Measurements of Student Progress

Test and Item Specifications

Grade 5 Science

Office of Superintendent of Public Instruction
OSPI

The purpose of the Measurements of Student Progress (MSP) is to measure the level of science proficiency that Washington students have achieved based on the *Washington State K-12 Science Learning Standards*. In the 2009 revision, the *Washington State K-12 Science Learning Standards* are organized by Big Ideas and Core Content. Each area of Core Content has specific performance expectations. The purpose of the Test and Item Specifications document is to guide the development of scenarios and items which align to the *Washington State K-12 Science Learning Standards*.

Test and Item Specifications Grade 5

Contents

Purpose Statement

The Test and Item Specifications describe how the scenarios and items for the Science Measurements of Student Progress (MSP) are developed.

The section titled Test Development Guidelines is written to guide the development of the Science MSP. Classroom teachers should find this section quite useful when creating MSP-like scenarios and items for use in classroom-based assessments.

The Standards section gives an overview of the 4-5 grade band of the *Washington State K-12 Science Learning Standards* (adopted June 2009).

The Test Organization section is a technical description of the exam that assures the assessment will validly measure the science standards in a reliable manner every year. The section is written to guide the developers of the Science MSPs.

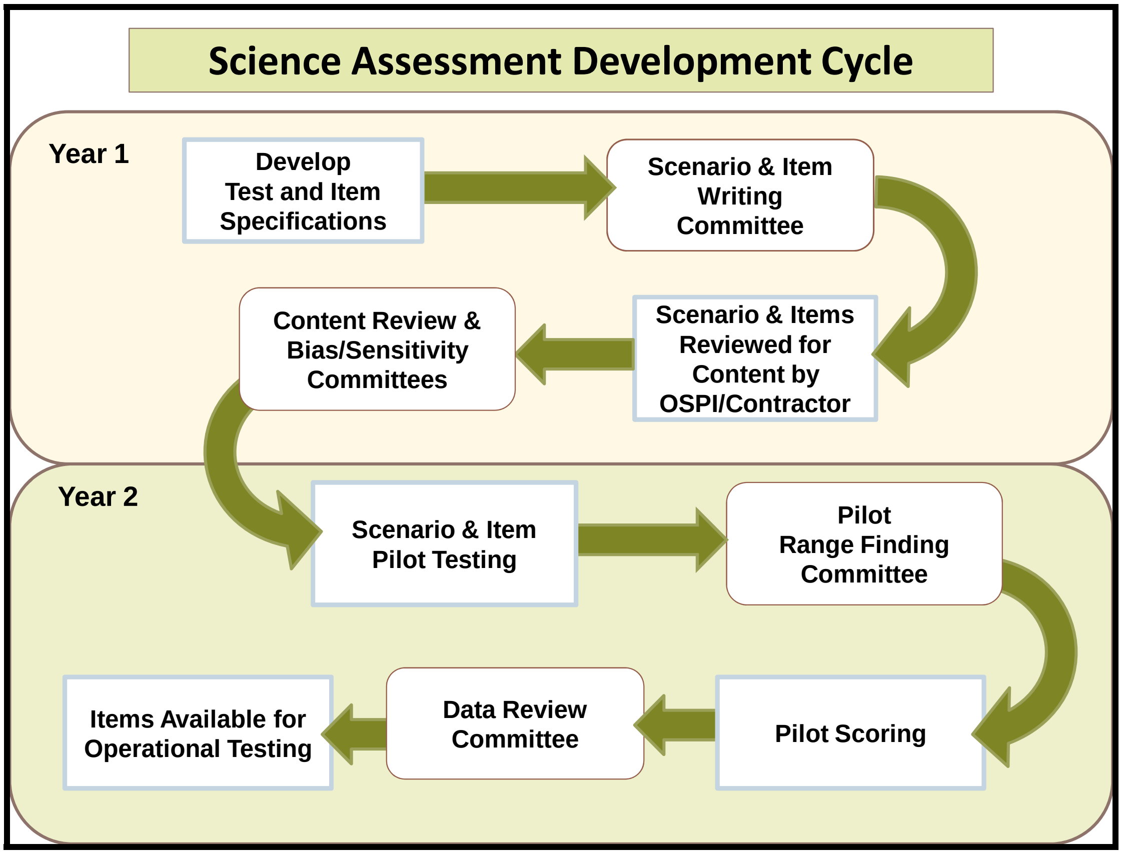
The Item Specifications section is useful for anyone interested in specific Science MSP items; every item on the Science MSP is described in this section.

Test Development Timeline

The Science MSP is written by trained science educators from Washington State. Each scenario and item is planned by the OSPI Science Assessment Team in conjunction with an educational assessment contractor and then written, reviewed, and revised during a scenario writing workshop. From there, the development process involves formal reviews with science educators for all scenarios and items and for the scoring criteria in the rubrics of completion and short-answer items. The development process assures the assessment contains items that meet the following criteria:

- Authentic scenarios describing what students might do in school
- Tight alignment to a specified science item specification
- Valid measure of a specified science learning standard
- Constructed response item scoring rubrics that can be applied in a valid manner
- Constructed response items that can be scored in a reliable manner

The Science Assessment Development Cycle flow-chart summarizes the two-year process of review and piloting that precedes scenarios and items being used on an operational exam.



Test Development Guidelines

The items on the MSP reflect the content standards and performance expectations of the *Washington State K-12 Science Learning Standards*. The guidelines in this document assist in writing items that match the standards, with sufficient restrictions to construct a valid and reliable on-demand assessment.

The scenario and item writer should be familiar with all scenario, item, and rubric development guidelines listed in this section as well as specific considerations listed within each Big Idea.

Considerations and procedures that make scenario and item development more efficient and effective include, but are not limited to, the following guidelines.

