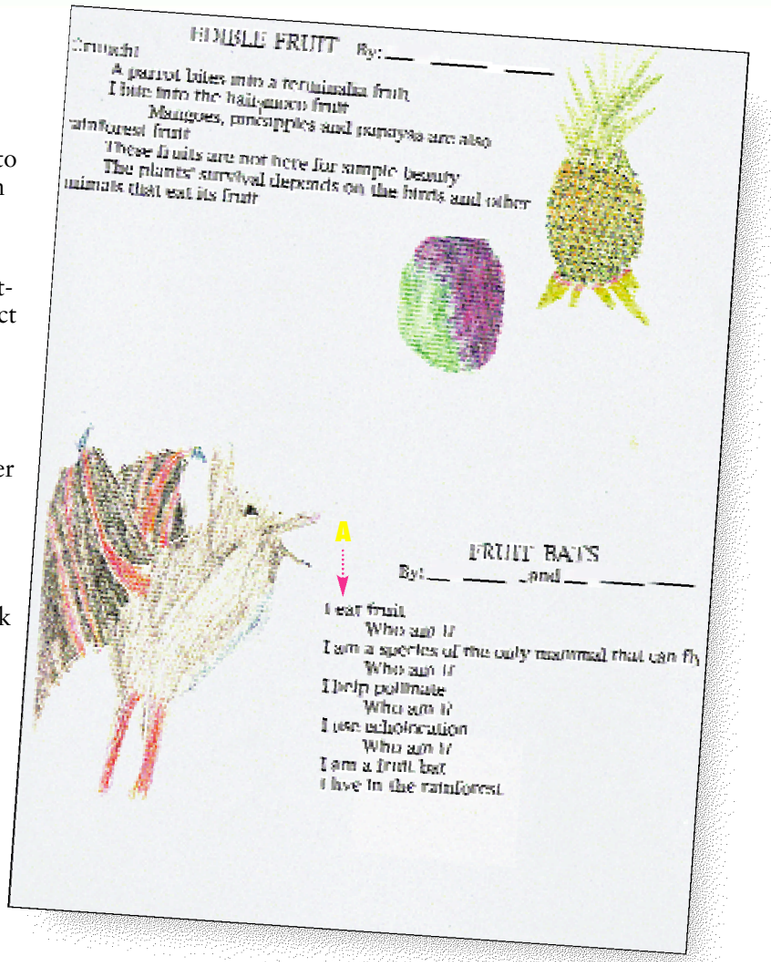
Students in a self-contained class participated in two units of study including poetry and nonfiction. During the poetry unit, they read and analyzed a wide variety of poems and learned how to write poetry. The nonfiction unit was focused on producing informational writing.

Two students asked if they could combine the informational writing assignment with their poetry using a topic that interested them. The product of that assignment was a book of poems on the rain forest which is excerpted here.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision



What the work shows

S2 a Life Sciences Concepts: The student produces evidence that demonstrates understanding of characteristics of organisms, such as survival and environmental support; the relationship between structure and function….

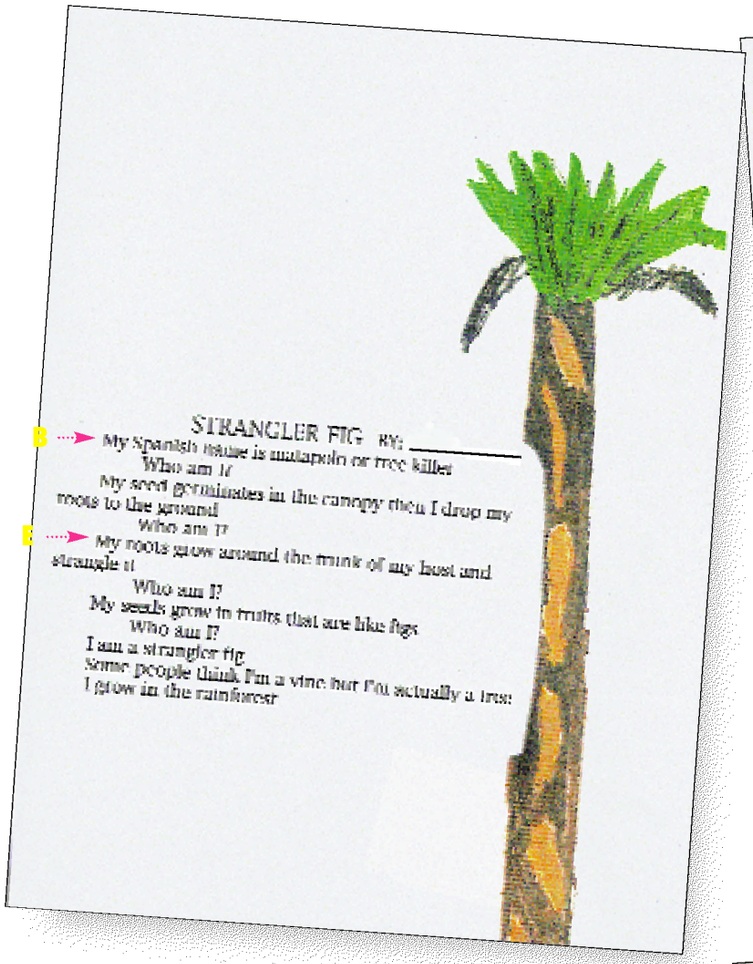
A B Each specific first person ("I" and "My") statement identifies characteristics of a specific organism.

C The importance of bright colors for flower reproduction is evidence of understanding of form and function.

This work sample illustrates a standard-setting performance for the following parts of the standards:

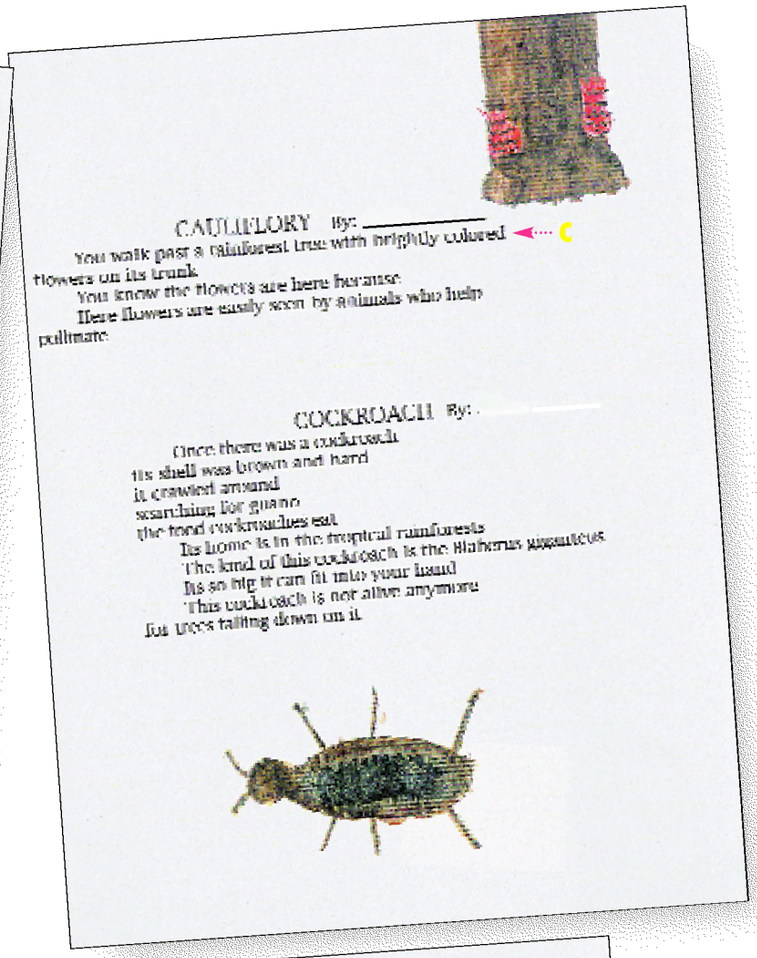
- S2 a **Life Sciences Concepts: Characteristics of organisms.**
- S2 c **Life Sciences Concepts: Organisms and environments.**
- S4 a **Scientific Connections and Applications: Big ideas and unifying concepts.**

Inside the Rain Forest



STRANGLER FIG By: _____

B My Spanish name is matapalo or tree killer
Who am I?
My seed germinates in the canopy then I drop my roots to the ground
Who am I?
E My roots grow around the trunk of my host and strangle it
Who am I?
My seeds grow in fruits that are like figs
Who am I?
I am a strangler fig
Some people think I'm a vine but I'm actually a tree
I grow in the rainforest

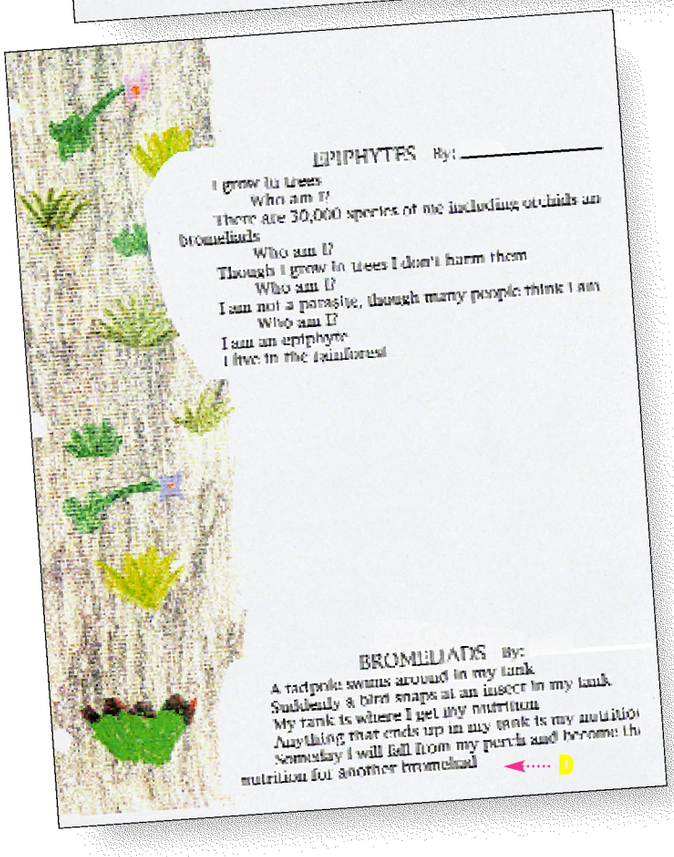


CAULIFLORY By: _____

You walk past a rainforest tree with brightly colored flowers on its trunk C
You know the flowers are here because
Here flowers are easily seen by animals who help pollinate

COCKROACH By: _____

Once there was a cockroach
Its shell was brown and hard
It crawled around
searching for guano
the food cockroaches eat
Its home is in the tropical rainforests
The kind of this cockroach is the Blaberus giganteus
Its so big it can fit into your hand
This cockroach is not alive anymore
for trees falling down on it



EPIPHYTES By: _____

I grow in trees
Who am I?
There are 30,000 species of me including orchids an bromeliads
Who am I?
Though I grow in trees I don't harm them
Who am I?
I am not a parasite, though many people think I am
Who am I?
I am an epiphyte
I live in the rainforest

BROMELIADS By: _____

A tadpole swims around in my tank
Suddenly a bird snaps at an insect in my tank
My tank is where I get my nutrition
Anything that ends up in my tank is my nutrition
Someday I will fall from my perch and become the nutrition for another bromelid D

S2 c Life Sciences Concepts: The student produces evidence of understanding organisms and environments, such as the interdependence of animals and plants in an ecosystem….

D This statement correctly illustrates the dependent relationships between and among the tank, the insects, and the bromeliad.

S4 a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as…form and function….

E The reference to the roots strangling a host tree illustrates understanding of the connection between form and function. This is also evident in a number of places in the remainder of the work.

Work Sample & Commentary: *Drop of Water*

The task

Students who had been studying weather were asked to write a story about a drop of water that goes through the water cycle.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

What the work shows

In an engaging story, this work sample shows conceptual understanding for parts of three standards.

S3 b Earth and Space Sciences Concepts: The student produces evidence that demonstrates understanding of objects in the sky, such as…the importance of the Sun to provide the light and heat necessary for survival.

A The story begins with the important role of the sun.

S1 a Physical Sciences Concepts: The student produces evidence that demonstrates understanding of properties of objects and materials, such as…different states of materials.

B Conceptual understanding of different states of matter is demonstrated in the consistent and accurate relationships among phase, temperature, and volume, particularly the recognition that gases rise, and in the descriptions of how it feels to be a gas ("getting bigger"), to be a solid ("smaller"), and to condense from gas to liquid ("getting really crowded").

My Big Trip
by _____

Good morning. I am Mr. H. Tuoh. I just woke up and the sun is coming up. I have been swimming with my friends in a nice lake in Nebraska. Since I am on top of this pile of sleeping friends the sun is going to take me for a ride today. ← A

Wow, that was fast. I am climbing really fast. I feel bigger. That's because I am a gas . It happens every time I get hot. When I get cold I get smaller. They call me a solid. Being solid gives me a headache. This is better than World's of fun! There is a big cloud ahead and we are slowing down. I am getting smaller now because my pants fit better. But, it's getting really crowded!!! I can hardly move. Who let in the ugly dust family? I think I will hang on to this dust guy so I can rest up. Hey, everybody is copying my idea and we are getting heavy. Oh Noooooooooooooooo we are falling!!! But that's OK because I was getting really cold. ← B ← C

What a trip. I am almost back to the lake. Wait, where is the lake. This looks like a big river . I don't think I am going to hit the river. Oh noooooooooo .I better put on my crash helmet and prepare for a land landing. OUCH! That hurt. But, at least I am down. hey, we are moving again. These dirt and rock hurt. Do they have to come along on MY trip?

