Washington Comprehensive Assessment Program

Test and Item Specifications

Biology

Office of Superintendent of Public Instruction
OSPI

The purpose of the end-of-course exam 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 Biology

Contents

Purpose Statement

The Test and Item Specifications describe how the scenarios and items for the biology end-of-course exam are developed.

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

The Standards section gives an overview of the 9-11 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 biology end-of-course exam.

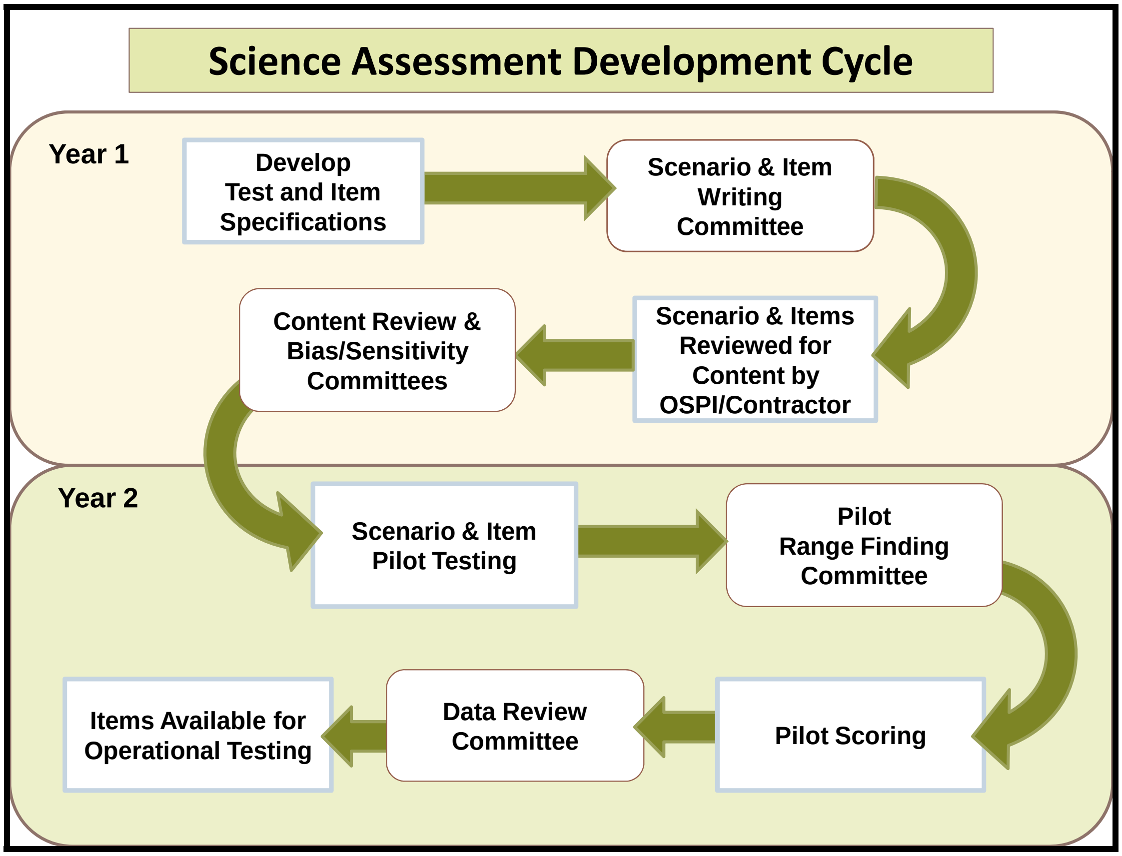
The Item Specifications section is useful for anyone interested in specific biology end-of-course exam items; every item on the biology end-of-course exam is described in this section.

Test Development Timeline

The biology end-of-course exam 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 biology end-of-course exam 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 5th grade released scenario example.

Directions tell the students which items are connected to the scenario.

A title signals the start of a new scenario.

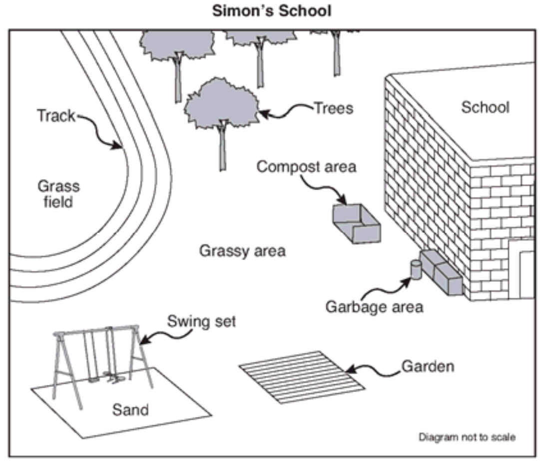
One- or two-page scenario establishes the context for the items that follow.

Compost Pile

Directions: Use the following information to answer questions 1 through 3 on page x through x.

Simon's school has an area for a compost pile. A compost pile contains plant waste that can be decomposed. Compost is used in the garden. The diagram below shows the location of Simon's compost pile at his school.

Simon's School



(This 5th grade 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.

(These 5th grade items are provided as an example.)

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:

(This 5th grade item is provided as an example.)

Common characteristics of scenarios

The following characteristics are common to all scenarios in the biology end-of-course exam. 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 an eighth grade reading level. Necessary high-school reading level life 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 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.

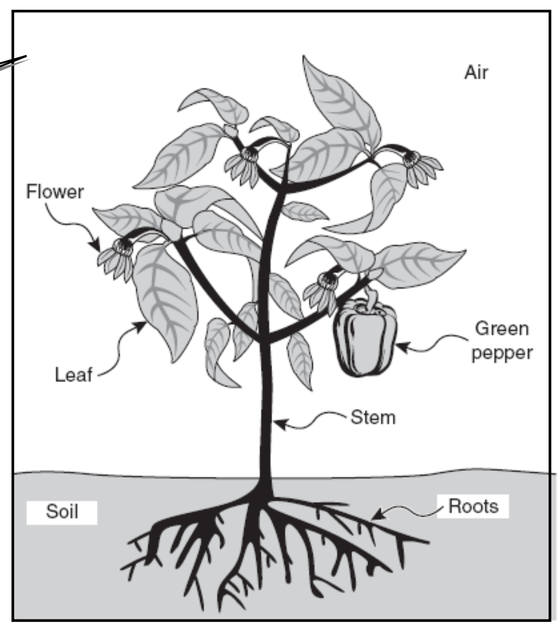
A Systems scenario explores only one system. There may be subsystems within the system, and the system may be part of a larger system; however, the focus of the scenario should be a single system.