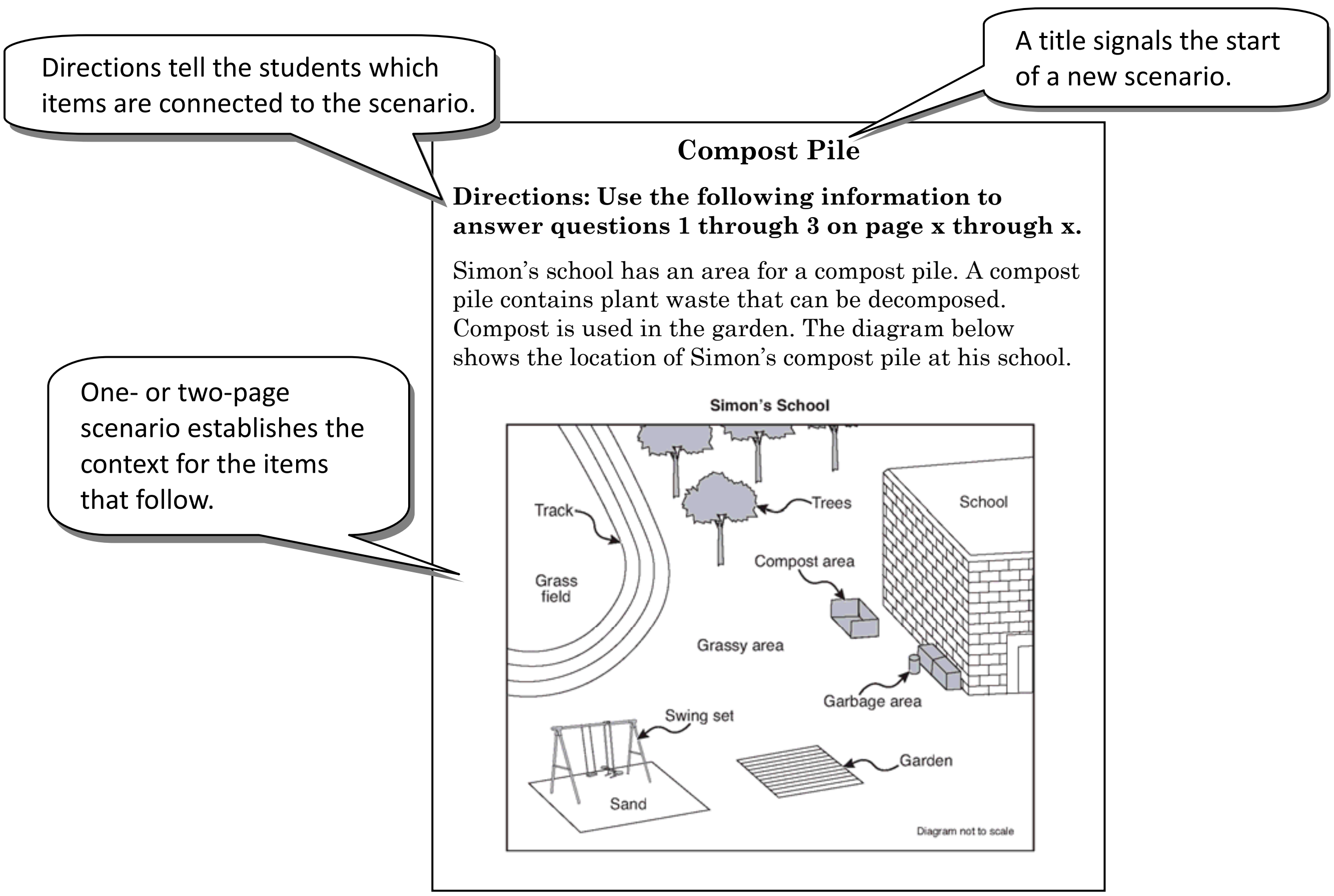
Scenario Development Guidelines

Introduction to Scenarios

Since 2001, the Washington science assessment has presented items within scenarios which provide context for a group of items. Advisory groups composed of national education experts, science assessment experts, and science educators decided to utilize the scenario structure for several reasons. First, scenarios are less likely to lead to discrete teaching of science facts, concepts and skills. Second, it is easier for students to demonstrate their scientific knowledge when they move from item to item within a scenario than when they have to orient to a new context for each item. Third, scenarios are consistent with the structure of the standards.

Overview of a Scenario

The organization of a scenario is summarized by the following example.



(This released scenario is provided as an example.)

A group of up to eight items follows the scenario.

Multiple-choice and completion items can appear together on a page. Students fill in the bubble or write a word or short phrase in the answer box.

1 Which one of these problems can be solved by putting waste in the compost pile?

- O **A.** Disposing of empty pop cans
- O **B.** Disposing of plastic containers
- O **C.** Disposing of leftover vegetables

2 Other than the worms in the compost pile, what is a living object in the school yard ecosystem?

Write your answer in the box.

Short-answer items fill an entire page. Students write their answers on the lines provided.

3 Simon asked his friends for ideas to help the compost pile decompose. They had these suggestions:

- ✓ turn (mix) the compost
- ✓ add leafy material to the compost
- ✓ add insects to the compost

Describe how **two** of these suggestions will help the plant waste decompose in the compost pile.

In your description, be sure to:

- Choose two of the suggestions.
- Describe how each suggestion will help the plant waste **decompose** in the compost pile.

First Suggestion:
Second Suggestion:

Common characteristics of scenarios

The following characteristics are common to all scenarios in the science MSP. In addition, there are unique characteristics for each of the three types of scenarios: Systems, Inquiry, and Application.

- Scenarios will be examples of situations students would encounter beyond school or of investigations to which they can relate.
- Scenarios should be **necessary but not sufficient** for student responses.
- Scenarios include short, textual information written at approximately a third grade reading level. Necessary fifth grade science words may also be included.
- Grade-level-appropriate terms that are pertinent to the scenario but may not be familiar to some students are defined in parentheses when they first appear. These terms will be italicized every time they appear throughout the scenario and associated items.
- Scenarios may have a combination of up to three elements (e.g., a data table, a diagram, and/or a written description).
- Titles for scenarios should be accurate, friendly, and interesting, but not distracting or misleading. Avoid titles that may have copyright issues (e.g., song titles).
- Character names on each test will be representative of the ethnic diversity of Washington students. The names will generally be short and simple to read.

Released scenarios are used to illustrate the unique characteristics of each of the three types of scenarios (Systems, Inquiry, and Application) on the following pages.

Systems Scenario Guidelines

Systems scenarios describe a physical, Earth/space, or living system. Systems scenarios may include systematic observations, models, or open-ended explorations of a system.

General Description of a System
The following characteristics are common to Systems scenarios.

A Systems scenario explores only one system. There may be subsystems within the system, and the system may be part of a larger system; however, the focus of the scenario should be a single system.

A short introduction defines the system by describing the system as an object or as connections of objects within defined boundaries.

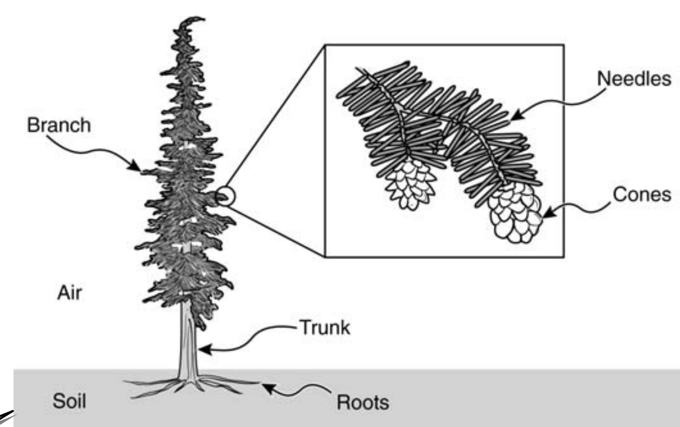
State Tree

The state tree for Washington is the Western Hemlock. The Western Hemlock tree is an important part of many forest ecosystems in Washington State.

The seeds of a hemlock tree can be found in the cones made by the tree. The Western Hemlock Tree diagram shows the cones on the branches.

Additional text can describe a phenomenon that occurs within that system, including descriptions of the inputs, transfers, and/or outputs of matter, information, and/or energy in the system.

Western Hemlock Tree



A labeled diagram of the system defines the boundaries of the system and labels the parts of the system.

(This released scenario is provided as an example.)

Inquiry Scenario Guidelines

Inquiry scenarios describe an investigation into a physical, Earth/space, or living system. Inquiry scenarios can be either controlled experiments or field studies and model age-appropriate investigations.

General Description of a Controlled Experiment

The following characteristics are common to Inquiry scenarios involving controlled experiments.

A short paragraph provides a context for the experiment.

The experimental question includes the changed and measured variables.

The prediction includes the changed and measured variables.

Materials necessary to carry out the experiment are listed.

A labeled setup diagram shows an overview of the experiment.

Better Boiling

Joel heard that cold water will begin boiling (bubbling at the surface) faster than hot water when heated the same. He and his father did the following controlled experiment.

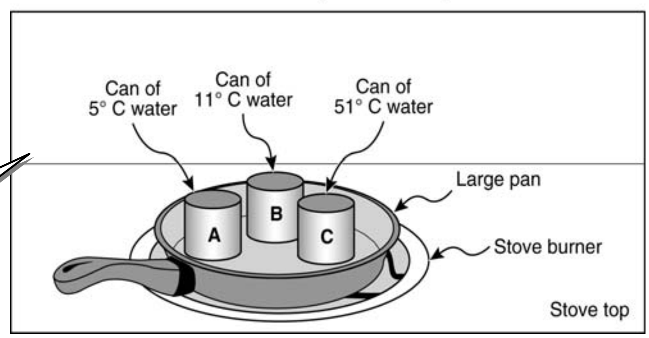
Question: What is the effect of different starting temperatures of water (5° C, 11° C, 51° C) on the time for the water to begin boiling?

Prediction: The lower the water's starting temperature, the quicker the water will begin boiling.

Materials:

empty cans of the same size labeled A, B, C
large pan
stove burner
water (5° C, 11° C, 51° C)
beaker
thermometer
stopwatch

Controlled Experiment Setup



(This released scenario is provided as an example.)

General Description of a Controlled Experiment (continued)

Steps to carry out the experiment are provided as a numbered list. The procedure is different from instructions to do the experiment; some details are unnecessary for the purpose of the assessment.

The changed variable has at least two conditions.

The measured variable is measured for each condition of the changed variable.

Other variables are kept the same so they do not confound the results.

Procedure:

1. Put three empty cans into the large pan.
2. Pour 5° C water into Can A. Pour the same amount of 11° C water into Can B and the same amount of 51° C water into Can C.
3. Place the pan on the stove burner. Turn the burner on to medium heat.
4. Measure and record the time for the water to begin boiling in each can as Trial 1.
5. Turn the burner off, and let the pan cool.
6. Repeat steps 1 through 5 two more times as Trials 2 and 3.
7. Find and record average time for the water to boil for each starting temperature.

Data:

Starting Temperature vs. Time to Boil

Starting Temperature	Time to Boil (seconds)			
	Trial 1	Trial 2	Trial 3	Average
5° C (Can A)	265	267	272	268
11° C (Can B)	257	252	253	254
51° C (Can C)	142	140	138	140

The conditions of the changed variable and the results for the measured variable are included in the data table.