This work sample illustrates a standard-setting performance for the following parts of the standards:

- **S1 a Physical Sciences Concepts: Properties of objects and materials.**
- **S3 a Earth and Space Sciences Concepts: Properties of Earth materials.**
- **S3 b Earth and Space Sciences Concepts: Objects in the sky.**
- **S4 a Scientific Connections and Applications: Big ideas and unifying concepts.**

Drop of Water

S3 a Earth and Space Sciences Concepts: The student produces evidence that demonstrates understanding of properties of Earth materials, such as water and gases….

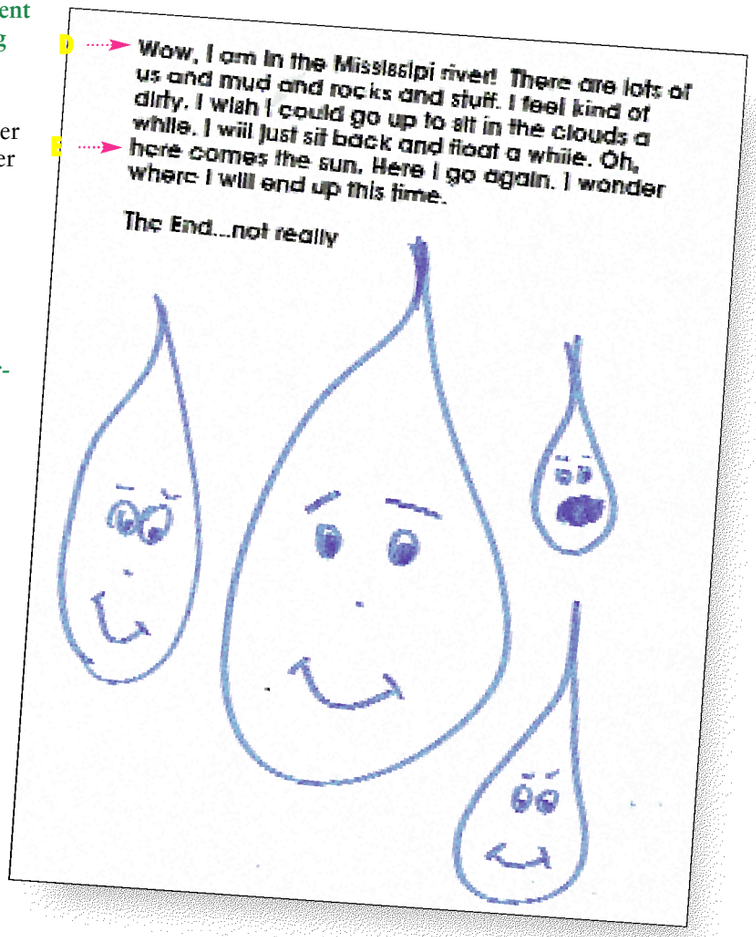
C The role of dust as something upon which water can condense is evidence of understanding the water cycle.

D The arrival in the Mississippi River, not in the original lake in Nebraska, shows further understanding of the water cycle.

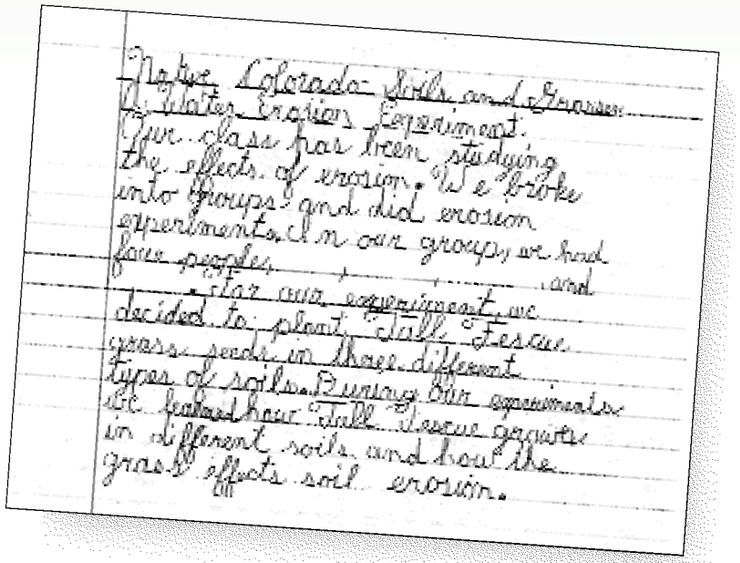
S4 a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as…change and constancy….

E The final sentences, especially the conclusion, "The End…not really," go beyond an understanding of the water cycle to suggest understanding of a unifying concept, change and constancy.

The response is distinguished by the representation of an abstract concept with clarity (i.e., molecular spacing and movement of water through the water cycle). The discussion of evaporation and condensation provide a more powerful explanation of the water cycle and demonstrates thorough understanding.



Work Sample & Commentary: *Erosion*


Name Colorado Soils and Grasses
Water Erosion Experiment.
Our class has been studying
the effects of erosion. We broke
into groups and did erosion
experiments. In our groups we had
four people, , , and
. for our experiment we
decided to plant Tall Fescue
grass seeds in three different
types of soils. During our experiment
we learned how Tall Fescue grows
in different soils and how the
grass affects soil erosion.

The task

An elementary class was involved in a year-long, interdisciplinary study of their state. On a field trip to a conservation center, they learned about wind and water erosion. When they returned, they wanted to learn more about erosion and which combinations of soil and grass were most effective in preventing erosion.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages132-135.

What the work shows

The first page explains that this group of students examined Tall Fescue grass. Other groups in their class studied Perennial Rye, Crested Wheat, and Irrigated Pasture Mix (a mixture of these three and two other types). The second, third, and fourth pages explain the question, hypothesis, and procedures. The fifth page shows the plan for studying soils; the sixth, seventh, and eighth pages show the observations from the three soil types. The results of the soils' analysis (without grass) are summarized on page 9. The next three pages (10-12) show the results of the same procedure for the same soils planted with Tall Fescue. The final page (13) summarizes the work.

This work sample illustrates a standard-setting performance for the following parts of the standards:

- **S3 a Earth and Space Sciences Concepts: Properties of Earth materials.**
- **S4 a Scientific Connections and Applications: Big ideas and unifying concepts.**
- **S5 a Scientific Thinking: Ask questions about natural phenomena; objects and organisms; and events and discoveries.**
- **S5 e Scientific Thinking: Identify problems; propose and implement solutions; and evaluate the accuracy, design, and outcomes of investigations.**
- **S6 a Scientific Tools and Technologies: Use technology and tools.**
- **S7 a Scientific Communication: Represent data and results in multiple ways.**
- **S7 b Scientific Communication: Use facts to support conclusions.**
- **S7 c Scientific Communication: Communicate in a form suitable to the purpose and audience.**

S3 a Earth and Space Sciences Concepts: The student produces evidence that demonstrates understanding of properties of Earth materials, such as…the properties of rocks and soils such as texture, color, and ability to retain water.

A B C There is ample evidence that the students have an understanding of erosion.

S4 a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts such as…cause and effect.

A B C D These pieces and the ending also show a good understanding of cause and effect.

S5 a Scientific Thinking: The student asks questions about natural phenomena; objects and organisms; and events and discoveries.

D The entire investigation came from students' questions about natural phenomena. The question and hypothesis are clearly stated.

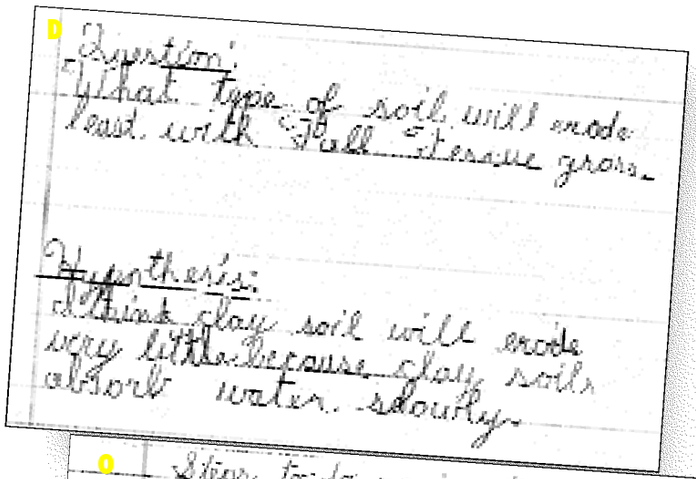
S5 e Scientific Thinking: The student identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

E The conclusion shows that students were focused on the best combination of grasses and soils to prevent erosion.

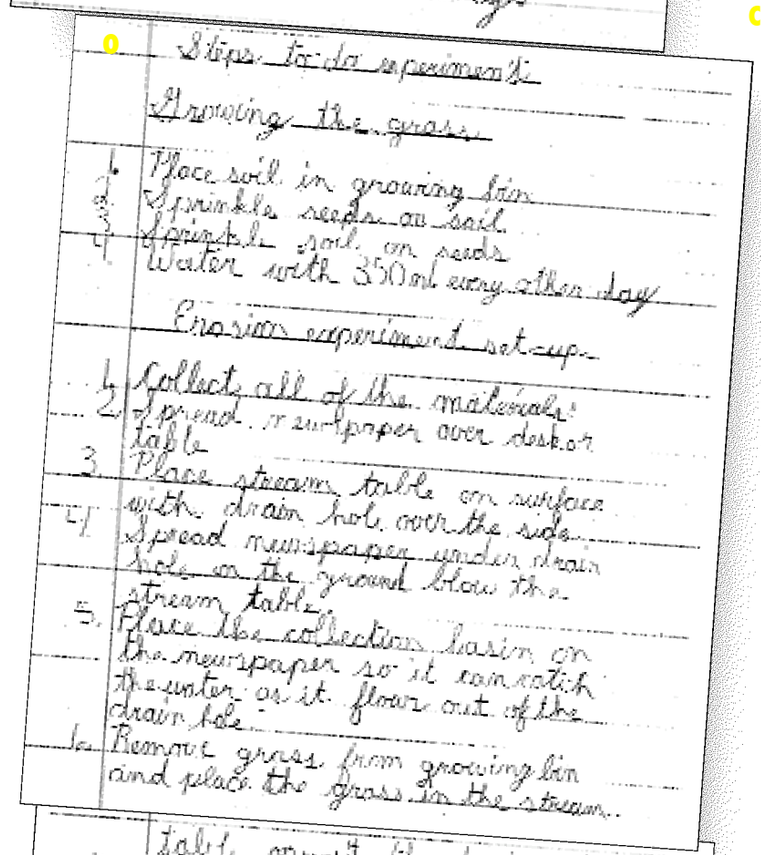
S6 a Scientific Tools and Technologies: The student uses technology and tools….

F G H I J K L The stream table was used effectively to gather data.

Erosion


D Question:
What type of soil will erode least with fall erosion grass.

Hypothesis:
I think clay soil will erode very little because clay soils absorb water slowly.

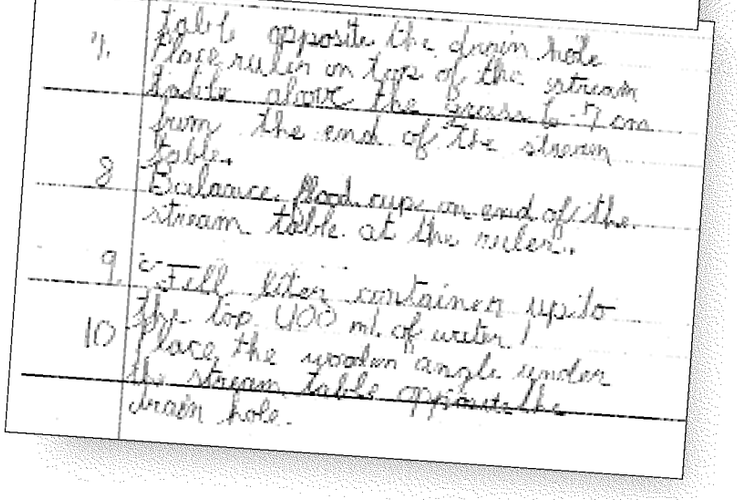

O Steps to do experiment:

Growing the grass

1. Place soil in growing bin
2. Sprinkle seeds on soil
3. Sprinkle soil on seeds
4. Water with 350 ml every other day

Erosion experiment set up

1. Collect all of the materials:
2. Spread newspaper over desk or table
3. Place stream table on surface with drain hole over the side
4. Spread newspaper under drain hole on the ground below the stream table
5. Place the collection basin on the newspaper so it can catch the water as it flows out of the drain hole
6. Remove grass from growing bin and place the grass in the stream.