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

The Green Machine

While helping to plant a school garden, Becky and Nate observed many different types of plants. They drew the following diagram of a pepper plant growing in the garden.

Green Pepper Plant



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

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.

(This released scenario is provided as an example.)

Inquiry Scenario Guidelines

Inquiry scenarios describe an investigation into a 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 manipulated and responding variables.

The prediction includes the manipulated and responding variables.

Materials necessary to carry out the experiment are listed.

A labeled setup diagram shows an overview of the experiment.

Guard Against *Giardia*

Celeste and Aaron knew drinking water containing *Giardia cysts* (microorganisms) can cause health problems in people. In the intestine, *Giardia cysts* develop into adult *Giardia* which can cause illness. Working with the health department, Celeste and Aaron investigated the effect of water temperature on *Giardia cysts*.

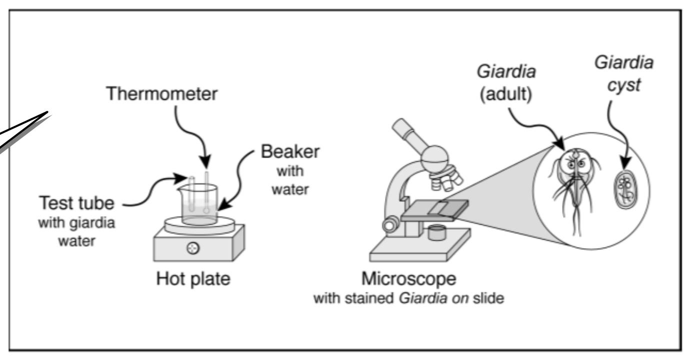
Question: What is the effect of the temperature of water on the survival of *Giardia cysts*?

Prediction: As the temperature of water increases, the number of *Giardia cysts* surviving will decrease.

Materials:

- water with *Giardia cysts*
- thermometer
- beaker with water
- test tubes labeled #1, #2, #3, and #4
- test tube rack and clamp
- hot plate
- microscope
- stain for *Giardia*
- graduated cylinder
- eyedroppers
- microscope slides
- 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 manipulated variable has at least three conditions.

The responding variable is measured for each condition of the manipulated variable.

Other variables are controlled so they do not confound the results.

Procedure:

1. Put 10 milliliters of water with *Giardia cysts* into each test tube.
2. Measure and record the temperature of test tube #1.
3. Put the beaker with water on the hot plate and increase the temperature of the water to 40° C.
4. Put test tube #2 in the beaker and keep the temperature of the water at 40° C for ten minutes. Return the test tube to the rack.
5. Repeat steps 3 and 4 with test tube #3 at 50° C, and #4 at 100° C.
6. Put a drop of water from each test tube on separate microscope slides using clean eyedroppers. Add one drop of the *Giardia* stain to each slide.
7. Put each slide under the microscope and look for *Giardia cysts*. Surviving *cysts* will be stained a different color from the dead cysts.
8. Identify 20 *Giardia cysts* and record how many of the 20 were surviving for each water temperature as Trial 1.
9. Clean the equipment and repeat the investigation for Trials 2 and 3.
10. Calculate and record the average of the three trials for each temperature.

Data:

Temperature of Water vs. Surviving *Giardia Cysts*

Temperature of Water in each test tube (° C)	**Surviving *Giardia Cysts*** (number)			
	Trial 1	Trial 2	Trial 3	Average
22	20	20	19	20
40	2	3	2	2
50	1	1	2	1
100	0	0	0	0

Note: Investigation was ... perature of 22° C.

The conditions of the manipulated variable and the results for the responding 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 an independent and a dependent variable.

A labeled diagram shows an overview of the field study.

Salmonberry Plants

Salmonberry plants can be found all along the Pacific coast. Salmonberry plants are a food source for many animals in Pacific coast ecosystems including hummingbirds, deer, and bear. Scientists conducted a field study to learn about salmonberry plant populations in different habitats in Washington.

Field Study Question: How does the salmonberry plant population vary by habitat?

Salmonberry Plants Field Study

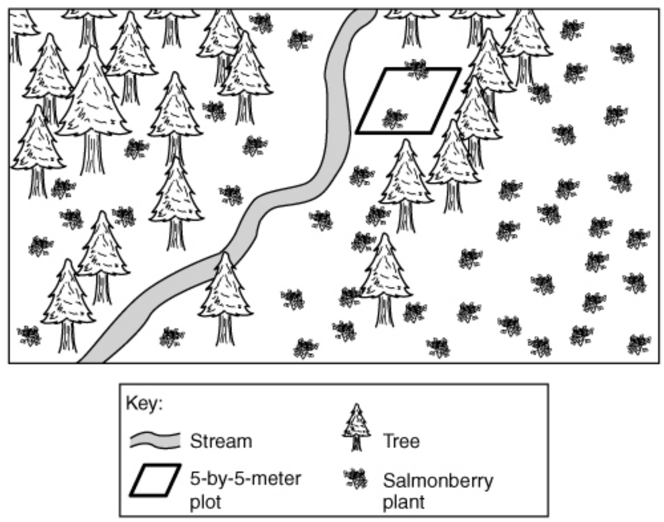


Diagram not to scale

(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.

The dependent variable is measured for each condition of the independent variable.

The independent variable has at least three conditions.

Other variables are controlled so they do not confound the results.

A data table includes all pertinent variables and data collected.

Procedure:

1. Go to the salmonberry field study area. Record location, date, time, and temperature.
2. Choose a random location in the forest edge habitat.
3. Measure a 5-meter-by-5-meter plot and label as Plot 1.
4. Count the number of salmonberry plants in Plot 1. Record as Plot 1 for the forest edge habitat.
5. Repeat steps 2 through 4 for Plot 2 and Plot 3, choosing a new location in the forest edge habitat for each plot.
6. Repeat steps 1 through 5 for the stream bank and forest habitats.
7. Calculate and record the average number of salmonberry plants for each habitat.