Repeated trials are needed for reliability.

(This released scenario is provided as an example.)

General Description of a Field Study

The following characteristics are common to Inquiry scenarios involving field studies.

A short paragraph provides a context for the field study.

The field study question investigates a relationship between two variables.

A labeled diagram shows an overview of the field study.

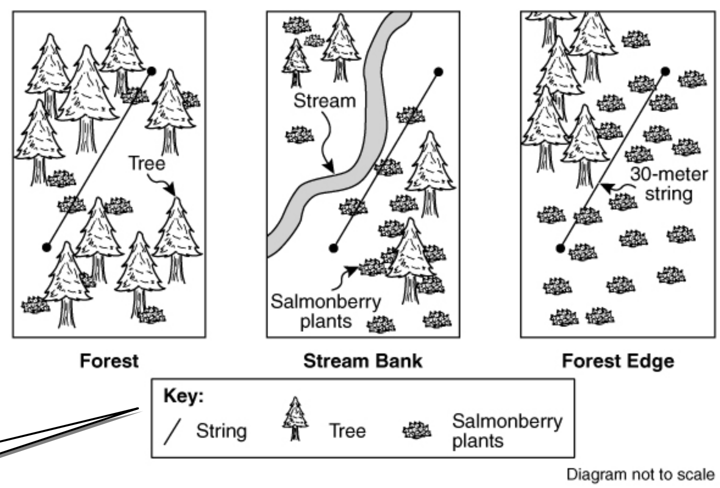
A key may sometimes be included in the diagram.

Berry Search

Greta and Scott's class wanted to learn where black bears find salmonberries to eat in different habitats in Washington. They did the following field study.

Field Study Question: How does the type of habitat affect the number of salmonberry plants growing in the habitat?

Berry Search Field Study



(This sample scenario is provided as an example.)

General Description of a Field Study (continued)

Steps to carry out the field study are provided as a numbered list. The procedure is different from instructions to actually do the field study; some details are unnecessary for the purpose of the assessment.

Data is collected for the measured variable.

There are at least two conditions being compared (changed variable).

Other variables are kept the same so they do not confound the results.

A data table includes all pertinent variables and data collected.

Procedure:

1. Go to the forest habitat. Record location, date and time.
2. Find a place to stretch out a 30-meter string.
3. Count and record the number of salmonberry plants touching the string as Path 1.
4. Repeat steps 2 through 3 and record as Paths 2 and 3.
5. Repeat steps 1 through 4 for the stream bank and forest edge habitats.
6. Find and record the average number of salmonberry plants for each habitat.

Data:

Location: Forest, stream bank, and forest edge habitats
Date and Time: May 1, 2 and 3, from 1:00 p.m. to 2:00 p.m.

Habitat vs. Number of Salmonberry Plants

Habitat	Number of Salmonberry Plants (touching 30-meter string)			
	Path 1	Path 2	Path 3	Average
Forest	7	3	8	6
Stream bank	19	17	21	19
Forest edge	23	22	27	24

Repeated trials are needed for reliability.

(This sample scenario is provided as an example.)

Application Scenario Guidelines

Application scenarios describe a technological design process students used to solve a problem. The problem must be one that involves a physical, Earth/space, or living system.

General Description of a Technological Design Process

The following characteristics are common to Application scenarios involving the technological design process.

A short paragraph provides a context for the technological design process.

The problem or challenge is defined.

A short summary of research about the problem is included.

Scientific information or concepts and principles that contribute to solving the problem (e.g., chart(s) of information, investigation results, or explaining how a scientific concept is used) are included throughout the scenario.

More than one idea that could solve the problem is explored. The problem and given materials of the scenario allow for various possible solutions.

The Birds

Tim's family moved to a new house with a fenced yard and a deck. The yard had no grass or plants. Tim helped his parents design a yard to attract birds and recorded the stages of their design process.

Problem: Attract birds to the yard.

Research the Problem: For two weeks, walk around the neighborhood for one hour each afternoon and record in the Bird Observations table what birds are seen doing.

Bird Observations

Where birds were seen	Bird actions; What birds were doing
Bird feeder in tree	Flew from tree branch to bird feeder, picked up seed, flew back to branch or ate seed on feeder
Neighbor's rooftop	Standing on roof, looking around
Telephone wires	Large group of birds perched on wire
Grassy area	Pecking grass and picking up worms, insects, and other things from the soil
Puddle of water	Drinking, jumping, splashing, and bobbing in the puddle
Flying in the air	Some birds flying with grass material dangling from beak; other birds circling and looking down
Sitting in the tree	Sitting in the tree and making birdcalls

Explore Ideas:

- ✓ Plant grass, flowers, shrubs, and trees.
- ✓ Put in a bird feeder, a birdbath, and birdhouses.
- ✓ Plan how to keep the plants healthy, the bird feeder full of seeds, and the birdbath clean and full of water.

(This released scenario is provided as an example.)

General Description of a Technological Design Process (continued)

The chosen plan is summarized and includes a scientific reason for choosing the solution.

The steps to implement the plan are described.

The solution is clearly illustrated in a labeled picture or labeled diagram.

How to test the effectiveness of the solution is briefly described.

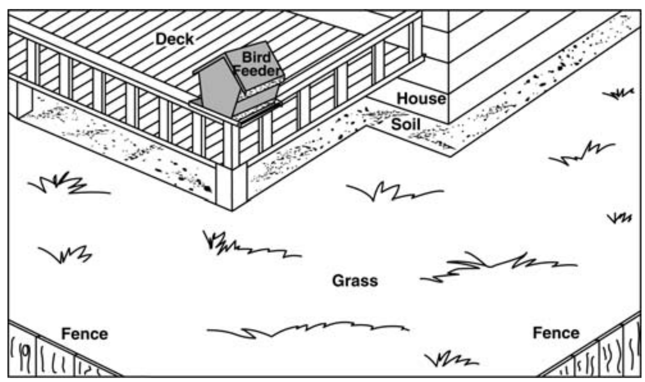
The test results are shown with a brief description and/or a chart.

Plan Summary: Plant grass for the birds to peck. Put in a bird feeder and keep the feeder full of seeds for the birds to eat. Keep the fence clear for birds to stand or sit like birds do on rooftops, telephone wires, and trees.

Steps to Do the Plan:

1. Plant grass leaving bare soil under the deck and around the house.
2. Water the grass.
3. Buy a bird feeder and install on the deck rail as shown in the Diagram of Solution.
4. Keep the bird feeder full of seed.

Diagram of Solution:



Test Solution: Count the birds in the yard one hour every afternoon for two weeks.

Test Results: Only 10 birds landed on the fence, flew into the yard, or came to the bird feeder during the two weeks.

(This released scenario is provided as an example.)

Item Development Guidelines

Considerations and procedures that make item development more efficient and effective include, but are not limited to, the following guidelines.

Standards

- Students are expected to know content from previous grade levels. However, items will only assess standards from the 4-5 grade band of the *Washington State K-12 Science Learning Standards*.
- An item may assess all or part of an item specification.

General Considerations

- A stimulus may include appropriate and relevant tables, charts, graphs, diagrams, and/or pictures.
- Items should avoid use of "not" or "if" unless that term is essential to communicate understanding of the task. Consider substituting "when" for "if".
- Items will include language that is unbiased and that will not disadvantage a particular group of students.

Cognitive Complexity

- Each item is assigned a cognitive complexity rating using Webb's Depth-of-Knowledge, as summarized in Appendix A.
- The cognitive complexity assigned to each item is confirmed through the stages of the item development process.
- The MSP is designed to include a range of cognitive complexity levels.

Vocabulary/Context

Clear Language

- Item stems and stimulus materials should be straightforward and use simple syntax.
- The stimulus should be as clear and simple as possible.
- The amount of reading should be kept to a minimum.
- Items will clearly indicate what is expected in a response and will help students focus their responses.
- Items should avoid the use of pronouns.

Vocabulary

- Items use language targeted to the previous grade level or lower readability, except for required scientific terms listed in the Vocabulary section of this document.
- A "Glossary of Non-Science Terms" is available for any student who may not be familiar with the non-science vocabulary in the items (e.g., soda can, puddle).