7. Tilt opposite the drain hole
Place ruler on top of the stream table above the grass 6-7 cm from the end of the stream table.
8. Balance flood cup on end of the stream table at the ruler.
9. Fill filter container up to the top 400 ml of water
10. Place the wooden angle under the stream table opposite the drain hole.

M N Attention to accuracy is evident throughout; these are but two examples.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as… diagrams…and…writing.

F G H I J K L The diagrams and accompanying explanations clearly describe the results of the investigations.

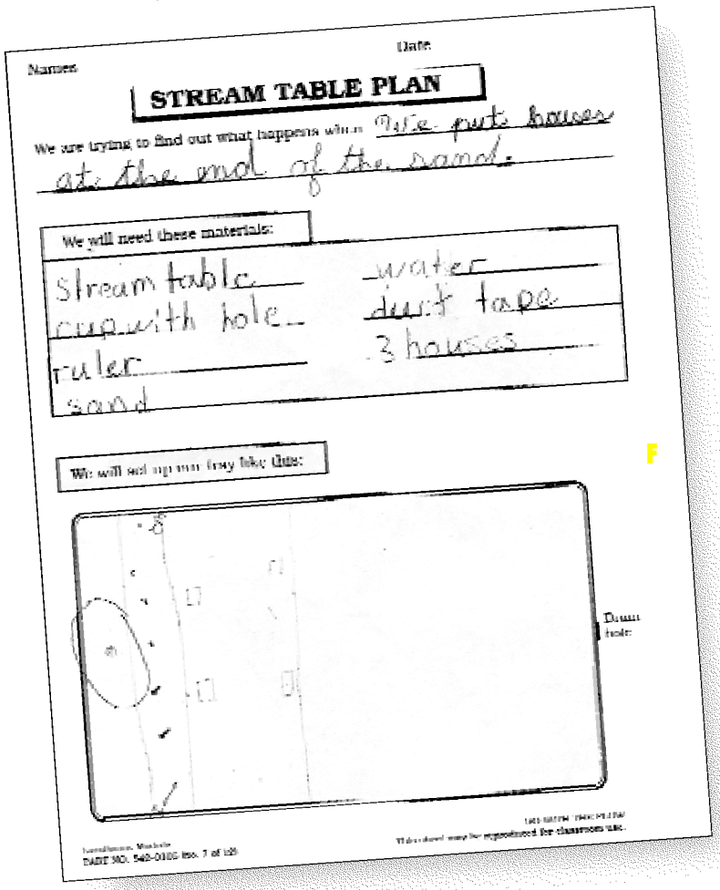
S7 b Scientific Communication: The student uses facts to support conclusions.

C Throughout the work, but particularly in the conclusion, the generalizations follow directly from the data.

S7 c Scientific Communication: The student communicates in a form suited to the purpose and the audience, such as writing instructions that others can follow.

O The procedures are well explained.

The attention to detail, and the recording and use of qualitative and quantitative data, support the judgment of this work as standard setting. Evidence of conceptual and applied understanding of Earth science is shown throughout.


Name: Date:

STREAM TABLE PLAN

We are trying to find out what happens when We put houses at the end of the sand.

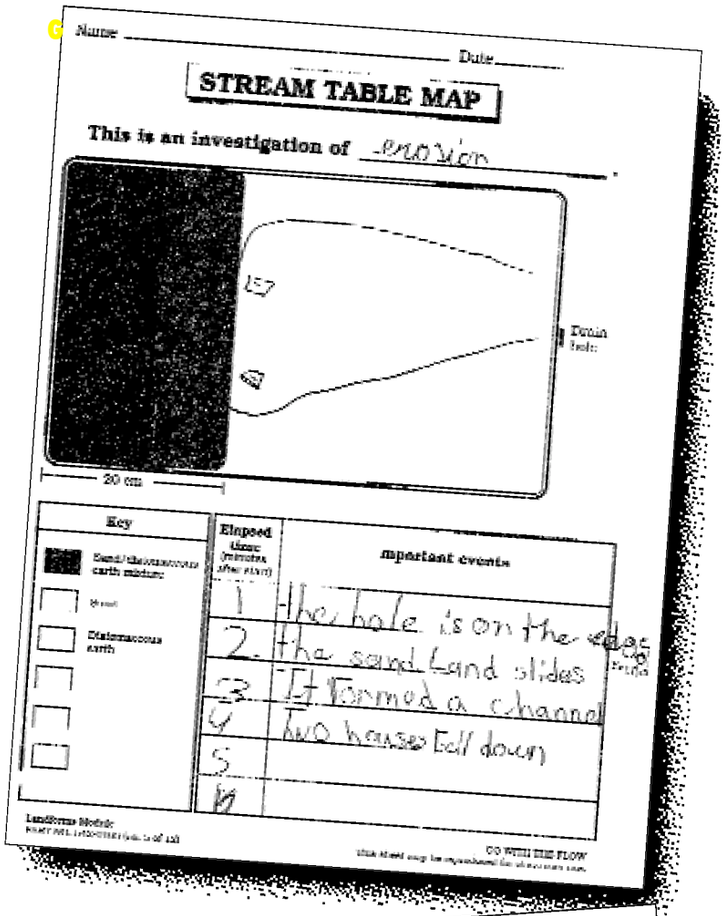
We will need these materials:

Stream table
cup with hole
ruler
sand
water
duct tape
3 houses

We will set up our tray like this:

F

Erosion


G

Name _____ Date _____

STREAM TABLE MAP

This is an investigation of erosion

Drain hole

20 cm

Key	Elapsed time (minutes after start)	Important events
Sand/diatomaceous earth mixture	1	the hole is on the edge
Sand	2	the sand Land slides
Diatomaceous earth	3	It formed a channel
	4	two houses fell down
	5	
	6	

Landforms Module
PART NO. 542-0106 (no. 5 of 12)

GO WITH THE FLOW

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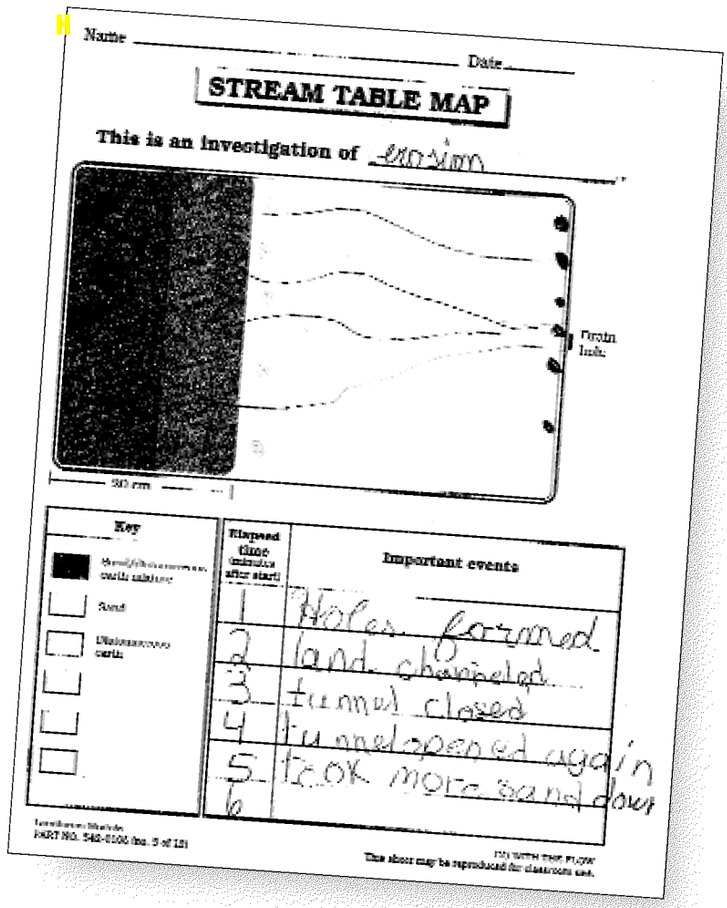
H

Name _____ Date _____

STREAM TABLE MAP

This is an investigation of erosion

Drain hole

20 cm

Key	Elapsed time (minutes after start)	Important events
Sand/diatomaceous earth mixture	1	Holes formed
Sand	2	land channeled
Diatomaceous earth	3	tunnel closed
	4	tunnel opened again
	5	took more sand down
	6	

Landforms Module
PART NO. 542-0106 (no. 5 of 12)

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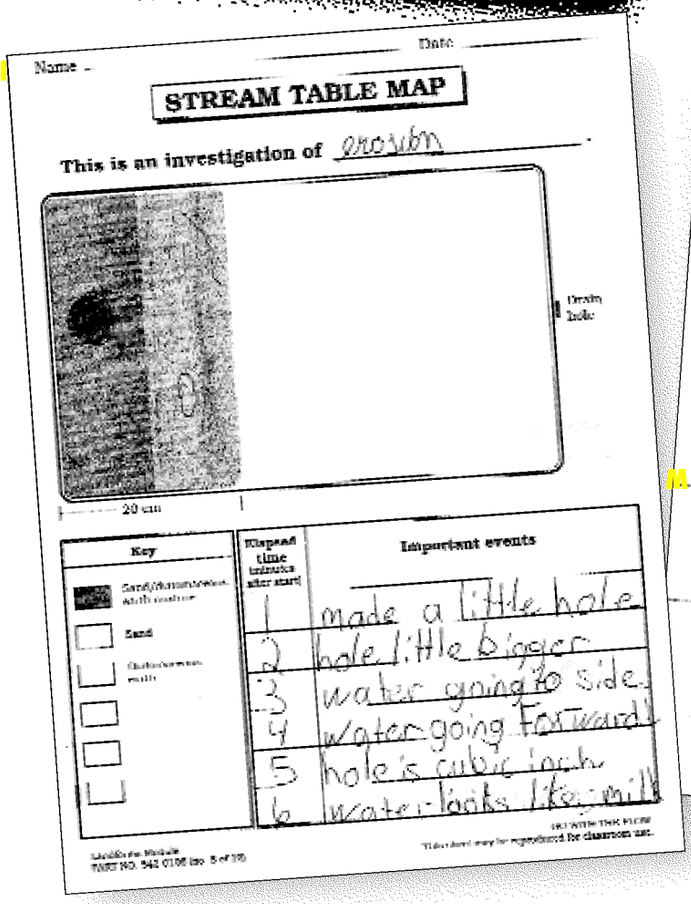
I

Name _____ Date _____

STREAM TABLE MAP

This is an investigation of erosion

Drain hole

20 cm

Key	Elapsed time (minutes after start)	Important events
Sand/diatomaceous earth mixture	1	made a little hole
Sand	2	hole little bigger
Diatomaceous earth	3	water going to side
	4	water going forward
	5	hole is cubic inch
	6	water looks like mill

Landforms Module
PART NO. 542-0106 (no. 5 of 12)

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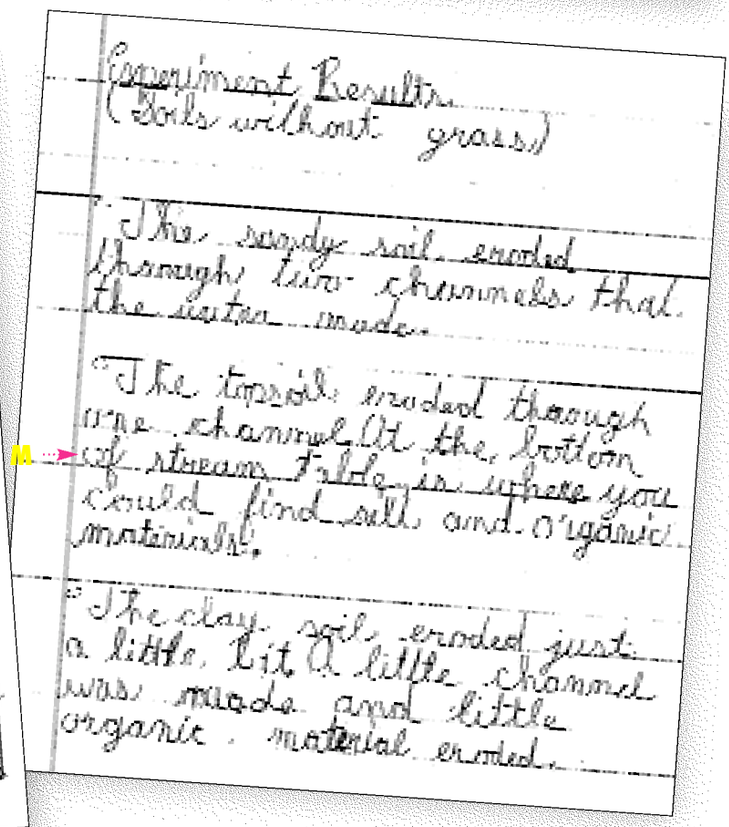

J

Experiment Results
(Soils without grass)

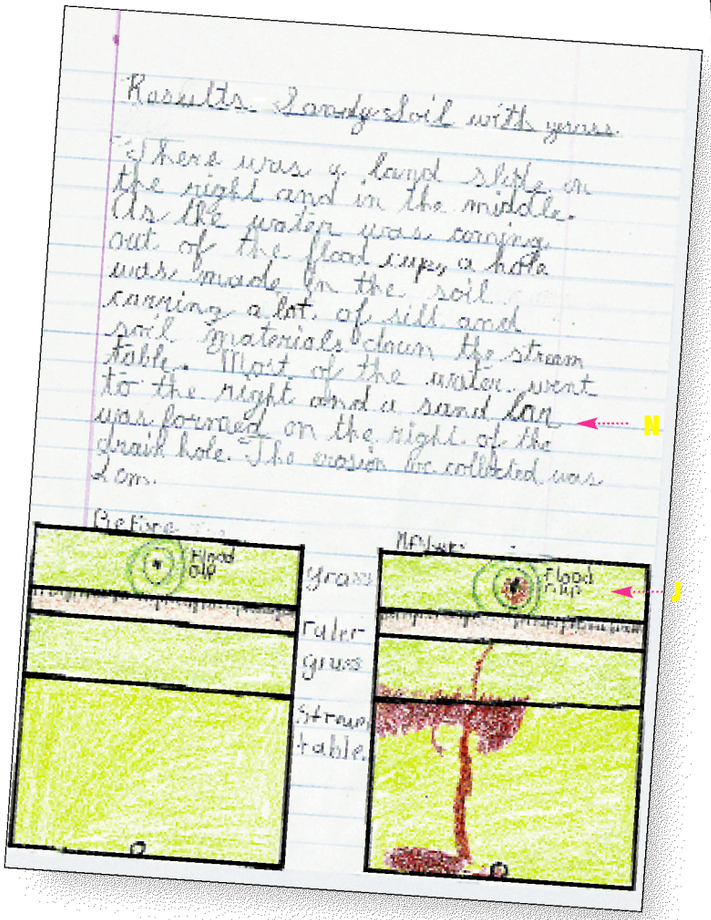
1. The sandy soil eroded through two channels that the water made.