Data:

Location: Forest edge, stream bank, and forest habitats
Date and Time: May 1, from 11:00 A.M. to 2:00 P.M.
Temperature: 10° C to 15° C

Habitat vs. Number of Salmonberry Plants

Habitat	Number of Salmonberry Plants (in a 5-meter-by-5-meter plot)			
	Plot 1	Plot 2	Plot 3	Average
Forest edge	15	18	15	16
Stream bank	11	13	12	12
Forest	5	5	2	4

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 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.

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

Ladybug Challenge

Ron and Kira decided to participate in the school's Ladybug Challenge as their science project. They documented the stages of their design process as follows.

Challenge (problem): Build a habitat for ladybugs

Challenge Rules (constraints):
Habitat must be closed; no substances may enter or leave.
Ladybugs must stay alive for 30 days.
Anything may be used as a habitat and anything may be placed inside.

Research the Problem:
Ladybug Research Results: an insect that lives in and around soil and plants; eats insects (primarily aphids); reproduces sexually and lays eggs that hatch into larvae; can be purchased.
Aphid Research Results: an insect that lives on and gets juices for food from broadleaf plants; sexually reproduces in spring, lays eggs, and newborns give birth all summer without mating resulting in a very high rate of reproduction.

Explore Ideas:
- ✓ Use a large, clear plastic container or glass jar as the habitat.
- ✓ Plant healthy, moist plants with broad leaves.
- ✓ Purchase or collect ladybugs.
- ✓ Collect plants with aphids on them.
- ✓ Place habitat under a lamp or on a sunny window ledge.
- ✓ Use moist potting soil or soil from a garden for the plants in the habitat.

Plan Summary: Build a habitat in a plastic container using ground cover plants with aphids, potting soil, and ladybugs. Place the habitat on a sunny window ledge. This habitat should provide energy, food, air, and water for the organisms for at least 30 days.

(This released scenario is provided as an example.)

General Description of a Technological Design Process (continued)

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.

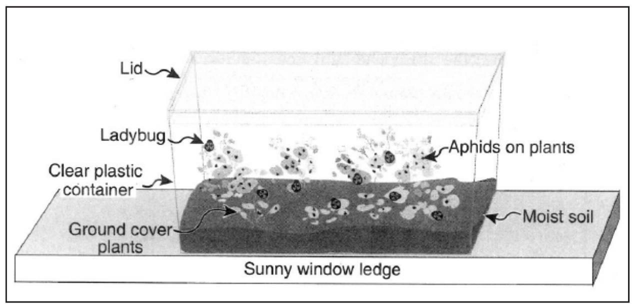
The steps to implement the plan are described.

Steps to Do the Plan:

1. Put moist potting soil in the bottom of a clear, plastic container.
2. Collect healthy ground cover plants with aphids.
3. Plant the ground cover in the soil in the container.
4. Buy ladybugs. Add four males and four females to the container.
5. Put the lid tightly on the container shown in the Diagram of the Solution.
6. Place the habitat (sealed container with plants, insects, moist soil, and air) on a sunny window ledge.

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

Diagram of Solution:



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

Test Solution: Record observations of the habitat at noon every five days for 30 days.

Test Results:

	Summary of the 30 days of Observations
Ladybugs	All 8 ladybugs were active during each observation. Ladybugs were seen crawling everywhere in the habitat.
Aphids	Aphids visible during each observation. Difficult to count but there seemed to be fewer toward the end of the 30 days.
Plants	About half the plants were alive at the end of the 30 days. Some of the remaining plants still looked healthy.
Soil	The soil did not change throughout the 30 days. Plant roots started to be seen between the soil and the plastic container.
Plastic Container	There were water droplets on the inside of the lid during each observation. The container itself did not change.

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

(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

- Items will only assess standards from EALRs 1 through 3 and the Life Science Domain of EALR 4 in the 9-11 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 biology end-of-course exam 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 an eighth 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 four answer choices, the correct answer and three 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 four 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. Number of times the goldfish gills moved in a minute **B.** The kind of fish used in the experiment **C.** How long they counted the gill movements **D.** Water temperature	**A.** Breathing rate of goldfish **B.** Markings on each goldfish **C.** Time to count gill movements **D.** 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 Big Ideas of Science in the 9-11 grade band that are assessed on the biology end-of-course exam. The Core Content statements are shaded, followed by a summary of the Big Ideas in white.

Crosscutting Concepts and Abilities	
EALR 1 Systems	**Predictability and Feedback**
	Create realistic models with feedback loops, and recognize that all models are limited in their predictive power.
EALR 2 Inquiry	**Conducting Analyses and Thinking Logically**
	Expand and refine skills and abilities of inquiry to gain a deeper understanding of natural phenomena.
EALR 3 Application	**Science, Technology, and Society**
	Transfer and apply abilities in science and technological design to develop solutions to societal issues.

EALR 4: The Domains of Science			
Life Science	**Processes Within Cells**	**Maintenance and Stability of Populations**	**Inheritance, Variation and Adaptation**
	Cells contain the mechanisms for life functions, reproduction, and inheritance.	A variety of factors can affect the ability of an ecosystem to maintain current population levels.	The underlying mechanisms of evolution include genetic variability, population growth, resource supply, and environment.

Test Organization

The biology end-of-course exam 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 four answer choices, the correct answer and three distractors. • There will be 26-29 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 1-4 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 five 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.

The Biology End-of-Course Exam is intended to be administered to intact classrooms over three days. Districts may choose to administer the EOC in a single, arena-style session. The approximate 150 minute administration time includes 30 minutes for directions/distributing materials. The majority of students will finish testing within the remaining 120 minutes. Contact your district assessment coordinator for further information on the specific test schedule for your district/building.

Tools, including approved calculators, are allowed for the test administration. Please refer to the calculator policy (http://www.k12.wa.us/Mathematics/CalculatorPolicy.aspx) for more information.