Rules for Multiple-Choice Items

- Each multiple-choice item has three answer choices, the correct answer and two distractors (wrong answer choices).
- A multiple-choice item will have a stem (a question, or a statement followed by a question).
- Multiple-choice item stems will present a clear indication of what is required so students will know what to do before looking at the answer choices.
- The three answer choices will be approximately the same length, will have the same format, and will be syntactically and semantically parallel. For example:

Not parallel:	Parallel:
A. The kind of fish used **B.** How long they counted the tail movements **C.** Water temperature	**A.** Markings on each goldfish **B.** Time to count tail movements **C.** Change in temperature of the water

- The answer choices will be arranged in numerical or chronological order or according to length.
- Students should not be able to rule out a distractor or to identify the answer simply because of superficial or trivial characteristics, syntactic complexity, or concept complexity.
- Distractors can reflect common errors or misunderstandings, naive preconceptions, or other misconceptions.
- Distractors will not be partially correct.
- The options "All of the above" and "None of the above" will not be used.

Rules for Completion Items

- Completion items should be written in the form of a clear and specific question.
- The question should allow for a very limited number of correct responses.
- The question will be followed by the phrase “Write your answer in the box.” An answer box space will be centered under the item.
- Answers will not be scored for labels. Labels should be included in the question and/or answer space.

Rules for Short-Answer Items

- Short-answer items will be in the form of a statement and give clear indications of the response required of students.
- When appropriate, bullets after phrases like "In your procedure, be sure to include:" or “In your description be sure to:” will provide extra details to assist students in writing a complete response.
- A response that requires multiple parts may be scaffolded within the response box to draw attention to the parts.

- Any short-answer item that requires the students to use information from a stimulus will specifically prompt for the information, e.g., “Use data from the table to …” or “Support your answer with information from the chart.”

Scoring Rubric Development Guidelines

- An item-specific scoring rubric will be developed for each completion and short-answer item during the writing of the item.
- Completion items will be scored with a 2-level scoring rubric (0 or 1).
- Short-answer items will be scored with a 3-level scoring rubric (0, 1, or 2).
- Some short-answer items will be scored by attributes that are converted to score points.
- Scoring rubrics will not consider conventions of writing (complete sentences, usage/grammar, spelling, capitals, punctuation, and paragraphing).
- Scoring rubrics will be edited during pilot range finding based on student responses.
- Scoring rubrics may be edited during operational range finding based on student responses.

Standards

The content of the *Washington State K-12 Science Learning Standards* is organized according to twelve Big Ideas of Science: nine in the domains of Life, Physical, and Earth and Space Science and three that cut across and unite all of the science domains: Systems, Inquiry, and Application. The following tables summarize the twelve Big Ideas of Science in the 4-5 grade band. The Core Content statements are shaded, followed by a summary of the Big Ideas in white.

Crosscutting Concepts and Abilities	
EALR 1 Systems	**Complex Systems**
	Analyze a system in terms of subsystems functions as well as inputs and outputs.
EALR 2 Inquiry	**Planning Investigations**
	Plan different kinds of investigations, including field studies, systematic observations, models, and controlled experiments.
EALR 3 Application	**Different Technologies**
	Define technologies and the technological design process to understand the use of technology in different cultures and career fields.

EALR 4: The Domains of Science			
Physical Science	**Measurement of Force and Motion**	**States of Matter**	**Heat, Light, Sound, and Electricity**
	Forces and motions can be measured.	A single kind of matter can exist as a solid, liquid, or gas. Matter is conserved.	Heat, light, sound, and electrical energy can be transferred.
Earth and Space Science	**Earth in Space**	**Formation of Earth Materials**	**Focus on Fossils**
	Earth is spherical in shape. It spins on its axis and orbits the Sun.	Earth materials are formed by various natural processes and can be used in different ways.	Fossils provide evidence that environments of the past were quite different from what we observe today.
Life Science	**Structures and Behaviors**	**Food Webs**	**Heredity and Adaptation**
	Plants and animals have different structures that meet their needs and respond to the environment.	Changes in ecosystems affect the populations that can be supported in a food web.	Ecosystems change. Organisms that can adapt to these changes will survive and reproduce in higher numbers.

Test Organization

The Science MSP includes three item formats: Multiple-Choice, Completion, and Short-Answer.

Multiple-Choice Items (MC)	Completion Items (CP)	Short-Answer Items (SA)
• Each multiple-choice item has three answer choices, the correct answer and two distractors. • There will be 20-25 multiple-choice items per operational test, worth one point each.	• Each completion item requires the student to enter a numerical answer, a word, or a short phrase. • There will be 1-6 completion items per operational test, worth one point each.	• Each short-answer item requires a constructed response. • The item may include a bulleted list to indicate the required elements in a response. • There will be 4 short-answer items per operational test, worth two points each.

Operational Test Forms

Each operational test book will contain the same items in a given year. Approximately 33% of the points of the test book are anchored or linking items with established calibration from previous years. Operational test forms will contain five embedded pilot items, which will either be associated with a pilot scenario or stand-alone items.

At grade 5, the test will be administered in a single testing session, which will be about 75-90 minutes long, plus an additional 25 minutes for set-up and directions. The test will contain 26 multiple-choice/completion items as well as four short-answer items. More details about the item composition are summarized in the Test Map shown below.

Test Map

EALR	MC/CP	SA	Percent of Test
Systems	6-8	0-1	At least 20%
Inquiry	6-10	0-2	30%
Application	6-7	0-2	20%
Domains of Science items not associated with a cross-cutting concept or ability	6-10	0-1	No more than 30%
Total Number of Items	**26**	**4**	
Total Number of Points	**26**	**8**	

Hypothetical Example Tests

Three hypothetical Grade 5 Science MSP tests are summarized on the next two pages. Each example shows the stimuli included on the test as a combination of different scenario types plus stand-alone items. Each example also demonstrates how points on the test can be spread across the four EALRs for items that assess only a domain of science (EALR 4), items that assess only a cross-cutting ability (EALRs 1 through 3), or items that assess both a cross-cutting ability and grade-level appropriate science domain knowledge.

Hypothetical Test 1:

Stimuli Included

Scenarios:

Earth Science **Inquiry** (Controlled Experiment)
Physical Science **System**
Physical Science **Application**
Life Science **System**

+ 5 Stand-Alone Items

Point Distribution within EALRs

	EALR 4 Domains of Science			**EALR 1-3 alone**	**Total**
	Physical	Earth/Space	Life		
EALR 1 SYSTEMS	1	2	4	0	7
EALR 2 INQUIRY				9	9
EALR 3 APPLICATION	2	2		4	8
EALR 4 alone	4	3	3	N/A	10
Total	7	7	7	13	34

Hypothetical Test 2:

Stimuli Included

Scenarios:

Physical Science **Inquiry** (Controlled Experiment)
Life Science **System**
Earth Science **Application**
Earth Science **System**

+ 4 Stand-Alone Items

Point Distribution within EALRs

	EALR 4 Domains of Science			**EALR 1-3 alone**	**Total**
	Physical	Earth/Space	Life		
EALR 1 SYSTEMS	3	3	3	0	9
EALR 2 INQUIRY	2			9	11
EALR 3 APPLICATION		2	1	4	7
EALR 4 alone	2	3	2	N/A	7
Total	7	8	6	13	34

Hypothetical Test 3:

Stimuli Included

Scenarios:

Life Science **Inquiry** (Field Study)
Earth Science **System**
Physical Science **Application**
Life Science **System**