2. The topsoil eroded through one channel. At the bottom of stream table is where you could find silt and organic materials.

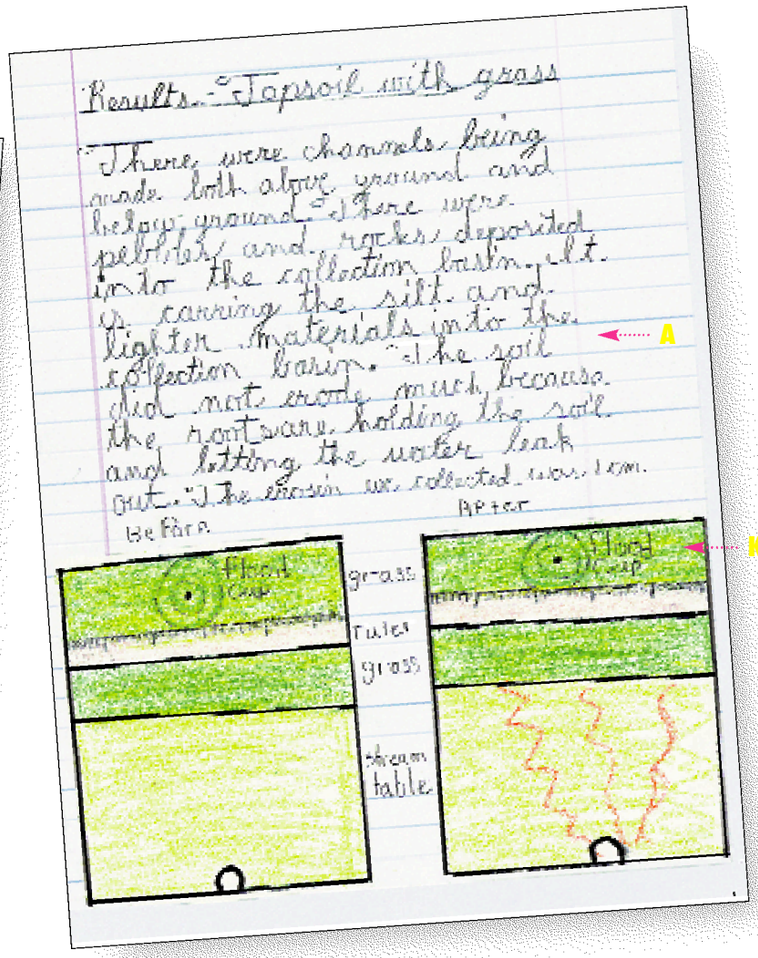
3. The clay soil eroded just a little. Bit a little channel was made and little organic material eroded.

Physical Sciences Concepts
Life Sciences Concepts
Earth and Space Sciences Concepts S3
Scientific Connections and Applications S4
Scientific Thinking S5
Scientific Tools and Technologies S6
Scientific Communication S7
Scientific Investigation

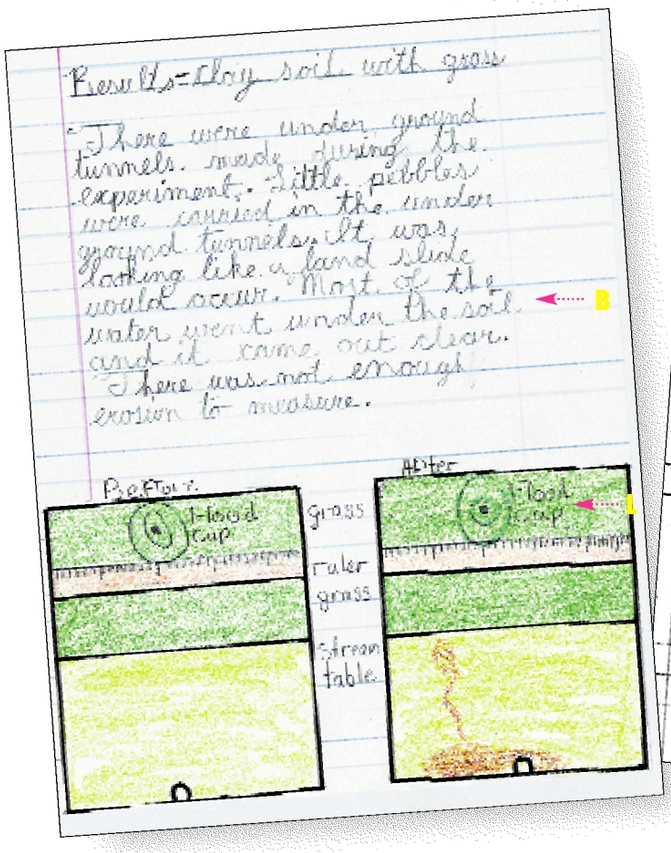
Erosion


Results - Sandy soil with grass

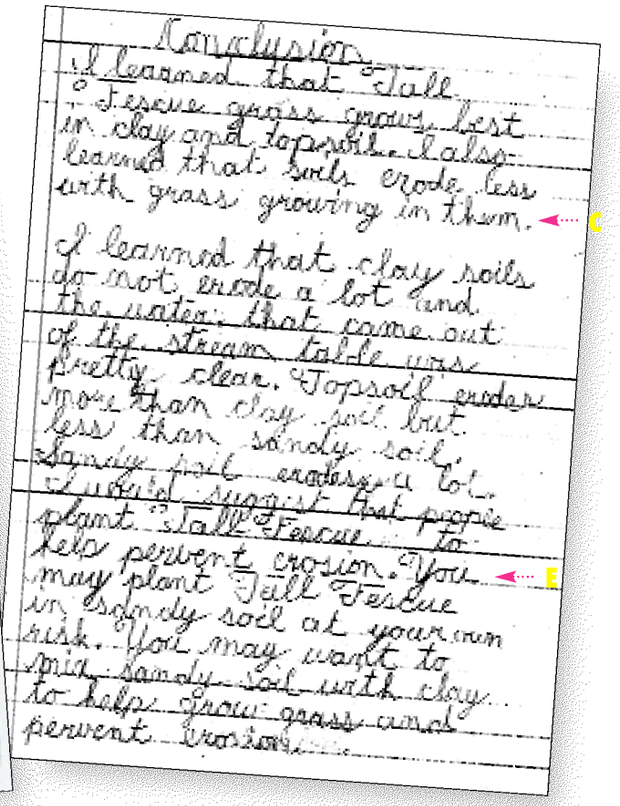
There was a land slide on the right and in the middle. As the water was coming out of the flood cups a hole was made in the soil carrying a lot of silt and soil materials down the stream table. Most of the water went to the right and a sand bar was formed on the right of the drain hole. The erosion we collected was 2cm.


Results - Topsoil with grass

There were channels being made both above ground and below ground. There were pebbles and rocks deposited into the collection basin. It is carrying the silt and lighter materials into the collection basin. The soil did not erode much because the root were holding the soil and letting the water leak out. The erosion we collected was 1cm.


Results - Clay soil with grass

There were under ground tunnels made during the experiment. Little pebbles were carried in the under ground tunnels. It was looking like a land slide would occur. Most of the water went under the soil and it came out clear. There was not enough erosion to measure.


Conclusion

I learned that Tall Fescue grass grows best in clay and topsoil. I also learned that soils erode less with grass growing in them. C

I learned that clay soils do not erode a lot and the water that came out of the stream table was pretty clear. Topsoil eroded more than clay soil but less than sandy soil. Sandy soil eroded a lot. I would suggest that people plant Tall Fescue to help prevent erosion. You may plant Tall Fescue in sandy soil at your own risk. You may want to mix sandy soil with clay to help grow grass and prevent erosion. E

Physical Sciences Concepts
Life Sciences Concepts
S3 Earth and Space Sciences Concepts
S4 Scientific Connections and Applications
S5 Scientific Thinking
S6 Scientific Tools and Technologies
S7 Scientific Communication
Scientific Investigation

Work Sample & Commentary: *Yeast Growth*

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

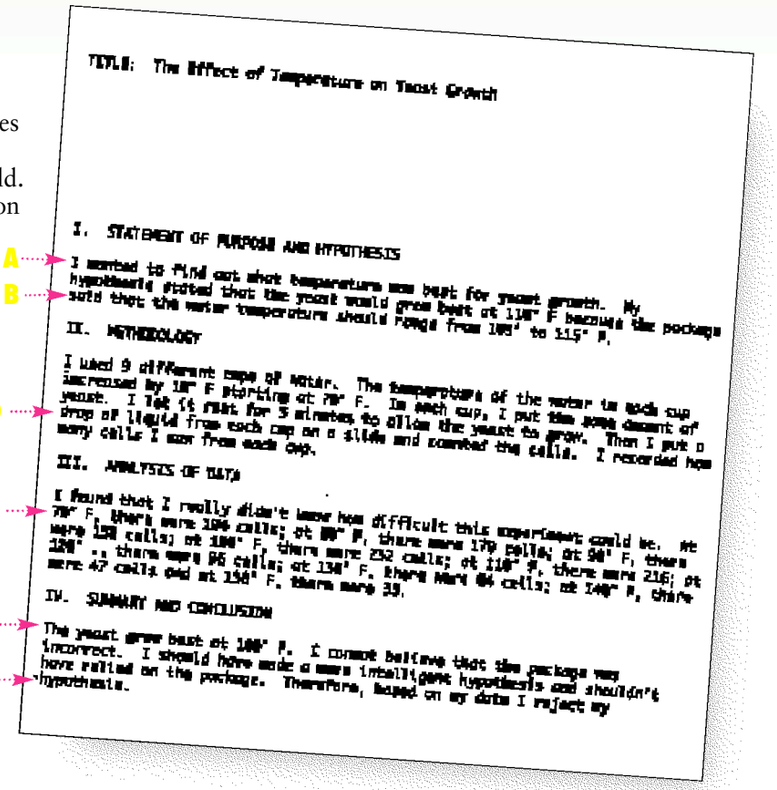
The task

The National Student Research Center encourages the establishment of student research centers in schools in the United States and around the world. The Center facilitates the exchange of information by publishing a journal of student investigations and by use of the Internet (nsrcmms@aol.com). It provides a standard format that students use to report their results. The format requires that students state a purpose and hypothesis; report their methods, data analysis, and conclusions; and suggest applications for their results.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision



TITLE: The Effect of Temperature on Yeast Growth

I. STATEMENT OF PURPOSE AND HYPOTHESIS

A I wanted to find out what temperature was best for yeast growth. My

B hypothesis stated that the yeast would grow best at 110° F because the package said that the water temperature should range from 105° to 115° F.

II. METHODOLOGY

I used 9 different cups of water. The temperature of the water in each cup increased by 10° F starting at 70° F. In each cup, I put the same amount of yeast. I let it rest for 5 minutes to allow the yeast to grow. Then I put a

D drop of liquid from each cup on a slide and counted the cells. I recorded how many cells I saw from each cup.

III. ANALYSIS OF DATA

F I found that I really didn't know how difficult this experiment could be. At 70° F, there were 196 cells; at 80° F, there were 179 cells; at 90° F, there were 158 cells; at 100° F, there were 252 cells; at 110° F, there were 216; at 120° F, there were 96 cells; at 130° F, there were 84 cells; at 140° F, there were 47 cells; and at 150° F, there were 39.

IV. SUMMARY AND CONCLUSION

E The yeast grew best at 100° F. I cannot believe that the package was incorrect. I should have made a more intelligent hypothesis and shouldn't have relied on the package. Therefore, based on my data I reject my

C hypothesis.

The Student Researcher. Used by permission of the National Student Research Center, Dr. John I. Swang, Mandeville Middle School, 2525 Soult Street, Mandeville, Louisiana 70448. 504-626-5980 or nsrcmms@aol.com.