Additional details about the item composition are summarized in the following three tables.

Table 1.
Relative weighting of Systems, Inquiry, Application (EALRs 1-3) and Life Science domain (EALR 4)

EALR	MC/CP	SA	Percent of Exam
1: Systems *(crossed with Life Science and alone)*	5-8	0-1	At least 15
2: Inquiry *(crossed with Life Science and alone)*	6-10	1-3	20 – 25
3: Application *(crossed with Life Science and alone)*	5-8	1-3	12-17
4: Life science domain of EALR 4 *(alone)*	18-24	0-1	45 – 50
Total number of items on exam	35	5	
Total number of points on exam	35	10	

Points do not match the points possible on the exam due to crossing (double-coding) of some items. For example, an item may assess both an EALR 1 and an EALR 4 content standard and therefore be "crossed."

Table 2.
Relative weighting of Core Content in the Life Science domain of EALR 4

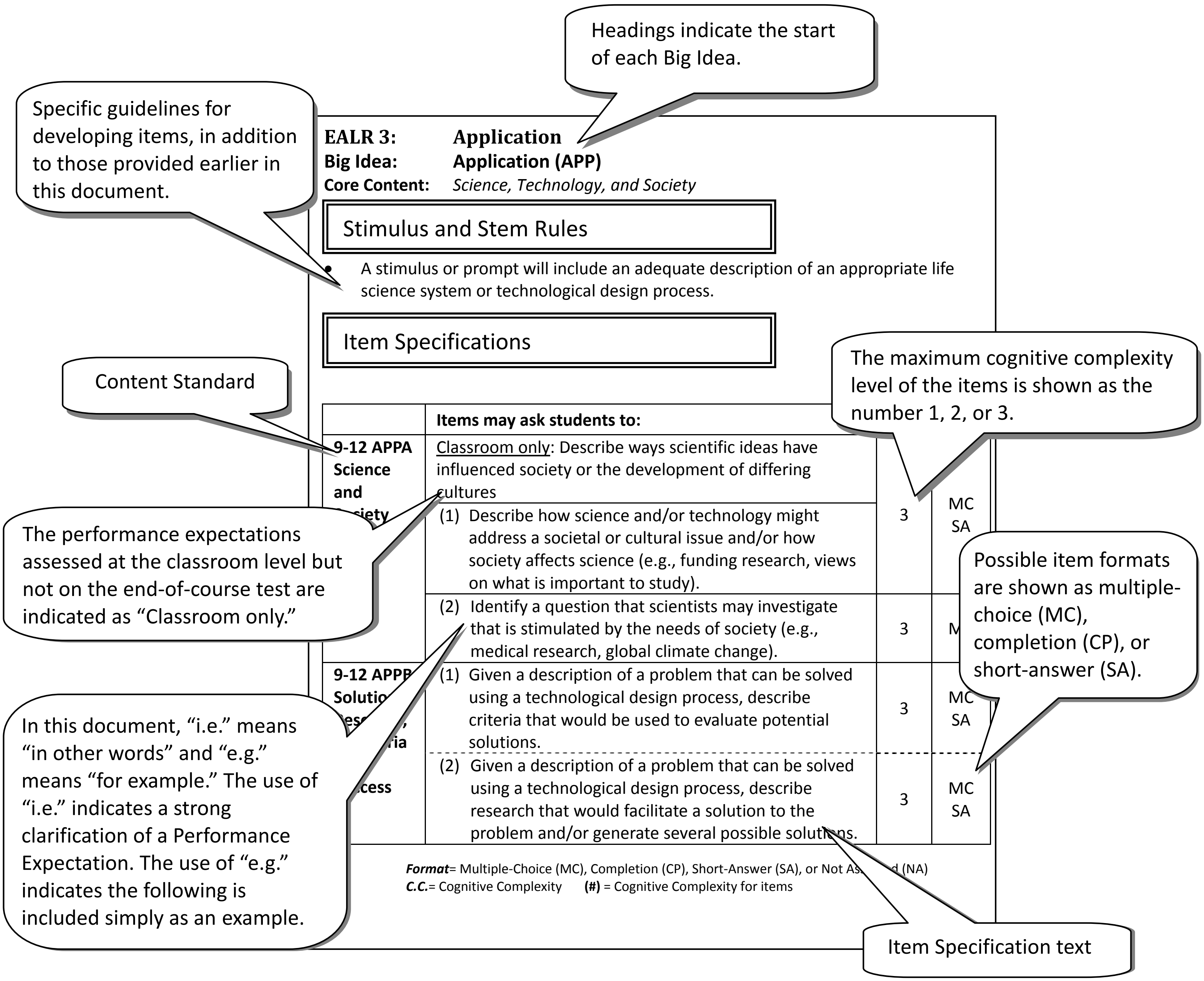
Life Science Domain of EALR 4	Percent of EALR 4 Points	Percent of Exam
Processes in Cells (LS1)	40-45	20-23
Maintenance and Stability of Populations (LS2)	30-35	15-18
Mechanisms of Evolution (LS3)	25-30	14-16

Table 3.
Biology End of Course Exam Booklet Format

Biology EOC Operational Exam		Number	Points
Scenarios		4-5	N/A
Items	MC/CP	35	35
	SA	5	10
Operational Exam Item Totals		**40**	**45**
Pilot			
Scenarios		0-1	NA
Items	MC/CP	4	4
	SA	1	2
Pilot Item Totals		**5**	
End of Course Exam Booklet Totals		**5-6 scenarios 45 items**	

Item Specifications

Item specifications pages have the following characteristics:



Item Specification Numbering System

Content Standard → **APPA(2)** ← (Item Specification)

EALR 1: Systems
Big Idea: Systems (SYS)
Core Content: *Predictability and Feedback*