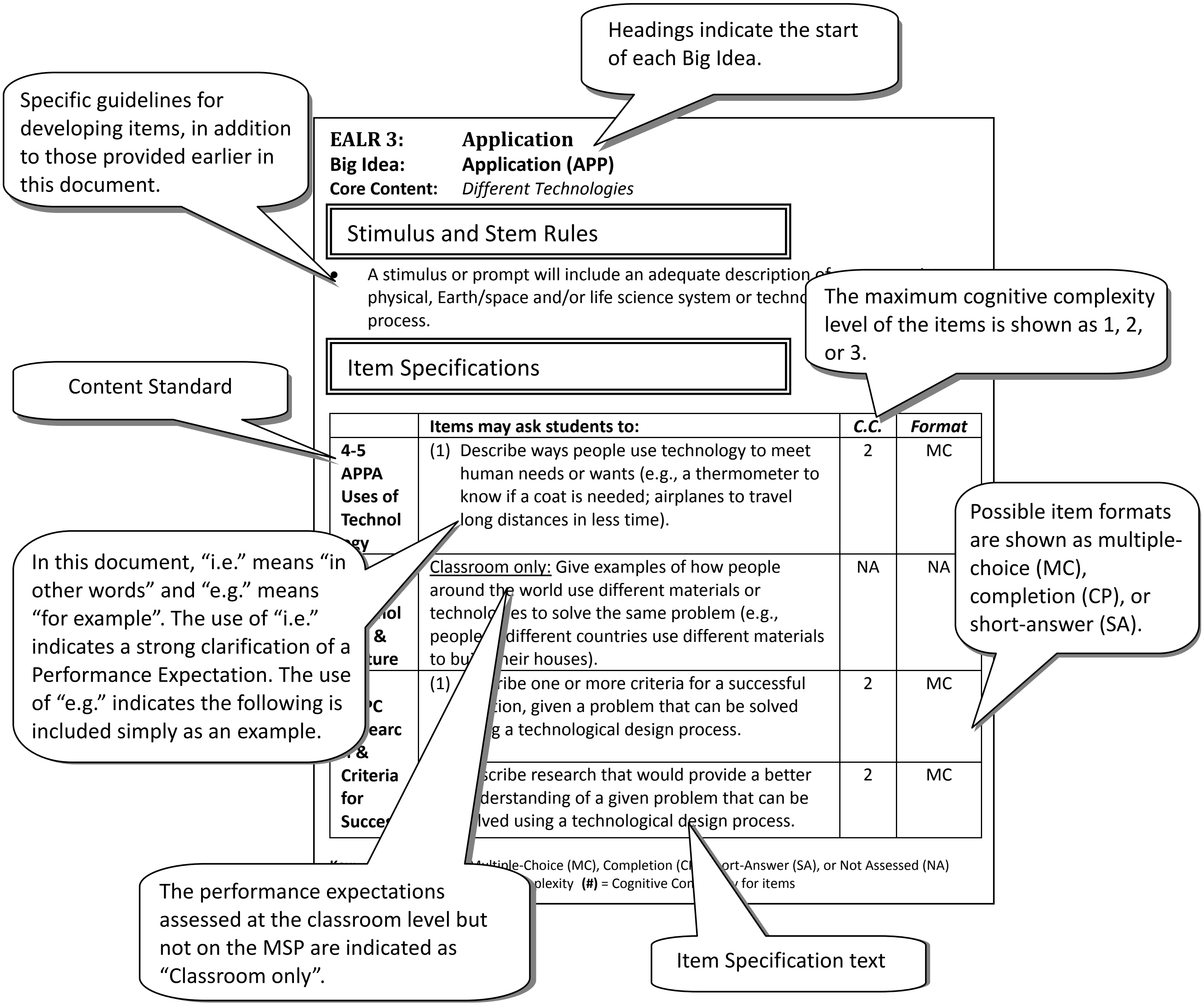
+ 6 Stand-Alone Items

Point Distribution within EALRs

	EALR 4 Domains of Science			**EALR 1-3 alone**	**Total**
	Physical	Earth/Space	Life		
EALR 1 SYSTEMS	3	4	2	0	9
EALR 2 INQUIRY		2		8	10
EALR 3 APPLICATION	3		1	2	6
EALR 4 alone	3	1	5	N/A	9
Total	9	7	8	10	34

Item Specifications

Item specifications pages have the following characteristics:



Item Specification Numbering System

EALR 1: Systems

Big Idea: Systems (SYS)

Core Content: *Complex Systems*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate physical, Earth/space, and/or life science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 SYSA Systems & Subsystems	(1) Identify one or more subsystems of a given system (e.g., the brakes in a bike system, water in an earth system).	2	MC
4-5 SYSB Functions of Systems	(1) Describe a function of a given system that any one of its subsystems is unable to do by itself (e.g., a bicycle can move forward, but the seat cannot move forward alone; the plant flower can make seeds, but not without the leaves using sunlight and the roots absorbing water).	2	MC
4-5 SYSC Inputs & Outputs of Systems	(1) Describe one or more inputs and/or outputs of a given system (e.g., *pushing on a pedal* is an input, and *the wheel moving* is an output in a bicycle system; *hitting a drum* is an input and *the sound of the drum* is an output of a drum system).	2	MC CP SA
	(2) Predict how changing an input to a given system might change the system (e.g., moving legs faster while on a swing makes the swing go higher).	2	MC SA
4-5 SYSD Changes to Parts of a System	(1) Predict what might happen to a given system if a part in one or more of its subsystems is missing, changed, broken, worn out, mismatched, or misconnected (e.g., if a wheel is broken a toy car will not move forward; if a battery is missing an electronic toy will not make sound; if flowers are taken off the plant cannot make seeds).	2	MC SA

<u>Key:</u> ***Format***= Multiple-Choice (MC), Completion (CP), Short-Answer (SA), or Not Assessed (NA)
C.C.= Cognitive Complexity **(#)** = Cognitive Complexity for items

EALR 2: Inquiry

Big Idea: **Inquiry (INQ)**

Core Content: *Planning Investigations*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate physical, Earth/space, and/or life science system or investigation.
- A definition for the term *variable* will be included in a glossary for all students to reference during testing as follows: All the parts of a system that could be changed are called variables. In an experiment one variable is changed and another variable is measured. The rest of the variables are kept the same.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 INQA Question & Evidence	(1) Given a brief description of an investigation, identify the question being asked.	2	MC
	(2) Describe evidence which could be gathered to answer a question.	2	MC CP
4-5 INQB Plan an Investigation	(1) Describe a plan to answer a given question for a controlled experiment with the following attributes: • One changed (manipulated) variable • One measured (responding) variable • Data to be gathered and recorded from multiple trials • Logical steps	3	MC SA
	(2) Describe a plan to answer a given question for a field study with the following attributes: • Conditions to be compared (manipulated variable) • Data to be collected (responding variable) • Data to be gathered and recorded from multiple observations • Logical steps	3	MC SA
	<u>Classroom only:</u> Work collaboratively with other students to carry out a controlled experiment, selecting appropriate tools and demonstrating safe and careful use of equipment.	NA	NA
4-5 INQC Analyze an Investigation	(1) Identify a variable kept the same (controlled) in a given description of a scientific investigation.	2	MC
	(2) Identify the changed (manipulated) variable in a given description of a scientific investigation.	2	MC CP
	(3) Identify the measured (responding) variable in a given description of a scientific investigation.	2	MC CP
	(4) Explain that things which might change the outcome of an experiment other than the changed (manipulated) variable must be kept the same.	2	MC

<u>Key:</u> ***Format***= Multiple-Choice (MC), Completion (CP), Short-Answer (SA), or Not Assessed (NA)
C.C.= Cognitive Complexity **(#)** = Cognitive Complexity for items

	Items may ask students to:	***C.C.***	***Format***
4-5 INQD Organize Data from an investigation	Assessed in INQA(2) and Mathematics (3.5.C, 3.5.D, 3.5.E, 3.6.F, 4.5.F, 5.4.D, 5.5.C, and 5.6.F): Gather, record, and organize data using appropriate units, tables, graphs, or maps.	NA	NA
4-5 INQE Reliability	(1) Describe that repeated trials are needed to be sure results are reliable (i.e., reliability means that repeating an investigation gives similar results).	2	MC
4-5 INQF Models	Classroom only: Create a simple model to represent an event, system, or process.	NA	NA
	(1) Tell what can be learned about an object, event, system, or process by using a given model.	2	MC SA
	(2) Describe how a model is similar to or different from the object, event, system, or process being modeled.	2	MC SA
4-5 INQG Conclusions from Data	(1) Generate a conclusion for a scientific investigation, including supporting data, given a description of and results from the investigation.	3	MC SA
	Assessed in EALR 4: Show how a conclusion is supported by scientific principles.	NA	NA
4-5 INQH Interpret Data from an investigation	Assessed in Mathematics (3.5.E, 3.6.F, 4.4.D, 5.4.D, 5.5.C, and 5.6.F): Display the findings of an investigation using tables, graphs, or other visual means to represent the data accurately and meaningfully.	NA	NA
	(1) Describe the results of a given scientific investigation.	2	MC
	Classroom only: Respond non-defensively to comments and questions about their investigation.	NA	NA
	(2) Propose an explanation for differences in results given a description of an investigation and differing results from more than one investigation group.	3	MC SA
4-5 INQI Intellectual Honesty	(1) Describe that results of an investigation must be reported honestly, even when the results do not match expectations.	2	MC

Key: ***Format***= Multiple-Choice (MC), Completion (CP), Short-Answer (SA), or Not Assessed (NA)
C.C.= Cognitive Complexity **(#)** = Cognitive Complexity for items