What the work shows

By investigating the optimum temperature for the growth of yeast, the investigation explores characteristics of organisms, particularly survival and environmental support, but the report does not explain why temperature or any other variable would be important to investigate, so the work does not illustrate conceptual understanding in Life Sciences Concepts. It does not illustrate misunderstanding either, however. The student does not mention sugar, but has followed the instructions on the package.

Although sugar is necessary for "proofing" yeast, it is not necessary for "activation." The package indicates that the yeast be "dissolved in water (1/4 cup) at a temperature between 105 and 115 degrees Fahrenheit. If it is to be proofed (foamy), a teaspoon of sugar is added. After five minutes in warm water, the yeast will begin to multiply with added food."

S5 a Scientific Thinking: The student asks questions about natural phenomena….

A

S5 c Scientific Thinking: The student uses evidence from reliable sources to construct explanations.

B The package instructions were used as a reliable source of information.

S5 e Scientific Thinking: The student…evaluates the accuracy, design, and outcomes of investigations.

C The testing and questioning of the source provide evidence for evaluation.

This work sample illustrates a standard-setting performance for the following parts of the standards:

- **S5 a Scientific Thinking: Ask questions about natural phenomena.**
- **S5 c Scientific Thinking: Use evidence from reliable sources to construct explanations.**
- **S5 e Scientific Thinking: Evaluate the accuracy, design, and outcomes of investigations.**
- **S6 a Scientific Tools and Technologies: Use technology and tools.**
- **S6 b Scientific Tools and Technologies: Collect and analyze data.**
- **S8 a Scientific Investigation: An experiment, such as conducting a fair test.**

Yeast Growth

S6 a Scientific Tools and Technologies: The student uses technology and tools (such as…microscopes) to gather data and extend the senses.

D "On a slide" implies that a microscope was used. The procedure of using a microscope to count cells and the persistence shown by counting 232 cells while viewing them through a microscope is impressive use of scientific tools and technologies for an elementary student.

S6 b Scientific Tools and Technologies: The student collects and analyzes data using concepts and techniques in Mathematics Standard 4, such as… variability….

E The student found the maximum of 100 degrees. At a more advanced level, a more "sophisticated" analysis would be expected: one that shows that the results at 100 degrees and 110 degrees are essentially the same. Further, students might study the way that yeast solutions cool slightly during use, so that it is good to start with a somewhat higher water temperature than recommended on the package; some recipes call for water at 120 to 130 degrees.

S8 a Scientific Investigation: The student demonstrates scientific competence by completing an experiment, such as conducting a fair test.

A full investigation includes:

- **Questions that can be studied using the resources available.**

A

- **Procedures that are safe, humane, and ethical; and that respect privacy and property rights.**
- **Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify and analyze using skills expected at this grade level (see also Mathematics Standard 4).**

D E F

- **Data and results that have been represented (see also Science Standard 7) in ways that fit the context.**
- **Recommendations, decisions, and conclusions based on evidence.**

C

- **Acknowledgment of references and contributions of others.**

The work includes references to the package instructions.

- **Results that are communicated appropriately to audiences.**
- **Reflection and defense of conclusions and recommendations from other sources and peer review.**

By sharing the work on the Internet, the student is publishing the work and asking for feedback.

Measurement issues related to repeated sampling from the same container, repeated trials, and checking the temperature of the water would be expected of a middle school student but are not expected at the elementary level. Controlling the time allowed for growth is explicitly mentioned. Controlling the shape of the container and the amount of sugar are not mentioned.

C The conclusion, that the hypothesis should be rejected is correct. The idea that the hypothesis was not intelligent and that the student would have had a basis better than the package instructions is not warranted. The fact that the package could have been correct and the temperature measurements could have been flawed in some way (inaccurate thermometer, for example) is an alternative explanation for the data. As noted above, however, analysis of some of the measurement issues is more sophisticated than would be expected for an elementary student. Finally, the willingness to report a result different from the hypothesis is a major accomplishment for an elementary student.

S6 makes explicit reference to using telecommunications to acquire and share information. A recent National Center on Education Statistics survey recently reported that only 50% of schools and fewer than 9% of instructional rooms currently have access to the Internet. We know this is an equity issue—that far more than 9% of the homes in the United States have access to the Internet and that schools must make sure that students' access to information and ideas does not depend on what they get at home—so we have crafted performance standards that would use the Internet so that people will make sure that all students have access to it. New Standards partners have made a commitment to create the learning environments where students can develop the knowledge and skills delineated here.

Work Sample & Commentary: *Smiles*

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

The task

The National Student Research Center encourages the establishment of student research centers in schools in the United States and around the world. The Center facilitates the exchange of information by publishing a journal of student investigations and by use of the Internet (nsrcmms@aol.com). It provides a standard format that students use to report their results. The format requires that students state a purpose and hypothesis; report their methods, data analysis, and conclusions; and suggest applications for their results.

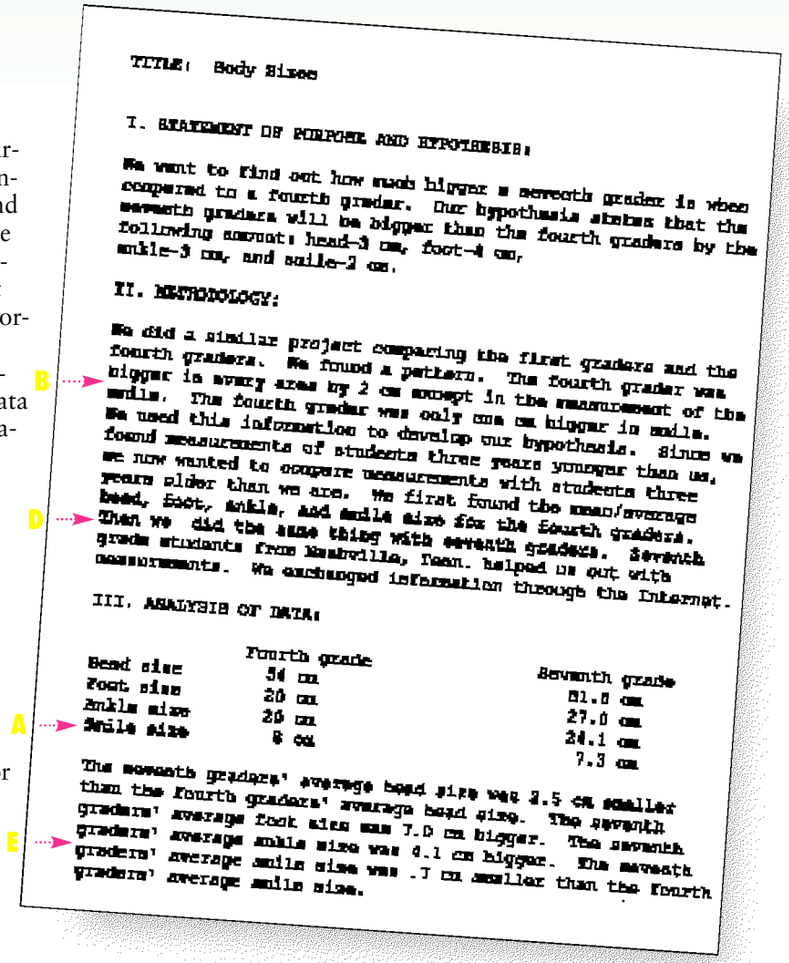
Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision

What the work shows

As part of their work in mathematics, fourth grade students chose to gather data on sizes of different body parts and to compare their data with first grade students. Having done so, they then used the Internet to locate a seventh grade class that was willing to provide comparable data to see if the same pattern continued with age. They then "published" their work by reporting it on the Internet in the standard format.



TITLE: Body Sizes

I. STATEMENT OF PURPOSE AND HYPOTHESIS:

We want to find out how much bigger a seventh grader is when compared to a fourth grader. Our hypothesis states that the seventh graders will be bigger than the fourth graders by the following amount: head-3 cm, foot-4 cm, ankle-3 cm, and smile-2 cm.

II. METHODOLOGY:

We did a similar project comparing the first graders and the fourth graders. We found a pattern. The fourth grader was bigger in every area by 2 cm except in the measurement of the smile. The fourth grader was only one cm bigger in smile. We used this information to develop our hypothesis. Since we found measurements of students three years younger than us, we now wanted to compare measurements with students three years older than we are. We first found the mean/average head, foot, ankle, and smile size for the fourth graders. Then we did the same thing with seventh graders. Seventh grade students from Nashville, Tenn. helped us out with measurements. We exchanged information through the Internet.

III. ANALYSIS OF DATA:

	Fourth grade	Seventh grade
Head size	54 cm	51.0 cm
Foot size	20 cm	27.0 cm
Ankle size	20 cm	24.1 cm
Smile size	8 cm	7.3 cm

The seventh graders' average head size was 3.5 cm smaller than the fourth graders' average head size. The seventh graders' average foot size was 7.0 cm bigger. The seventh graders' average ankle size was 4.1 cm bigger. The seventh graders' average smile size was .7 cm smaller than the fourth graders' average smile size.

The Student Researcher. Used by permission of the National Student Research Center, Dr. John I. Swang, Mandeville Middle School, 2525 Soult Street, Mandeville, Louisiana 70448. 504-626-5980 or nsrcmms@aol.com.

This work sample illustrates a standard-setting performance for the following parts of the standards:

- **S5 a Scientific Thinking: Ask questions about natural phenomena.**
- **S5 c Scientific Thinking: Use evidence from reliable sources to construct explanations.**
- **S5 d Scientific Thinking: Evaluate different points of view using relevant experiences, observations, and knowledge.**
- **S5 f Scientific Thinking: Work individually and in teams to collect and share information and ideas.**
- **S6 c Scientific Tools and Technologies: Acquire information from multiple sources.**
- **S7 a Scientific Communication: Represent data and results in multiple ways.**
- **S7 b Scientific Communication: Use facts to support conclusions.**
- **S7 c Scientific Communication: Communicate in a form suited to the purpose and the audience.**

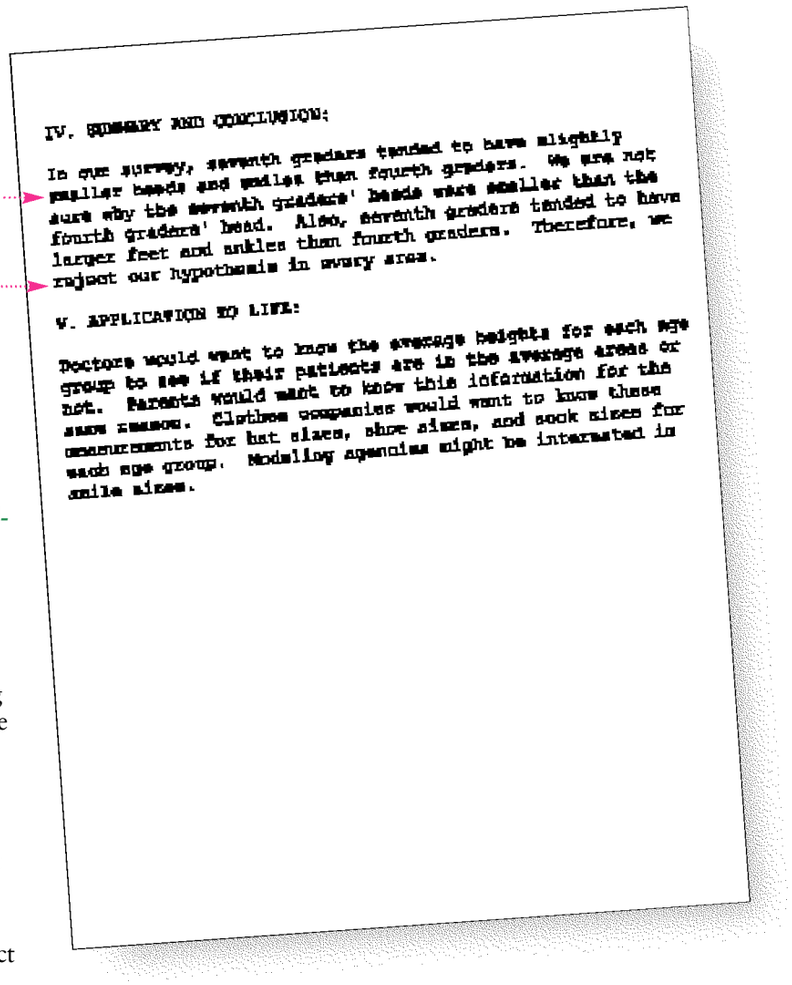
S5 a Scientific Thinking: The student asks questions about natural phenomena….

A Questions about body sizes are of great interest to children. The value of allowing students to formulate their own questions is demonstrated by their including "smiles" in their list of body parts, something that would not occur to many adults.

S5 c Scientific Thinking: The student uses evidence from reliable sources to construct explanations.

B The students used data from their previous study with first graders to construct a hypothesis for seventh graders.

Smiles



IV. SUMMARY AND CONCLUSION:

In our survey, seventh graders tended to have slightly smaller heads and smiles than fourth graders. We are not sure why the seventh graders' heads were smaller than the fourth graders' head. Also, seventh graders tended to have larger feet and ankles than fourth graders. Therefore, we reject our hypothesis in every area.