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
9-12 SYSA Feedback	(1) Describe feedback as a process in which the output of a given system provides information used to regulate the operation of the system.	2	MC
	(2) Determine whether a given system involves positive feedback or negative feedback.	2	MC CP
	(3) Describe the regulatory inputs and/or outputs of a given positive feedback system (e.g., after a cut, a clotting process cascades to form a scab; increased CO_2 and methane inputs to the atmosphere result in higher temperatures, ice caps melt decreasing light reflected to space, and sea levels rise).	3	MC SA
	(4) Describe the regulatory inputs and/or outputs of a given negative feedback system (e.g., temperature increase in a human body results in sweating that cools the body by evaporative cooling, predator/prey interactions regulating population size).	3	MC SA
9-12 SYSB Systems Thinking	(1) Identify how a systems approach will be helpful in answering a given question or solving a given problem.	2	MC
	(2) Identify the components, boundaries, flows, and/or feedbacks of a given system.	2	MC
	(3) Describe one or more subsystem(s) and/or the larger system that contains a given system.	2	MC
	(4) Describe how a given system functions with respect to other systems.	3	MC SA
9-12 SYSC Modeling Complex Systems	(1) Given a model of a complex system that is lacking sufficient detail to make reliable predictions about that system, describe inadequacies of the model.	3	MC SA
	(2) Predict the possible consequences of a change in a given complex system and/or describe why a simplified model may not be able to reliably predict those consequences.	3	MC SA
	Classroom only: Create a simplified model of a complex system. Trace the possible consequences of a change in one part of the system and explain how the simplified model may not be adequate to reliably predict consequences.	NA	NA
9-12 SYSD Equilibrium	(1) Identify whether a given system is changing or in equilibrium.	2	MC
	(2) Determine whether a state of equilibrium in a given system is static (i.e., the net force on all particles is zero) or dynamic (i.e., inflows of matter equal outflows of matter).	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 2: Inquiry

Big Idea: Inquiry (INQ)

Core Content: *Conducting Analyses and Thinking Logically*

Stimulus and Stem Rules

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

Item Specifications

	Items may ask students to:	**C.C.**	**Format**
9-12 INQA Questions	Classroom only: Generate questions that could be investigated scientifically.	NA	NA
	(1) Explain whether a given question can be investigated scientifically.	2	MC
	(2) Critique question(s) in terms of whether investigating the question will provide evidence for a given prediction or hypothesis.	2	MC
9-12 INQB Plan an Investigation	(1) Describe a plan to answer a given question for a controlled experiment with the following attributes: • At least two controlled variables • One manipulated (independent) variable with three or more conditions • One responding (dependent) variable • Experimental control condition, when appropriate • Additional validity measure • 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: • Method for collecting data (controlled variable) • Conditions to be compared (independent/manipulated variable) • Data to be collected (dependent/responding variable) • Data to be gathered and recorded from multiple observations • Environmental conditions recorded • Logical steps	3	MC SA
	(3) Describe an appropriate type of investigation for a given investigative question (e.g., field study, systematic observation, controlled experiment, model, or simulation).	2	MC
	(4) Describe a plan for a scientific investigation using a model, simulation, or systematic observation.	3	MC
	Classroom only: Conduct a scientific investigation, choosing a method appropriate to the question being asked.	NA	NA
	Classroom only: Collect, analyze, and display data using calculators, computers, or other technical devices when available.	NA	NA

	Items may ask students to:	C.C.	Format
9-12 INQC Conclusions from Data	(1) Generate a logical conclusion that is supported by evidence from the investigation and/or provide a scientific reason to explain the trend in data given a description of and the results from a scientific investigation.	3	MC SA
	(2) Analyze multiple explanations for a given set of data and identify the explanation that best fits the data.	2	MC
9-12 INQD Reports	Assessed in INQB and Classroom: Write a detailed laboratory report that includes: the question that motivated the study, a justification for the kind of investigation chosen, hypotheses (if any), a description of what was done, a summary of data in tables and graphs, and a conclusion, based on the evidence, that responds to the question.	NA	NA
9-12 INQE Model and Theory	(1) Describe a testable prediction or hypothesis that can be generated from a given model, theory, or new condition in an existing model.	2	MC SA
	(2) Explain how scientific inquiry results in the development of a theory or conceptual model that can generate testable predictions or hypotheses.	2	MC
9-12 INQF Analyze an Investigation	(1) Evaluate an investigation in terms of validity (e.g., answered the investigative question with confidence; the manipulated variable caused the change in the responding variable).	2	MC SA
	(2) Evaluate an investigation in terms of reliability (e.g., reliability means that repeating an investigation gives similar results).	2	MC SA
	(3) Describe how to increase the reliability of the results of an investigation (e.g., repeating the investigation exactly the same way increases the reliability of the results).	2	MC SA
	(4) Describe how to improve the validity of an investigation (e.g., more controlled variables, better measuring technique, control for sample bias, include experimental control condition or a placebo group when appropriate).	2	MC SA
	(5) Describe the development of scientific theories through logical reasoning, creativity, testing, revision, and replacement of prior ideas in light of new evidence.	2	MC
	(6) Describe new evidence that can lead to scientists revising a theory.	2	MC
9-12 INQG Communicate Clearly	(1) Explain inconsistencies in findings from a given investigation.	3	MC SA
	Classroom only: Participate in a scientific discussion about their own investigations and those performed by others.	NA	NA
	Classroom only: Respond to questions and criticisms, and if appropriate, revise explanations based on these discussions.	NA	NA
9-12 INQH Sources of Information	(1) Explain that scientists evaluate sources of information to establish reliability before using the information.	2	MC SA
	(2) Evaluate or compare source(s) of information in terms of their reliability.	3	MC SA
	(3) Explain consequences of failure to provide appropriate citations and/or reasons for appropriately citing the contributions of others and/or information sources (e.g., undocumented sources of information prevents the verification of data and undermines the credibility of explanations and investigations).	2	MC

EALR 3: Application

Big Idea: Application (APP)