EALR 3: Application

Big Idea: **Application (APP)**

Core Content: *Different Technologies*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate physical, Earth/space, and/or life science system or technological design process.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 APPA Uses of Technology	(1) Describe ways people use technology to meet human needs or wants (e.g., a thermometer to know if a coat is needed; airplanes to travel long distances in less time).	2	MC
4-5 APPB Technology & Culture	Classroom only: Give examples of how people around the world use different materials or technologies to solve the same problem (e.g., people in different countries use different materials to build their houses).	NA	NA
4-5 APPC Research & Criteria for Success	(1) Describe one or more criteria for a successful solution, given a problem that can be solved using a technological design process.	2	MC
	(2) Describe research that would provide a better understanding of a given problem that can be solved using a technological design process.	2	MC
4-5 APPD Choosing a Solution	(1) Describe multiple solutions and/or reasons for choosing each solution given a problem that can be solved using a technological design process.	3	MC SA
	(2) Describe a reason(s) for choosing a solution given possible solution(s) and a problem that can be solved using a technological design process.	3	MC SA
	Classroom only: Work with other students to generate possible solutions to a problem and agree on the most promising solution based on how well each different idea meets the criteria for a successful solution.	NA	NA
4-5 APPE Testing Solutions	(1) Write a summary of a solution and/or describe a scientific test of the solution given a description of a problem that can be solved using a technological design process.	3	MC SA
	(2) Modify the original design to improve results given a solution to a problem and results of a test of the solution.	3	MC SA
4-5 APPF Communicate Solutions	Assessed in APPE(1) and Classroom: Communicate the solution, results of any tests, and modifications persuasively, using oral, written, and/or pictorial representations of the process and product.	NA	NA

Key: ***Format***= Multiple-Choice (MC), Completion (CP), Short-Answer (SA), or Not Assessed (NA)
C.C.= Cognitive Complexity **(#)** = Cognitive Complexity for items

	Items may ask students to:	***C.C.***	***Format***
4-5 APPG Impacts of Technology	(1) Describe specific ways science and technologies have improved the quality of humans' lives (e.g., food quality and/or quantity, transportation, health, sanitation, communication).	2	MC SA
4-5 APPH Science & Technology Careers	(1) Describe activities or careers that require people to apply knowledge and abilities in science, technology, engineering, and/or mathematics.	3	MC SA

EALR 4: Physical Science

Big Idea: **Force and Motion (PS1)**

Core Content: *Measurement of Force and Motion*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate physical science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 PS1A Weight & Gravity	(1) Describe the force of gravity acting on an object as the weight of that object.	2	MC CP
	(2) Identify that a spring scale measures the force of gravity.	1	MC
4-5 PS1B Relative Speed	(1) Describe the relative speed of objects traveling for the same amount of time given the distance each object moved or describe the relative distances moved of objects traveling for the same amount of time given the relative speeds of the objects.	2	MC CP
	(2) Describe the relative speed of objects traveling for the same distance given the amount of time each object moved or describe the relative times moved of objects traveling for the same distance given the relative speeds of the objects.	2	MC CP

EALR 4: Physical Science

Big Idea: **Matter: Properties and Changes (PS2)**

Core Content: *States of Matter*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate physical science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 PS2A States of Matter	(1) Explain that a given familiar substance (e.g., water) remains the same substance whatever its state.	1	MC CP
	(2) Identify whether a given substance is a solid, liquid or gas.	1	MC CP
	(3) Describe that the physical state of a substance can be changed by heating or cooling the substance.	1	MC
4-5 PS2B Air	(1) Describe the characteristics of air that make air a gas (e.g., expands to fill a closed container, increases pressure in a closed container when more is added).	2	MC
	(2) Describe wind as moving air and/or describe what wind can do (e.g., move sailboats, move a flag).	1	MC
4-5 PS2C Conservation of Matter	(1) Describe evidence that when a solid substance is dissolved in a liquid the substance still exists.	2	MC CP
	(2) Describe or predict that the weight of a sample of a substance remains the same when the sample is dissolved into another substance, is added to a mixture, or undergoes a change of state.	2	MC CP
	(3) Describe or predict that the weight of a sample of a substance remains the same when the sample is broken into small pieces.	2	MC CP

<u>Key:</u> ***Format***= Multiple-Choice (MC), Completion (CP), Short-Answer (SA), or Not Assessed (NA)
C.C.= Cognitive Complexity **(#)** = Cognitive Complexity for items

EALR 4: Physical Science

Big Idea: Energy: Transfer, Transformation and Conservation (PS3)

Core Content: *Heat, Light, Sound, and Electricity*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate physical science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 PS3A Forms of Energy	(1) List the form(s) of energy present in a given system (i.e., light, heat, sound, motion, electricity).	1	MC CP
4-5 PS3B Energy Transfer	(1) Describe an energy transfer in a given system (e.g., sound energy from a source moves through air to a receiver, light energy travels from the Sun to Earth).	2	MC SA
4-5 PS3C Heat Energy	(1) Describe one or more ways heat energy can be generated (e.g., lighting a match, rubbing hands together).	1	MC CP
	(2) Describe that heat energy is transferred from warmer objects to cooler objects (e.g., heat energy transfers from a flame to a cool frying pan).	1	MC
4-5 PS3D Sound Energy	(1) Describe that sound energy is generated by making an object vibrate.	1	MC CP
	(2) Describe that sound energy is transferred through air by vibrations (e.g., sound energy travels from a vibrating source to an observer by making air particles vibrate).	1	MC
4-5 PS3E Electric Circuits & Energy Trans-formations	(1) Describe that electric circuits require a complete loop of conducting materials through which an electric current can pass.	1	MC
	(2) Describe how to make a circuit complete, given an incomplete electric circuit.	1	MC CP
	(3) Describe electrical energy transferring from one place to another and/or transforming from electrical energy to different form(s) of energy in a given complete electric circuit (e.g., electrical energy moves from a battery, through a wire to a bulb; electrical energy changes to light and heat energy in a bulb; electrical energy changes to sound and motion in a buzzer).	2	MC CP SA

__Key:__ ***Format***= Multiple-Choice (MC), Completion (CP), Short-Answer (SA), or Not Assessed (NA)
C.C.= Cognitive Complexity **(#)** = Cognitive Complexity for items

EALR 4: Earth and Space Science

Big Idea: **Earth in the Universe (ES1)**

Core Content: *Earth in Space*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate Earth/space science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 ES1A Shape of Earth & Force of Gravity	(1) Describe Earth's shape as approximately spherical.	1	MC
	Classroom only: Give evidence to support the idea that Earth is spherical in shape.	NA	NA
	(3) Describe the force of gravity as the cause of the downward motion of falling objects on Earth.	2	MC CP
4-5 ES1B Day & Night	(1) Identify that Earth's daily spin relative to the Sun causes night and day.	1	MC CP
4-5 ES1C Constellations	(1) Explain that Earth's orbit around the Sun causes different constellations (i.e., star patterns) to be visible from Earth at different times of year.	1	MC
4-5 ES1D The Sun	(1) Identify the Sun as a star.	1	MC CP
	(2) Describe the location of the Sun as the center of our Solar System.	1	MC CP
	(3) Explain that the Sun appears to be brighter and larger than any other star because the Sun is very close to Earth.	1	MC

EALR 4: Earth and Space Science

Big Idea: Earth Systems, Structures, and Processes (ES2)

Core Content: *Formation of Earth Materials*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate Earth science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 ES2A Earth Materials	(1) Describe Earth materials in terms of their physical and/or chemical properties (e.g., color, texture, hardness, weight, shape, size of particles, magnetism, amount of dead plant and animal material).	2	MC
	(2) Describe how a property of an Earth material makes the material useful to people.	2	MC SA
	Classroom only: Give examples of human-made materials, including those that are changed only a little (e.g., wood and stones used for building) and those that look very different from the raw materials (e.g., metal, ceramics, plastics).	NA	NA
4-5 ES2B Weathering	(1) Describe physical and/or chemical processes that cause the breaking down of rock resulting in weathering (i.e., heating, cooling, pressure, acid rain).	2	MC CP
4-5 ES2C Erosion	(1) Describe natural processes or forces that cause the movement of Earth materials resulting in erosion (i.e., wind, water moving, ice forming, gravity).	2	MC CP
	(2) Identify examples where erosion has happened and describe the most likely cause(s) of the erosion.	2	MC SA
4-5 ES2D Formation of Soil	(1) Describe one or more of the processes involved in the formation of soil (e.g., weathering, erosion, decay of plant matter, settling, transport by water, deposition of sediments).	1	MC SA
4-5 ES2E Layers of Soil	(1) Describe or compare layers of soil based on the composition and/or physical properties of the soil (i.e., color, texture, size/shape of particles, amount of dead plant/animal material, capacity for holding water) given a diagram of the layers.	2	MC
4-5 ES2F Erosion Control	(1) Describe that erosion can result in the loss of soil from ecosystems because of wind blowing, water moving, ice forming, or gravity pulling.	2	MC CP
	(2) Describe methods used by people to slow down soil erosion.	2	MC SA