V. APPLICATION TO LIFE:

Doctors would want to know the average heights for each age group to see if their patients are in the average areas or not. Parents would want to know this information for the same reason. Clothes companies would want to know these measurements for hat sizes, shoe sizes, and sock sizes for each age group. Modeling agencies might be interested in smile sizes.

S5 d Scientific Thinking: The student evaluates different points of view using relevant experiences, observations, and knowledge….

C The students checked their data against their prediction, which had been based on a reasonable idea that comparable rates of growth would be observed over three year spans prior to and following their age. They were surprised by their results. Attempting to explain the unexpected results, that the seventh graders had smaller heads and smiles, by critiquing the measurement procedure, would have provided more complete evidence for this standard.

S5 f Scientific Thinking: The student works individually and in teams to collect and share information and ideas.

D These students went beyond their immediate experience by seeking out a seventh grade class so that they could extend their study beyond the grade levels contained in their elementary school. Working as a class and with other classes, even classes outside their own school, demonstrates the beginnings of a scientific community that shares data and publishes results.

S6 c Scientific Tools and Technologies: The student acquires information from multiple sources such as…non-print sources and from experimentation.

Information was acquired electronically and by direct measurement.

The other aspects of the Scientific Tools and Technologies standard are not fully realized. The tools are not identified, nor are the procedures for measuring (e.g., Were smiles measured at their greatest length? Corner to corner or edge of lips?), but measurements are reported in a reasonable way. The middle school students, who measured themselves, reported with more significant digits, which is probably appropriate. The results of the analysis are reported here but not the procedures. A full report of the data would reveal the adequacy of the sample and the appropriateness of using the average.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables, and…writing.

E The data are presented in both a text and a table. A bar graph might have been an effective way to show the contrast from first to fourth to seventh grade, though it would be difficult to convey in many Internet environments.

S7 b Scientific Communication: The student uses facts to support conclusions.

F

S7 c Scientific Communication: The student communicates in a form suited to the purpose and the audience….

The report is formatted to follow the NSRC guidelines completely and clearly.

The report is not a full investigation consistent with the Scientific Investigation standard. Attempting to explain the unexpected results, that the seventh graders had smaller heads and smiles, by critiquing the measurement procedure, would have provided more complete evidence of an investigation. Attempting to explain the results, by pursuing, for example, developmental reasons for heads attaining their adult size in babies and children more rapidly than limbs do, would have taken the investigation into the Life Sciences Concepts standard. Dealing with the size and representativeness of the sample and the analysis of the data would have addressed parts of Mathematics Standard 4, Statistics and Probability Concepts.

Work Sample & Commentary: *Aquarium*

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

The task

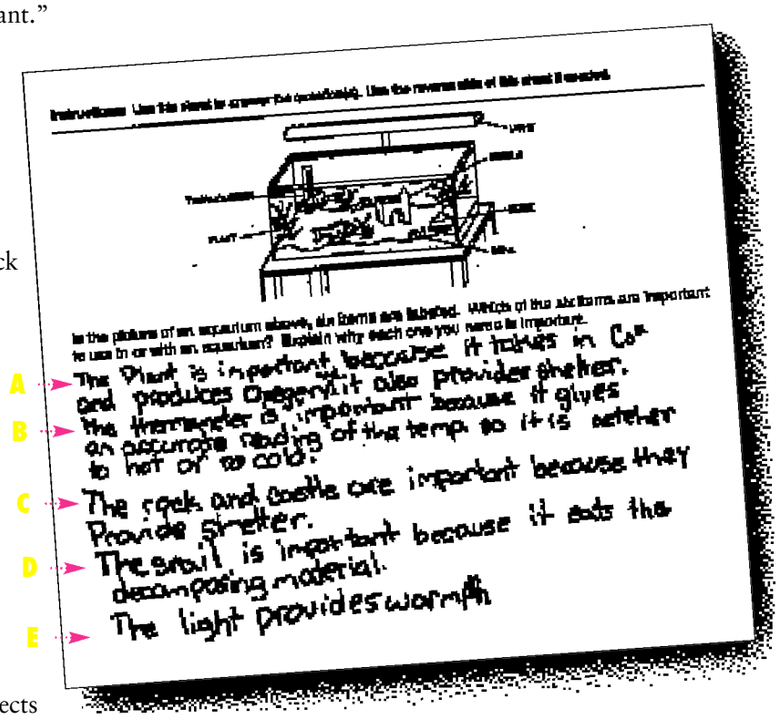
Given a drawing of an aquarium with six labeled items (light, thermometer, castle, rock, snail, and plant), students were told: "In the picture of an aquarium above, six items are labeled. Which of the six items are important to use in or with an aquarium? Explain why each one you name is important."

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed (20 minutes)	opportunity for revision

The task was part of a state assessment program and unrelated to the curriculum that the students were studying.



What the work shows

S2 a Life Sciences Concepts: The student produces evidence that demonstrates understanding of the characteristics of organisms, such as survival and environmental support....

This response correctly identifies the role each labeled item plays in the environment and connects the item to the needs of the fish. For a fairly straightforward question, the response provides elaborations that show a depth of understanding.

A The explanation of the role of the plant is very complete for the elementary level, since specifying either function would have been adequate.

B The elaboration of the function of the thermometer shows a good degree of accuracy for the elementary level.

C Objects such as the rock and the castle are used in aquaria for decoration as well as protection. From the drawing, one could argue that the fish are large enough not to need protection and that these objects are ornamental. That would also be a correct response.

D The language, "decomposing material," is particularly precise for the elementary level.

E This reference to the function of the light is correct. It also helps the plant to grow. Although one might assume that the room's ambient light would suffice for plant growth, this is a refinement appropriate for middle level, not for an elementary student producing a comprehensive response on a timed test.

The systematic treatment of all the items is also a strength at the elementary level. At the middle school level, it would be expected that students could provide a similar analysis for an environment with which they have less first hand experience.

This work sample illustrates a standard-setting performance for the following part of the standards:

S2 a Life Sciences Concepts: Characteristics of organisms.

Work Sample & Commentary: *Snow Melt*

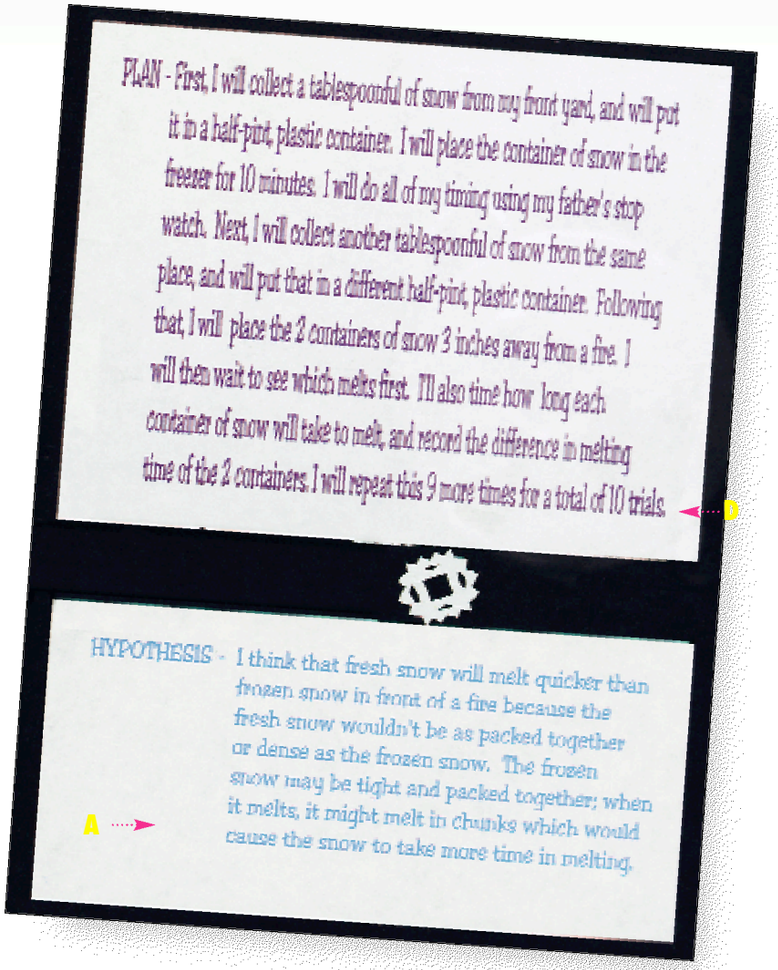
The task

This work sample is from a student investigation for a science fair. The instructions asked the students to select a question they wished to investigate and required that some experiment be performed to gather data and come to a conclusion. An explanation of the scientific concepts involved in the experiment was not required. The science fair rules required that data be displayed in a poster presentation format.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision



PLAN - First, I will collect a tablespoonful of snow from my front yard, and will put it in a half-pint, plastic container. I will place the container of snow in the freezer for 10 minutes. I will do all of my timing using my father's stop watch. Next, I will collect another tablespoonful of snow from the same place, and will put that in a different half-pint, plastic container. Following that, I will place the 2 containers of snow 3 inches away from a fire. I will then wait to see which melts first. I'll also time how long each container of snow will take to melt, and record the difference in melting time of the 2 containers. I will repeat this 9 more times for a total of 10 trials. B

HYPOTHESIS - I think that fresh snow will melt quicker than frozen snow in front of a fire because the fresh snow wouldn't be as packed together or dense as the frozen snow. The frozen snow may be tight and packed together; when it melts, it might melt in chunks which would cause the snow to take more time in melting. A

This work sample illustrates a standard-setting performance for the following parts of the standards:

- **S5 a Scientific Thinking: Ask questions about natural phenomena.**
- **S5 c Scientific Thinking: Use evidence from reliable sources to construct explanations.**
- **S5 e Scientific Thinking: Evaluate the accuracy, design, and outcomes of investigations.**
- **S6 a Scientific Tools and Technologies: Use technology and tools.**
- **S6 b Scientific Tools and Technologies: Collect and analyze data.**
- **S7 a Scientific Communication: Represent data and results in multiple ways.**
- **S7 b Scientific Communication: Use facts to support conclusions.**
- **S7 c Scientific Communication: Communicate in a form suited to the purpose and the audience.**
- **S8 a Scientific Investigation: An experiment, such as conducting a fair test.**

What the work shows

S5 a Scientific Thinking: The student asks questions about natural phenomena….

S5 c Scientific Thinking: The student uses evidence from reliable sources to construct explanations.

A The statement of the hypothesis includes a rationale based on observation.

S5 e Scientific Thinking: The student…evaluates the accuracy, design, and outcomes of investigations.

B The reasoning about the results, both "I have no reason for it," and "2 possible reason(s)," shows a good degree of self-evaluation for the elementary level.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

Snow Melt

S6 a Scientific Tools and Technologies: The student uses technology and tools (such as…thermometers, watches)…to gather data and extend the senses.

S6 b Scientific Tools and Technologies: The student collects and analyzes data using concepts and techniques in Mathematics Standard 4, such as…data displays, graphing….

B C The calculation and display of the differences sets up an interesting analysis in the conclusion.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables, and graphs….

S7 b Scientific Communication: The student uses facts to support conclusions.

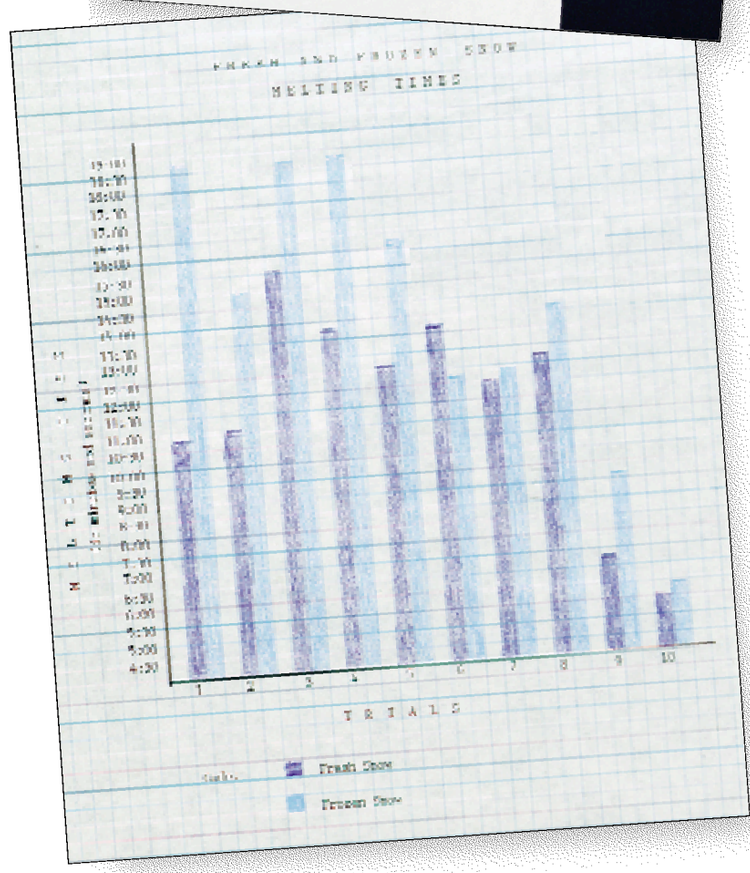
S7 c Scientific Communication: The student communicates in a form suited to the purpose and the audience….