Core Content: *Science, Technology, and Society*

Stimulus and Stem Rules

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

Item Specifications

	Items may ask students to:	**C.C.**	**Format**
9-12 APPA Science and Society	Classroom only: Describe ways scientific ideas have influenced society or the development of differing cultures	NA	NA
	(1) Describe how science and/or technology might influence society or the development of cultures and/or how society might influence science (e.g., funding research, views on what is important to study).	3	MC SA
	(2) Identify a question that scientists may investigate that is stimulated by the needs of society (e.g., medical research, global climate change).	3	MC
9-12 APPB Solutions, Research, & Criteria for Success	(1) Describe criteria that would be used to evaluate potential solutions and/or describe constraints (i.e., limitations) on potential solutions given a description of a problem that can be solved using a technological design process.	3	MC SA
	(2) Describe research that would facilitate a solution to the problem and/or generate several possible solutions given a description of a problem that can be solved using a technological design process.	3	MC SA
9-12 APPC Choosing a Solution	(1) Evaluate the solution(s) with respect to criteria on which to judge success and/or constraints (i.e., limitations) on the solution(s) given one or more solution(s) to a problem that can be solved using a technological design process.	3	MC SA
	(2) Describe a method for testing the solution(s) given a problem that can be solved using a technological design process and possible solution(s).	3	MC SA
	(3) Describe a redesign of a solution given a solution to a technological design problem and the results of a test of that solution.	3	MC SA
9-12 APPD Math and Technology	Assessed in Mathematics: Use proportional reasoning, functions, graphing, and estimation to solve problems.	NA	NA
	Classroom only: Use computers, probes, and software when available to collect, display, and analyze data.	NA	NA
9-12 APPE Trade-offs and Consequences	(1) Describe trade-offs and/or unintended consequences for one or more given solution(s) to a given technological design problem.	3	MC SA
9-12 APPF Informed Citizens	Classroom only: Critically analyze scientific information in current events to make personal choices or to understand public-policy decisions.	NA	NA

EALR 4: Life Science

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

Core Content: *Processes Within Cells*

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
9-11 LS1A Matter and Energy in Photosynthesis	(1) Identify inputs and/or outputs of matter and/or energy in photosynthesis using words and/or chemical formulas (i.e., inputs of matter are carbon dioxide/CO_2 and water/H_2O; outputs of matter are glucose/$C_6H_{12}O_6$ and oxygen/O_2; input energy form is light energy; output energy form is chemical energy).	2	MC CP
	(2) Describe the rearrangement of atoms during photosynthesis using the chemical equation for photosynthesis.	2	MC
	(3) Explain the role of photosynthesis in the life of plants (e.g., photosynthesis is the only source of glucose that provides chemical energy or is incorporated into large molecules). **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.	2	MC
	(4) Explain the role of photosynthesis in the life of animals (e.g., photosynthesis is the source of the chemical energy animals require to live and grow; photosynthesis provides oxygen).	2	MC
9-11 LS1B Cellular Respiration	(1) Describe cellular respiration as the process cells use to change the energy of glucose into energy in the form of ATP and/or the process that provides the energy source for most living organisms.	2	MC
	(2) Compare cellular respiration to the burning of fossil fuels (e.g., large carbon-containing compounds are broken into smaller carbon compounds as chemical energy is transformed to different forms of energy in both cellular respiration and combustion of fossil fuels).	2	MC CP
	(3) Describe the inputs and/or outputs of matter and/or energy in cellular respiration and/or in combustion (i.e., inputs of matter include glucose/$C_6H_{12}O_6$ or other large carbohydrates and oxygen/O_2; outputs of matter include carbon dioxide/CO_2, water/H_2O, and ATP; input form of energy is chemical energy in carbohydrates; output form of energy is chemical energy in ATP).	2	MC CP SA
9-11 LS1C Function of Organelles	(1) Describe the essential function(s) of structures within cells (i.e., cell membrane, cell wall, nucleus, chromosome, chloroplast, mitochondrion, ribosome, cytoplasm, vacuole).	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

	Items may ask students to:	C.C.	Format
9-11 LS1D Cell Membrane	(1) Describe the structure of the cell membrane as a lipid bilayer with embedded proteins capable of regulating the flow of materials into and out of the cell.	2	MC
	(2) Describe the process(es) (i.e., active transport, passive transport, osmosis, facilitated diffusion, diffusion) that allows substances to pass through the cell membrane.	2	MC CP SA
9-11 LS1E DNA, Genes, and Protein Synthesis	(1) Describe the structure of DNA molecules in terms of the four nucleotides (i.e., A, C, G, and T subunits are combined in various sequences).	1	MC CP
	(2) Describe that the sequence of the four nucleotides in the DNA molecule encodes genetic information.	1	MC
	(3) Describe the relationships among DNA, chromosomes, genes, amino acids, proteins, and/or traits.	1	MC
	(4) Describe that the sequence of the nucleotides in a gene specifies the amino acids needed to make a protein.	1	MC
	(5) Describe inherited traits (e.g., eye color, hair texture, attached earlobes, tongue rolling) and cell functions as primarily determined by the proteins expressed by genes.	1	MC
	(6) Predict the complementary strand of mRNA given the nucleotide sequence in a single strand of DNA.	2	MC CP
	(7) Describe the steps and/or structures in the process by which gene sequences are copied to produce proteins (e.g., the sequence of nucleotides in DNA determines the sequence of subunits in mRNA assembled in the nucleus, and the mRNA is held by ribosomes in the cytoplasm where amino acids carried by tRNA are assembled into proteins based on the codons in the mRNA sequence).	2	MC SA
9-11 LS1F Chemical Reactions in Cells	(1) Describe that large molecules in food are broken down into smaller molecules by cells to provide energy or building blocks (i.e., proteins into amino acids, carbohydrates into simple sugars, fats into fatty acids, DNA into nucleotides).	2	MC
	(2) Describe that cells build large molecules required for cell functions from smaller molecules (i.e., proteins from amino acids, carbohydrates from simple sugars, lipids/fats from fatty acids, DNA from nucleotides).	2	MC
	(3) Describe enzymes as proteins that regulate reactions that break down and/or build molecules needed by cell structures and/or functions.	1	MC
	(4) Describe that enzymes regulate the reactions that transfer chemical energy from food molecules to special molecules that store the chemical energy (i.e., ATP, lipids/fats, carbohydrates).	1	MC
	(5) Describe that chemical energy stored in special molecules (i.e., ATP, lipids/fats, carbohydrate) is used by cells to drive cell processes.	1	MC