EALR 4: Earth and Space Science

Big Idea: **Earth History (ES3)**

Core Content: *Focus on Fossils*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate Earth science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 ES3A Formation of Fossils	(1) Describe an event that causes the formation of a fossil (e.g., the plant or animal may have been buried in sediment that hardened into rock and left an imprint, dissolved minerals may have seeped into a piece of wood and hardened into rock).	1	MC
4-5 ES3B Fossil Environments	(1) Describe the environment that likely existed when a given fossil was formed (e.g., fish fossils would indicate that a body of water existed at the time the fossils formed).	2	MC

EALR 4: Life Science

Big Idea: **Structures and Functions of Living Organisms (LS1)**

Core Content: *Structures and Behaviors*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate life science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 LS1A Sorting Organisms	(1) Describe how organisms can be sorted into groups based on characteristics such as their structures and/or behaviors (e.g., shape of leaves; presence of hair, feathers, or scales on their skin; grazing, hunting, or diving for food).	2	MC SA
4-5 LS1B Structure and Function	(1) Describe the function(s) served by a structure of an organism (e.g., thick fur helps the organism survive in cold climates; the hummingbird has a long beak for getting nectar from a flower; the bones support the body so the body can move; leaves absorb light; seeds grow into new plants; roots absorb water and mineral nutrients; flowers produce fruit).	2	MC SA
	(2) Identify the structure that performs a given function in an organism.	2	MC
	<u>Assessed in LS1C and LS1D:</u> Describe the function of a given animal behavior.	NA	NA
4-5 LS1C Responses to External Changes	(1) Describe a plant or animal response to a change in the environment (e.g., some animals react to a threat by making their hair stand on end to look larger; some animals hide when they see a predator; many plants grow toward light).	2	MC
4-5 LS1D Responses to Internal Needs	(1) Describe a plant or animal response to an internal need (e.g., plants wilt when they do not have water; animals seek food when hungry).	2	MC
4-5 LS1E Food	<u>Classroom only:</u> Describe how various types of foods contribute to the maintenance of healthy body structures.	NA	NA
	<u>Classroom only:</u> Develop a balanced plan for eating that will allow you to build and maintain your body.	NA	NA

EALR 4: Life Science

Big Idea: **Ecosystems (LS2)**

Core Content: *Food Webs*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate life science system.
- Scenario, stimulus, and/or stem may include a food web with arrows pointing in the direction of energy transfer.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5LS2A Ecosystems	(1) Identify one or more living and/or nonliving parts of a given ecosystem (i.e., living includes anything that is or once was living; nonliving parts include air, water, rocks).	1	MC
	(2) Explain how two given organisms in an ecosystem depend on one another for survival (e.g., worms decompose waste returning minerals to the soil, which help plants grow).	2	MC SA
	(3) Describe that an organism(s) depends on one or more non-living resources in a given ecosystem for survival (e.g., plants and animals need water).	2	MC SA
4-5LS2B Food Energy	(1) Describe that plants make their own food using the Sun's energy. **Note:** On the science assessments, the term 'mineral nutrient' will be used to describe the matter plants generally get from soil. Mineral nutrients are not food for plants. Plants make their food (energy-rich molecules) with light energy and matter from air, water, and mineral nutrients.	1	MC CP
	(2) Describe that animals get food by eating plants and/or other animals that eat plants.	2	MC CP
4-5 LS2C Roles in Food Webs	(1) Identify the producer(s), consumer(s), and/or decomposer(s) in given food web.	1	MC
	(2) Place three given organisms into a food web with arrows representing the direction of energy transfer.	2	CP
	(3) Compare/describe the role(s) of producer(s), consumer(s), and/or decomposer(s) in an ecosystem.	2	MC SA
4-5 LS2D Effect of Ecosystem Changes on Populations	(1) Predict how a given change to an ecosystem (i.e., forest fire, floods, ice/snow/wind storm, change in daily temperature, change in yearly rainfall, changes in one population) might affect a population of a plant or animal.	2	MC SA

<u>Key:</u> ***Format***= Multiple-Choice (MC), Completion (CP), Short-Answer (SA), or Not Assessed (NA)
C.C.= Cognitive Complexity **(#)** = Cognitive Complexity for items

	Items may ask students to:	***C.C.***	***Format***
4-5 LS2E Effect of Populations on Each Other	(1) Predict or describe how a change made in an ecosystem by one population of plant or animal (e.g., less fruit produced; a new species enters area) could impact the access to resources or population of another plant or animal population.	2	MC SA
4-5 LS2F Effect of Humans on Ecosystems	(1) Predict the impact of a given human activity on an ecosystem (e.g., recycling wastes, establishing rain gardens, planting native species to prevent flooding and erosion, overuse of fertilizers, littering).	2	MC SA

EALR 4: Life Science

Big Idea: **Biological Evolution (LS3)**

Core Content: *Heredity and Adaptation*

Stimulus and Stem Rules

- A stimulus or stem will include an adequate description of an appropriate life science system.

Item Specifications

	Items may ask students to:	***C.C.***	***Format***
4-5 LS3A Survival	(1) Describe one or more characteristics of a population of organisms that enable that population of organisms to thrive and grow in a given ecosystem (e.g., insects with green and brown body parts blend with surrounding trees; flowers with bright colors attract bees; animals with thicker fur can survive in colder ecosystems).	2	MC
	(2) Given two populations of organisms within one ecosystem, tell why one may thrive in the ecosystem while the other may not (e.g., bird populations with different colors of feathers).	3	MC SA
4-5 LS3B Inherited Characteristics	(1) Describe that many characteristics of an organism are inherited from the organism's parents.	2	MC
	(2) Describe how a given inherited characteristic might allow an organism to better survive and reproduce in a given ecosystem (e.g., the color of a moth could help the moth hide from predators).	2	MC
4-5 LS3C Non-inherited Characteristics	(1) Describe a characteristic and/or behavior that results from an individual organism's interactions with the environment and is not passed from one generation to the next by heredity (e.g., trees can lose a limb; animals can have accidents that cause scars; people can exercise and build muscles).	2	MC
4-5 LS3D Fossil Evidence	(1) Describe that fossils can provide evidence that plant and animals species have changed over time.	2	MC
	(2) Describe how fossils can provide evidence that a plant or animal species is extinct.	2	MC

Science Vocabulary Used in Assessment Items at Grade 5

Items use language targeted to the previous grade level or lower readability with the exception of the required science terms in the following list.

a

absorb
air
amount
attract

b

balance
benefit

c

career
cause
centimeter (cm)
changed (manipulated) variable
characteristic
circuit
classify
collect
compost
conclude
conclusion
conditions to be compared
conserve
constellations
consumer
controlled experiment
cycle

d

data
decay
decomposer
decrease
deposition
depth
describe
design
diagram
direction
dissolve

e

Earth
ecosystem
electric circuit
electrical energy
electricity
energy
energy of motion
environment
erode
erosion
event
evidence
experiment
experimental question
explain
explanation
explore
extinct

f

field study
food web
force
forest
form of energy
fossil
freeze
function

g

gas
gram (g)
graph
gravitational force
gravity

h

habitat
hardness
heat energy

i

identical
identify
inch (in.)
increase
inherited
input
invent
invention
investigation

k

kilogram (kg)
kilometer (km)

l

lamp
light energy
liquid
liter (L)
living
logical

m

machine
magnetic
magnetism
mass
material
matter
measure

measured (responding) variable
melt
meter (m)
mile (mi)
milliliter (mL)
millimeter (mm)
mineral nutrient
model
Moon
motion
movement

n

newtons (N)
non-living

o

object
observation
observe
orbit (as a noun)
orbit (as a verb)
organism
organize
output

p

part
particle
pattern
pollution
population
pound
predator
predict
prediction
prevent
problem
procedure
process
producer
property
protect
provide

q

question

r

recycle
redesign
reduce
reliable
report
research
resource
respond
result
role

s

scientific
scientist
sediment
soil
Solar System
solid
solution (to a problem)
solve
sound energy
speed
spin (rotate)
spring scale
state of matter
structure
substance
subsystem
summary
Sun
supported
surface
survive
switch
system

t

table
technology
temperature
texture
thermometer
transfer
transform
transformation

v

variable
variable kept the same (controlled)
versus (vs.)
vibration

w

waste
weather
weathering
weight

Progression of Variables Language Used in Assessment Items

Terms for the variables in a controlled experiment that build through the grade levels are listed below.