The format of the science fair was executed successfully.

COLLECTION T

Trial	Fresh Snow	Time Min:Sec.	Frozen Snow	Time Min:Sec	Difference in Times
1	I	10:55		18:49	7:54
2	I	11:03		15:00	3:57
3	I	15:30		18:39	3:09
4	I	13:48		18:40	4:52
5	I	12:40		16:16	3:36
6		13:46	I	12:13	1:33
7	I	12:00		12:20	0:20
8	I	12:45		14:05	1:20
9	I	6:43		9:13	2:30
10	I	5:31		5:50	0:19

FRESH SNOW WILL MELT QUICKER THAN FROZEN SNOW IN FRONT OF A FIRE.



Snow Melt

S8 a Scientific Investigation: The student demonstrates scientific competence by completing an experiment, such as conducting a fair test.

A full investigation includes:

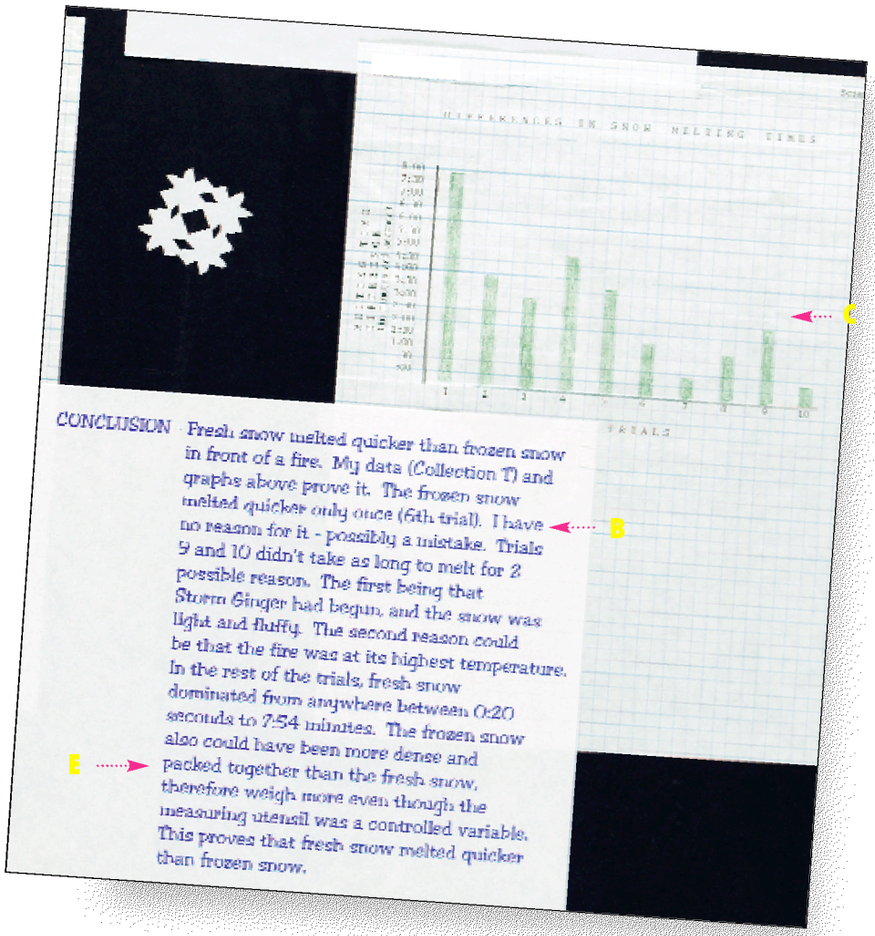
- Questions that can be studied using the resources available.
- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.
- Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify and analyze using skills expected at this grade level (see also Mathematics Standard 4).
- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.
- Recommendations, decisions, and conclusions based on evidence.
- Acknowledgment of references and contributions of others.
- Results that are communicated appropriately to audiences.
- Reflection and defense of conclusions and recommendations from other sources and peer review.

D The investigation includes a logical and sequential plan including multiple trials. It uses multiple representations and data displays to communicate scientific findings.

B It explores different interpretations of data and applies the information to potentially relevant environmental conditions in concluding remarks.

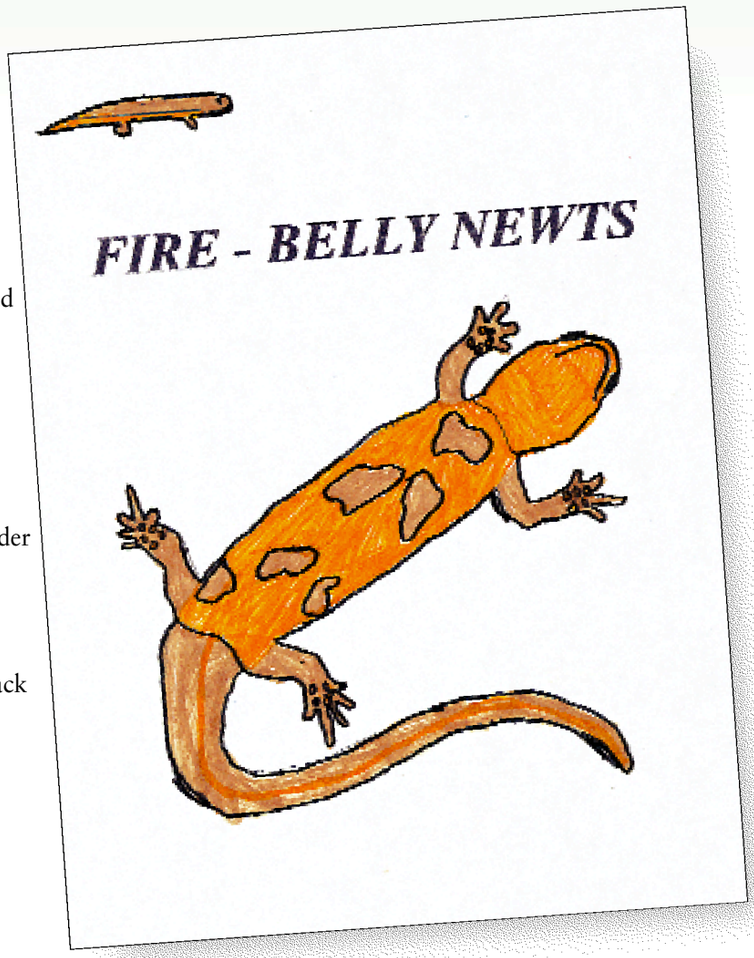
E It considers potentially confounding and uncontrolled variables in the experimental design in making appropriate conclusions based on experimental data.

The work touches on the concept of density. More evidence, such as an explanation of the relationship between density and melting times, would be required to meet the standard for Physical Sciences Concepts.



Physical Sciences Concepts
Life Sciences Concepts
Earth and Space Sciences Concepts
Scientific Connections and Applications
S5 Scientific Thinking
S6 Scientific Tools and Technologies
S7 Scientific Communication
S8 Scientific Investigation

Work Sample & Commentary: *Fire-Belly Newts*



The task

An elementary student participated in a 4-H program in which she raised an animal, learning about and caring for its needs. The culmination of this project involved a county-wide fair at which the student's project was judged against other similar projects. The task involved observation of the animal, some library research, the production of a display, a report, and an interview with a judge. The student's original report and a follow-up interview are included here.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	in a group
in class	as homework
with teacher feedback	with peer feedback
timed	opportunity for revision

The work was done in a 4-H program.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 132-135.

Best practice in science has always included intensive inquiry and investigation, but these are frequently given less emphasis at the elementary level in the face of competing demands from English language arts and mathematics. There are many opportunities to learn science outside of school, including the Girl Scouts of the U.S.A., Boy Scouts of America, Boys and Girls Clubs of America, 4-H, and Future Farmers of America. The work done in these venues can and should be used to provide evidence of meeting these standards.

Physical Sciences Concepts
Life Sciences Concepts S2
Earth and Space Sciences Concepts
Scientific Connections and Applications
Scientific Thinking S5
Scientific Tools and Technologies
Scientific Communication S7
Scientific Investigation S8

This work sample illustrates a standard-setting performance for the following parts of the standards:

- **S2 a Life Sciences Concepts: Characteristics of organisms.**
- **S2 b Life Sciences Concepts: Life cycles of organisms.**
- **S2 c Life Sciences Concepts: Organisms and environments.**
- **S5 c Scientific Thinking: Use evidence from reliable sources to construct explanations.**
- **S5 d Scientific Thinking: Evaluate different points of view using relevant experiences, observations, and knowledge.**
- **S7 a Scientific Communication: Represent data and results in multiple ways.**
- **S7 b Scientific Communication: Use facts to support conclusions.**
- **S7 c Scientific Communication: Communicate in a form suited to the purpose and the audience.**
- **S8 b Scientific Investigation: A systematic observation, such as a field study.**

What the work shows

S2 a Life Sciences Concepts: The student produces evidence that demonstrates understanding of characteristics of organisms, such as survival and environmental support….

A

S2 b Life Sciences Concepts: The student produces evidence that demonstrates understanding of life cycles of organisms….

B

S2 c Life Sciences Concepts: The student produces evidence that demonstrates understanding of organisms and environments, such as the interdependence of animals and plants in an ecosystem….

C

S5 c Scientific Thinking: The student uses evidence from reliable sources to construct explanations.

C D The student used several sources and was able to identify what information came from which source.

Fire-Belly Newts

S5 d Scientific Thinking: The student evaluates different points of view using relevant experiences, observations, and knowledge; and distinguishes between fact and opinion.

E The student differentiated between things she had read and things that she had observed.

S7 a Scientific Communication: The student represents data and results in multiple ways, such as…drawings, diagrams, and artwork; and technical and creative writing.

The student communicated with a drawing, a written report, a poster, an oral presentation, and through an interview.

S7 b Scientific Communication: The student uses facts to support conclusions.

F

S7 c Scientific Communication: The student communicates in a form suited to the purpose and the audience….

Consistent with the context of a 4-H project for presentation at a county fair, the student communicated with a drawing, a written report, a poster, an oral presentation, and an interview with the judge.

S8 b Scientific Investigation: The student demonstrates scientific competence by completing a systematic observation, such as a field study.

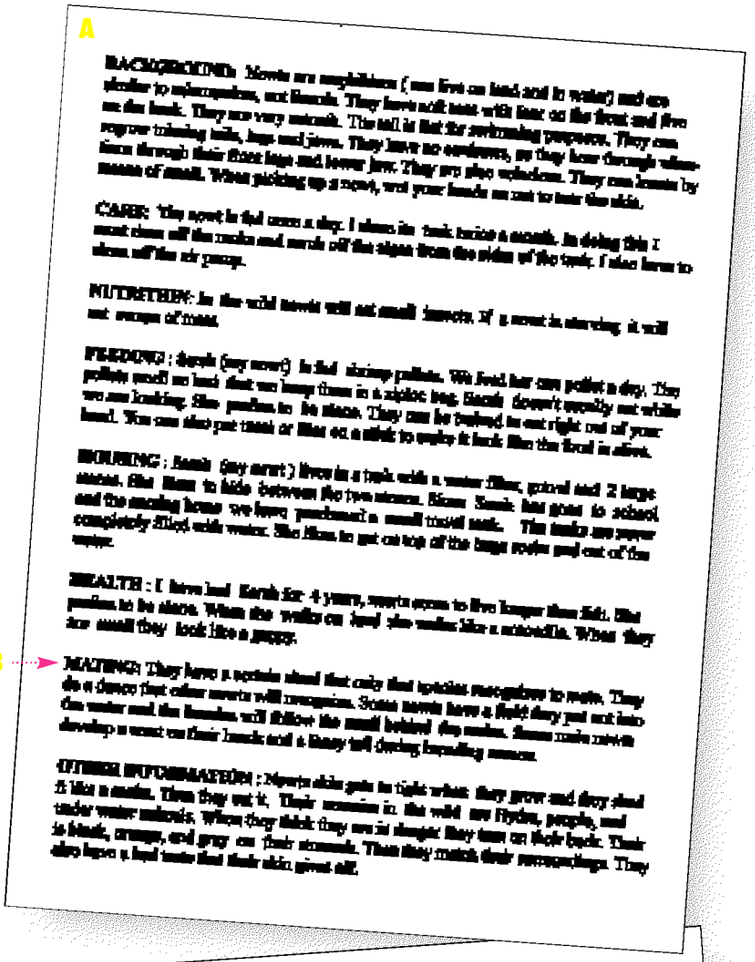
A full investigation includes:

- Questions that can be studied using the resources available.

A

- Procedures that are safe, humane, and ethical; and that respect privacy and property rights.

C G



A

BACKGROUND: Newts are amphibians (can live on land and in water) and are similar to salamanders, not lizards. They have soft skin with feet on the front and five on the back. They are very animals. The tail is flat for swimming purposes. They can regrow missing tails, legs and jaws. They have no eardrums, so they hear through vibrations through their front legs and lower jaw. They are also voracious. They can lounge by means of mucus. When picking up a newt, wet your hands so not to hurt the skin.

CARE: The newt in the cover a day. I clean its tank twice a month. In doing this I must clean all the rocks and scrub off the algae from the sides of the tank. I also have to clean off the air pump.