	Items may ask students to:	C.C.	Format
9-11 LS1G Enzymes and Other Proteins	(1) Describe that cells use DNA that forms their genes to encode enzymes and other proteins.	1	MC
	(2) Describe that cell functions (e.g., cell growth and division, response to the environment) can be regulated by changing the activity of proteins and/or by changing whether and how often particular genes are expressed.	2	MC
	(3) Describe that changes in the environment can cause changes in the amount and/or activity of proteins (e.g., enzymes) produced by a gene.	2	MC
9-11 LS1H Chromosomes and Mitosis	(1) Describe that genes are carried on chromosomes.	1	MC CP
	(2) Describe that typical animal cells contain two copies of each chromosome, one from each biological parent, with genetic information that regulates body structure and function.	2	MC
	(3) Describe the process of mitosis (e.g., the genetic information is copied and each of two new cells receives exact copies of the original chromosomes) and/or the product of mitosis (e.g., two cells each with the same number of chromosomes as the original cell).	2	MC CP
9-11 LS1I Meiosis, Fertilization, and Offspring Variation	(1) Describe the process of meiosis (e.g., each egg or sperm cell receives only one representative chromosome from each pair of chromosomes found in the original cell) and/or product of meiosis (e.g., egg and sperm cells with only one set of chromosomes).	2	MC CP
	(2) Describe that the processes of recombination during meiosis (e.g., segregation, independent assortment) result in a unique combination of genetic information in the egg or sperm cell.	2	MC SA
	(3) Describe the relationship between the unique combination of genetic information in an egg or sperm cell and the differing characteristics in offspring from a single set of parents.	2	MC
	(4) Describe the process of fertilization as restoring the original chromosome number (e.g., an egg and sperm, each with half the number of chromosomes of the original cell, combine to restore the number of chromosomes from the original cell).	2	MC CP
	(5) Describe that the process of fertilization allows for variation among offspring from a single set of parents.	2	MC
	(6) Describe possible allele combinations in an egg or sperm cell given a combination of two traits and a parent's genotype for the two traits.	2	MC CP
	(7) Describe the possible combinations of offspring in a simple Mendelian genetic cross for two traits (e.g., given a Punnett square for two traits, fill in missing cell(s); given parent genotypes determine genotypic/phenotypic ratios of offspring).	2	MC CP

EALR 4: Life Science

Big Idea: **Ecosystems (LS2)**

Core Content: *Maintenance and Stability of Populations*

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
9-11 LS2A Transfers and Cycles of Matter and Energy	(1) Describe the cycle of carbon through ecosystems (e.g., carbon dioxide in air becomes large carbon-containing molecules in the tissues of plants through photosynthesis, these molecules can be cycled to animals that consume the plants, then returned as carbon dioxide to the atmosphere through cellular respiration, combustion, and decomposition).	2	MC CP SA
	(2) Describe examples of matter cycling that can affect the health of an ecosystem (e.g., composting to improve soil quality, crop rotation, worm bins, fertilizer runoff, bioaccumulation).	2	MC
	(3) Describe the cycle of nitrogen through ecosystems (e.g., nitrogen in air is taken in by bacteria in soil, then made directly available to plants through the soil or to the plants through animal waste, and returned to the soil and atmosphere when the plants decompose).	2	MC CP
	(4) Describe the transfers and transformations of matter and/or energy in an ecosystem (e.g., sunlight transforms to chemical energy during photosynthesis, chemical energy and matter are transferred when animals eat plants or other animals, carbon dioxide produced by animals and plants during respiration is used by plants and transformed to glucose during photosynthesis, decomposition of organisms produces carbon dioxide).	2	MC SA
9-11 LS2B Population Density	(1) Describe conditions necessary for populations to increase rapidly (e.g., adequate living and nonliving resources, no disease or predators).	2	MC
	(2) Describe population density and/or the factors that affect population density.	2	MC
	(3) Calculate population density given an area or volume and the number of a given organism within the area or volume.	2	MC CP
9-11 LS2C Limiting Factors	(1) Describe factors that limit growth of plant and/or animal populations in an ecosystem.	2	MC SA
	(2) Explain how a change to a factor (e.g., matter, energy, space, predatory, or competing organisms) would limit the population of a species.	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**
9-11 LS2D Population Graphs	(1) Predict the changes in the population size of a species given a quantitative description of an ecosystem (e.g., predator-prey graph; J-curve of carrying capacity of ecosystem; available range vs. population size graph).	2	MC
	Classroom only: Draw a systems diagram to illustrate and explain why introduced (nonnative) species often do poorly and have a tendency to die out, as well as why they sometimes do very well and force out native species.	NA	NA
9-11 LS2E Biodiversity	(1) Given a description of the biodiversity in two ecosystems (e.g., rain forest, grassland, desert), identify reasons for differences in biodiversity.	2	MC
	(2) Describe interrelationships of organisms that affect the stability of a given ecosystem (e.g., nutrient cycles, food relationships, use of resources and succession).	2	MC
	(3) Describe that biodiversity contributes to the stability of an ecosystem.	2	MC
9-11 LS2F Sustainability	(1) Explain scientific concepts and/or findings that relate to a given resource issue (e.g., removal of dams to facilitate salmon spawning in rivers; construction of wind farms; recycling).	2	MC SA
	(2) Describe how sustainable development could help with a current resource issue (e.g., using renewable rather than nonrenewable resources, using recycled resources).	2	MC SA