Grade 5
variable kept the same (controlled)
changed (manipulated) variable
measured (responding) variable

A definition for the term *variable* will be included in a glossary for all grade 5 students to reference during testing as follows: All the parts of a system that could be changed are called variables. In an experiment one variable is changed and another variable is measured. The rest of the variables are kept the same.

Grade 8
controlled (kept the same) variable
manipulated (independent) variable
responding (dependent) variable

Biology
controlled (kept the same) variable
manipulated (independent) variable
responding (dependent) variable

Appendix A: Cognitive Complexity

The cognitive level assigned to an Item Specification is the ceiling for the assessment. Different items written to the same specification can and should be written to different cognitive levels.

Webb's Depth-of-Knowledge (DOK) Levels for Science

Karin K. Hess

According to Norman L. Webb ("Depth-of-Knowledge Levels for Four Content Areas," March 28, 2002), interpreting and assigning depth-of-knowledge levels to both objectives within standards and assessment items is an essential requirement of alignment analysis. Four levels of Depth of Knowledge are used for this analysis.

A general definition for each of the four (Webb) Depth-of-Knowledge levels is followed by Table 1, which provides further specification and examples for each of the DOK levels in science. Generally speaking, large-scale, on-demand assessments should only assess Depth-of-Knowledge Levels 1, 2, and 3. Depth-of-Knowledge at Level 4 should be reserved for local assessment and is included here primarily for illustrative purposes.

Descriptors of DOK Levels for Science (based on Webb, March 2002 and TIMSS Science Assessment framework, 2003)

Level 1 Recall and Reproduction requires recall of information, such as a fact, definition, term, or a simple procedure, as well as performing a **simple** science process or procedure. Level 1 only requires students to demonstrate a rote response, use a well-known formula, follow a set procedure (like a recipe), or perform a clearly defined series of steps. A "simple" procedure is well-defined and typically involves only **one-step**. Verbs such as "identify," "recall," "recognize," "use," "calculate," and "measure" generally represent cognitive work at the recall and reproduction level. Simple word problems that can be directly translated into and solved by a formula are considered Level 1. Verbs such as "describe" and "explain" could be classified at different DOK levels, depending on the complexity of what is to be described and explained.

A student answering a Level 1 item either knows the answer or does not: that is, the answer does not need to be "figured out" or "solved." In other words, if the knowledge necessary to answer an item automatically provides the answer to the item, then the item is at Level 1. If the knowledge necessary to answer the item does not automatically provide the answer, the item is at least at Level 2.

Level 2 Skills and Concepts includes the engagement of some mental processing beyond recalling or reproducing a response. The content knowledge or process involved is **more complex** than in Level 1. Items require students to make some decisions as to how to approach the question or problem. Keywords that generally distinguish a Level 2 item include "classify," "organize," "estimate," "make observations," "collect and display data," and "compare data." These actions imply **more than one step**. For example, to compare data requires first identifying characteristics of the objects or phenomenon and then grouping or ordering the objects. Level 2 activities include making observations and collecting data; classifying, organizing, and comparing data; and organizing and displaying data in tables, graphs, and charts.

Some action verbs, such as "explain," "describe," or "interpret," could be classified at different DOK levels, depending on the complexity of the action. For example, interpreting information from a simple graph, requiring reading information from the graph, is a Level 2. An item that requires interpretation from a complex graph, such as making decisions regarding features of the graph that need to be considered and how information from the graph can be aggregated, is at Level 3.

Level 3 Strategic Thinking requires deep knowledge using reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. The cognitive demands at Level 3 are **complex and abstract**. The complexity does not result only from the fact that there could be multiple answers, a possibility for both Levels 1 and 2, but because the multi-step task requires **more demanding reasoning**. In most instances, requiring students to explain their thinking is at Level 3; requiring a very simple explanation or a word or two should be at Level 2. An activity that has more than one possible answer and requires students to justify the response they give would most likely be a Level 3. Experimental designs in Level 3 typically involve more than one dependent variable. Other Level 3 activities include drawing conclusions from observations; citing evidence and developing a logical argument for concepts; explaining phenomena in terms of concepts; and using concepts to solve non-routine problems.

Level 4 Extended Thinking requires **high cognitive demand** and is **very complex**. Students are required to make several connections—relate ideas *within* the content area or *among* content areas—and have to select or devise one approach among many alternatives on how the situation can be solved. Many on-demand assessment instruments will not include any assessment activities that could be classified as Level 4. However, standards, goals, and objectives can be stated in such a way as to expect students to perform extended thinking. "Develop generalizations of the results obtained and the strategies used and apply them to new problem situations," is an example of a Grade 8 objective that is a Level 4. Many, but not all, performance assessments and open-ended assessment activities requiring significant thought will be Level 4.

Level 4 requires complex reasoning, experimental design and planning, and **probably will require an extended period of time** either for the science investigation required by an objective, or for carrying out the multiple steps of an assessment item. However, the extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking. For example, if a student has to take the water temperature from a river each day for a month and then construct a graph, this would be classified as a Level 2 activity. However, if the student conducts a river study that requires taking into consideration a number of variables, this would be a Level 4.

Table 1: Examples for each of the DOK Levels in Science, based on Webb (working draft K. Hess, November 2004)

Level 1 **Recall & Reproduction**	**Level 2** **Skills & Concepts**	**Level 3** **Strategic Thinking**	**Level 4** **Extended Thinking**
a) Recall or recognize a fact, term, definition, simple procedure (such as one step), or property b) Demonstrate a rote response c) Use a well-known formula d) Represent in words or diagrams a scientific concept or relationship e) Provide or recognize a standard scientific representation for simple phenomenon f) Perform a routine procedure, such as measuring length g) Perform a **simple** science process or a set procedure (like a recipe) h) Perform a clearly defined set of steps i) Identify, calculate, or measure **NOTE: If the knowledge necessary to answer an item automatically provides the answer, it is a Level 1.**	a) Specify and explain the relationship between facts, terms, properties, or variables b) Describe and explain examples and non-examples of science concepts c) Select a procedure according to specified criteria and perform it d) Formulate a routine problem given data and conditions e) Organize, represent, and compare data f) Make a decision as to how to approach the problem g) Classify, organize, or estimate h) Compare data i) Make observations j) Interpret information from a simple graph k) Collect and display data **NOTE: If the knowledge necessary to answer an item does not automatically provide the answer, then the item is at least a Level 2. Most actions imply more than one step.**	a) Interpret information from a complex graph (such as determining features of the graph or aggregating data in the graph) b) Use reasoning, planning, and evidence c) Explain thinking (beyond a simple explanation or using only a word or two to respond) d) Justify a response e) Identify research questions and design investigations for a scientific problem f) Use concepts to solve non-routine problems/more than one possible answer g) Develop a scientific model for a complex situation h) Form conclusions from experimental or observational data i) Complete a multi-step problem that involves planning and reasoning j) Provide an explanation of a principle k) Justify a response when more than one answer is possible l) Cite evidence and develop a logical argument for concepts m) Conduct a designed investigation n) Research and explain a scientific concept o) Explain phenomena in terms of concepts	a) Select or devise approach among many alternatives to solve problem b) Based on provided data from a complex experiment that is novel to the student, deduct the fundamental relationship between several controlled variables c) Conduct an investigation, from specifying a problem to designing and carrying out an experiment, to analyzing its data and forming conclusions d) Relate ideas *within* the content area or *among* content areas e) Develop generalizations of the results obtained and the strategies used and apply them to new problem situations **NOTE: Level 4 activities often require an extended period of time for carrying out multiple steps; however, time alone is not a distinguishing factor if skills and concepts are simply repetitive over time.**

Depth-of-Knowledge as a "Ceiling" NOT as a "Target"
An important consideration of large-scale assessment design is to use the highest Depth-of-Knowledge (DOK) demand implicit in an assessment limit as the "ceiling" for assessment, not the "target." When considering the highest DOK Level as the ceiling and not the target, it has the potential to be assessed at Depth-of-Knowledge Levels at the ceiling, and up to the ceiling, depending upon the cognitive demand of the assessment limit.

Why is this distinction between "ceiling" and "target" important?
If assessed only as the "target" level, all assessment limits with a Level 2 or Level 3 as their highest demand would only be assessed at those highest levels. This would potentially have two negative impacts on the assessment: 1) The assessment as a whole could be too difficult; and 2) important information about student learning along the achievement continuum would be lost. Multiple items covering a range of DOK levels can provide useful instructional information for classroom teachers.

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An updated version is available at: http://www.nciea.org/publications/DOKscience_KH11.pdf