NUTRITION: In the wild newts will eat small insects. If a newt is starving, it will eat scraps of meat.

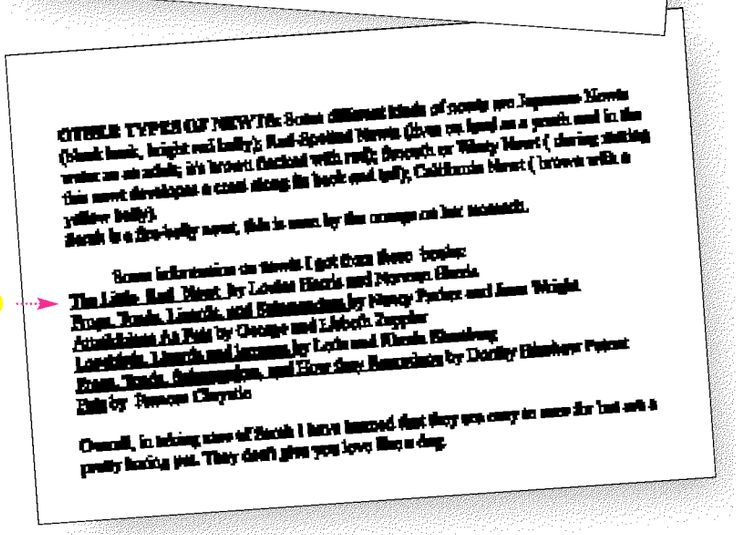
FEEDING: Sarah (my newt) is fed shrimp pellets. We feed her one pellet a day. The pellets smell so bad that we keep them in a zipper bag. Sarah doesn't usually eat while we are looking. She prefers to be alone. They can be trained to eat right out of your hand. You can feed pet meat or fish or a stick to make it look like the food is alive.

HOUSING: Sarah (my newt) lives in a tank with a water filter, gravel and 2 large rocks. She likes to hide between the two rocks. Since Sarah has grown to school size and the existing home we have purchased a small metal tank. The tanks are never completely filled with water. She likes to get on top of the large rocks and out of the water.

HEALTH: I have had Sarah for 4 years, she seems to live longer than fish. She prefers to be alone. When she walks on land she walks like a crocodile. When they are small they look like a puppy.

B **MATING:** They have a section about that only that species recognizes to mate. They do a dance that other newts will recognize. Some newts have a field day put out into the water and the females will follow the male behind the males. Some male newts develop a scent on their heads and a heavy tail during breeding seasons.

OTHER INFORMATION: Newts skin gets to tight when they grow and they shed it like a snake. Then they eat it. Their enemies in the wild are flyers, people, and under water animals. When they think they are in danger they turn on their back. Their is black, orange, and gray on their stomach. Then they match their surroundings. They also have a bad taste that their skin gives off.



OTHER TYPES OF NEWTS: Some different kinds of newts are Japanese Newts (black back, bright red belly); Red-Spotted Newts (live on land as a youth and in the water as an adult, it's brown flecked with red); Smooth or Warty Newt (during mating this newt develops a crest along its back and tail); California Newt (brown with a yellow belly).
Sarah is a fire-belly newt, this is seen by the orange on her stomach.

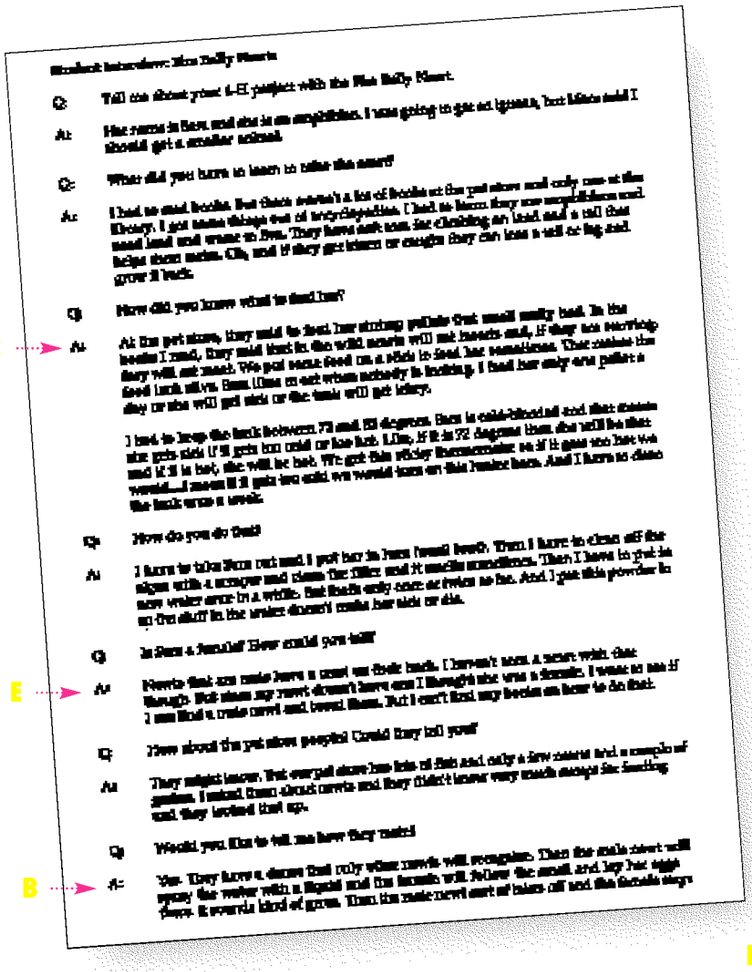
Some information on newts I got from these books:

D The Little Red Newt, by Louise Harris and Norman Harris
Frogs, Toads, Lizards, and Salamanders, by Nancy Parker and Joan Wright
Amphibians As Pets by George and Elizabeth Zappler
Lizards, Lizards and Lizards, by Lydia and Harold Hershberg
Frogs, Toads, Salamanders, and How-Say Reptiles by Dorthy Hinshaw Patent
Pets by Frances Chaysin

Overall, in taking care of Sarah I have learned that they are easy to care for but not a pretty looking pet. They don't give you love like a dog.

Physical Sciences Concepts
S2 Life Sciences Concepts
Earth and Space Sciences Concepts
Scientific Connections and Applications
S5 Scientific Thinking
Scientific Tools and Technologies
S7 Scientific Communication
S8 Scientific Investigation

Fire-Belly Newts



Student Interview: Fire Belly Newts

Q: Tell me about your 4-H project with the Fire Belly Newt.

A: Her name is Ben, and she is an amphibian. I was going to get an iguana, but Mom said I should get a smaller animal.

Q: What did you have to learn to raise the newt?

A: I had to read books. But there weren't a lot of books at the pet store and only one at the library. I got some things out of my classroom. I had to learn they are amphibians and need land and water to live. They have soft skin, for breathing air land and a tail that helps them swim. Oh, and if they get injured or caught they can lose a leg or tail and grow it back.

Q: How did you know what to feed her?

C → A: At the pet store, they said to feed her stringy pellets that smell really bad. In the books I read, they said that in the wild newts will eat insects and, if they are starving they will eat meat. We put some food on a stick to feed her sometimes. That makes the food look alive. Then (then we eat when nobody is looking.) I feed her only one pellet a day or she will get sick or the tank will get icky.

I had to keep the tank between 72 and 78 degrees. Ben is cold-blooded and that makes she gets sick if it gets too cold or too hot. Like, if it is 72 degrees then she will be fine and if it is hot, she will be hot. We get this sticky thermometer so if it goes too hot we would.....I mean if it gets too cold we would turn on this heater here. And I have to clean the tank once a week.

Q: How do you do that?

A: I have to take Ben out and I put her in bowl bowl bowl. Then I have to clean off the sides with a scraper and clean the filter and it smells sometimes. Then I have to put in new water once in a while. But that's only once or twice so far. And I put this powder in so the stuff in the water doesn't make her sick or die.

Q: Is Ben a female? How could you tell?

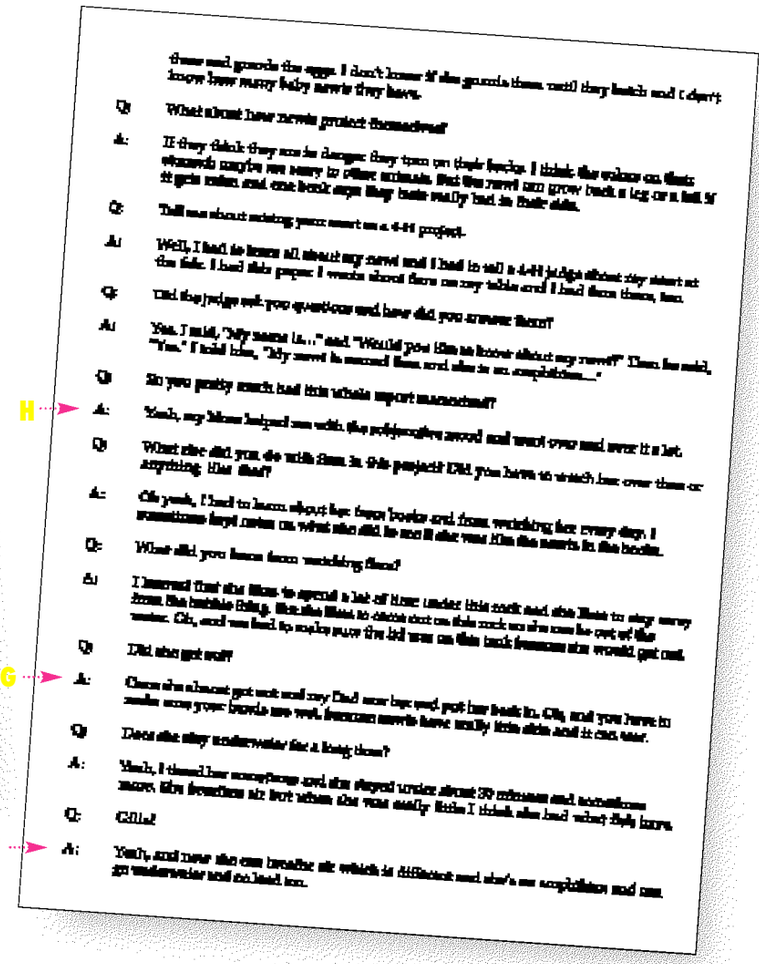
E → A: Newts that are male have a crest on their back. I haven't seen a crest with that though. But when my newt doesn't have one I thought she was a female. I want to see if I can find a male newt and breed them. But I don't find my books on how to do that.

Q: How about the pet store people? Could they tell you?

A: They might know. But everpet store has lots of fish and only a few reptiles and a couple of amphibians. I asked them about newts and they didn't know very much except the feeding and they looked that up.

Q: Would you like to tell me how they mate?

B → A: Yes. They have a dance that only white newts will recognize. Then the male newt will spray the water with a liquid and the female will follow the smell and lay her eggs there. It sounds kind of gross. Then the male newt sort of takes off and the female stays



there and guards the eggs. I don't know if she guards them until they hatch and I don't know how many baby newts they have.

Q: What about how newts protect themselves?

A: If they think they are in danger they turn on their backs. I think the colors on their stomach maybe are scary to other animals. But the newt can grow back a leg or a tail if it gets eaten and one book says they taste really bad in their skin.

Q: Tell me about entering your newt in a 4-H project.

A: Well, I had to learn all about my newt and I had to tell a 4-H judge about my newt at the fair. I had this paper I wrote about them on my table and I had them there, too.

Q: Did the judge ask you questions and how did you answer them?

A: Yes. I said, "My name is..." and "Would you like to know about my newt?" Then he said, "Yes." I told him, "My newt is named Ben and she is an amphibian..."

Q: So you pretty much had this whole report memorized?

H → A: Yeah, my Mom helped me with the polysyllabic word and we'd over and over it a lot.

Q: What else did you do with Ben in this project? Did you have to watch her over them or anything like that?

A: Oh yeah, I had to learn about her from books and from watching her every day. I sometimes kept notes on what she did. So not if she was like the newts in the books.

Q: What did you learn from watching them?

A: I learned that she likes to spend a lot of time under this rock and she likes to stay away from the bubble thing. But she likes to climb out on this rock so she can be out of the water. Oh, and we had to make sure the lid was on this tank because she would get out.

Q: Did she get out?

G → A: Once she almost got out and my Dad saw her and put her back in. Oh, and you have to make sure your bowls are wet, because newts have really thin skin and it can tear.

Q: Does she stay underwater for a long time?

A: Yeah, I timed her sometimes and she stayed under about 30 minutes and sometimes more. She breathes air but when she was really little I think she had what they have.

Q: Gills?

F → A: Yeah, and now she can breathe air which is different and she's an amphibian and can go underwater and on land, too.

Physical Sciences Concepts
Life Sciences Concepts S2
Earth and Space Sciences Concepts
Scientific Connections and Applications
Scientific Thinking S5
Scientific Tools and Technologies
Scientific Communication S7
Scientific Investigation S8

- Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify and analyze using skills expected at this grade level (see also Mathematics Standard 4).
- Data and results that have been represented (see also Science Standard 7) in ways that fit the context.
- Recommendations, decisions, and conclusions based on evidence.
- Acknowledgment of references and contributions of others.

C D G H

- Results that are communicated appropriately to audiences.
- Reflection and defense of conclusions and recommendations from other sources and peer review.