EALR 4: Life Science

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

Core Content: *Mechanisms of Evolution*

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
9-11 LS3A Natural Selection	(1) Describe the genetic variability of offspring due to mutations and genetic recombination as allowing some offspring to be better able to survive and produce offspring.	2	MC SA
	(2) Describe that some traits will improve an individual's survival rate and subsequent reproduction in environments with a finite supply of resources.	2	MC
	(3) Explain biological evolution as the consequence of the interaction of population growth, inherited variability of offspring, a finite supply of resources, and/or natural selection by the environment of offspring better able to survive and reproduce.	2	MC SA
	(4) Describe how environmental pressure on a population drives natural selection (e.g., warming climate causes extinction of species not able to adapt).	2	MC
	(5) Predict the effect on a population of a given change in inherited variability of offspring, potential for population growth, resources, and/or environmental pressure (e.g., decreased variation in alleles).	2	MC
9-11 LS3B Mutations	(1) Describe mutations as random changes or occasional mistakes in the copying of genetic material that, when in egg or sperm cells, can be inherited by future generations.	2	MC
	(2) Describe the molecular processes (e.g., insertion, deletion, substitution) and/or environmental factors (e.g., UV radiation in sunlight) by which mutations can occur.	2	MC
	(3) Describe that changes caused by mutations will often be harmful, but a small minority of mutations will cause changes that allow the offspring to survive longer and reproduce more.	2	MC
	(4) Predict how a given trait or mutation will allow a species to survive and reproduce in a given environment.	2	MC SA
9-11 LS3C Species Diversification	(1) Explain that species alive today have diverged from a common ancestor (e.g., by interpreting diagram representing an evolutionary tree).	2	MC
	(2) Explain how filling an available niche can allow a species to survive.	2	MC
	(3) Describe that genes in very different organisms can be similar because the organisms all share a common ancestor.	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**
9-11 LS3D Evidence of Evolution	(1) Explain how the fossil record, anatomical similarities, and/or molecular (DNA) similarities can be used as evidence for the evolutionary development of a given species (e.g., birds, horses, elephants, whales).	2	MC
9-11 LS3E Relatedness of Organisms	(1) Describe that scientists infer the degree of evolutionary relationship among organisms using physiological traits, genetic information, and/or the ability of two organisms to produce fertile offspring.	2	MC
	(2) Describe relationship(s) among organisms based on similarities and/or differences in physical and/or functional characteristics.	2	MC
	(3) Describe the similarities and/or differences (i.e., embryology, homology, analogous structures, genetic sequences) of given organisms in terms of biological evolution (e.g., Darwin's finches had different beaks due to food sources on the islands where they evolved).	2	MC
	(4) Describe the evolutionary relationship between two organisms and/or identify the organisms that are most closely related given a diagram representing an evolutionary tree.	2	MC

Science Vocabulary Used in Assessment Items

Items on the biology end-of-course exam use language targeted to an eighth grade or lower readability with the exception of the required biology terms in the following list. Appropriate science vocabulary allowed for all earlier grade level science assessments may also be used on the biology end-of-course exam. Example vocabulary from life science in earlier grade levels is also included in the following list.

a

Used in grade 8:
accuracy
acquired (learned) characteristic
adaptation
asexual reproduction
atom

Used in Biology:
absorption
active transport
allele
amino acid
atmospheric
ATP
aquatic

b

Used in grade 8:
boundary

Used in Biology:
bacteria
bacterium
biodiversity
biomass

c

Used in grade 5:
characteristic
classify
conclude
conclusion
conserve
consumer
controlled experiment
cycle

Used in grade 8:
cell membrane
cell nucleus
cell wall
chemical energy
chemical reaction
chloroplast
chromosomes
circulatory system
closed system
compound

Used in Biology:
carbon cycle
carbon dioxide
carbohydrates
carrying capacity
cellular respiration
chlorophyll
combustion
complementary
computer simulation
concentration
constraint
contraction
criteria
cytoplasm

d

Used in grade 5:
data
decomposer
depth
dissolve

Used in grade 8:
digestive system
dominant

Used in Biology:
diffusion
divergent
diversity
DNA
dynamic equilibrium

e

Used in grade 5:
ecosystem
energy
environment
evidence
experimental question
extinct

Used in grade 8:
effective
element
evolution

Used in Biology:
embryo
endangered
endocrine system
energy chain
enzyme
equilibrium
estuary
expansion
experimental control condition

f

Used in grade 5:
field study
food web
form of energy
fossil
function

Used in grade 8:
factor
filter

Used in Biology:
facilitated diffusion
fatty acids
finite
fossil fuels
fungus

g

Used in grade 8:
gene
genetic
glucose

Used in Biology:
gender
gene pool
genetic cross
genetic recombination
genotype
glucose

h

Used in grade 5:
habitat

Used in grade 8:
hypothesis

Used in Biology:
heterozygous
homozygous
honesty
hormone
host
hydrosphere

i

Used in grade 5:
inherited
input
investigation

Used in grade 8:
impact
infer

Used in Biology:
invasive
inadequacy

k

Used in grade 8:
kinetic energy

l

Used in grade 5:
light energy

Used in Biology:
lipid
lipid bilayer

m

Used in grade 8:
mitochondria
mitochondrion
molecule

Used in Biology:
mammals
meiosis
microorganism
mitosis
mRNA
mutate
mutation

n

Used in Biology:
native
natural selection
negative feedback
neurological system
niche
nitrogen cycle
nonnative
nonrenewable
nucleic acid
nucleotides

o

Used in grade 5:
organism
output

Used in grade 8:
offspring
open system

Used in Biology:
osmosis
ova
ozone

p

Used in grade 5:
particle
pollution
population
predator
predict
prediction
procedure
producer

Used in grade 8:
particles
photosynthesis
prey

Used in Biology:
parasite
passive transport
pesticide
pH
phenotype
photosynthesize
pollinate
population density
positive feedback
principle
protein

r

Used in grade 5:
recycle
redesign
reliable
resource
respond
role

Used in grade 8:
recessive
respiratory system
ribosome

Used in Biology:
random
regulate
reliability
renewable
reproduce
research question

s

Used in grade 5:
structure
subsystem
summary
survive

Used in grade 8:
sexual reproduction
skeletal system
soluble
species

Used in Biology:
sensor
simulation
skeptical
solubility
solution (aqueous)
species
sperm
spherical
spinal cord
spore
stability
static equilibrium
succession
sustainability
systematic observation

t

Used in grade 5:
technology
texture
thermometer
transform
transformation

Used in grade 8:
thermal (heat) energy
tissue

Used in Biology:
theory
toxin
trade-off
trait
transmission
trend
tRNA

u

Used in Biology:
unintended consequence

v

Used in grade 5:
variable
versus (vs.)

Used in grade 8:
valid

Used in Biology:
vacuole
validate
validity
virus

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.

<u>Grade 5</u>
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.

<u>Grade 8</u>
controlled (kept the same) variable
manipulated (independent) variable
responding (dependent) variable

<u>Biology</u>
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 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