Minnesota Comprehensive Assessments Series II (MCA-II)

Test Specifications for Science

January 2, 2008

MINNESOTA DEPARTMENT OF EDUCATION

MCA-II Test Specifications for Science

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Table of Contents

THE MINNESOTA COMPREHENSIVE ASSESSMENTS – SERIES II

Introduction

In 2004, the Minnesota legislature passed an education omnibus bill that established standards in science and "assessments aligned with state academic standards that districts and sites must use to monitor student growth toward achieving those standards." The law requires "annual science assessments in one grade in the grades 3 through 5 span, the grades 6 through 9 span, and a life sciences assessment in the grades 10 through 12 span for the 2007-2008 school year and later." The Minnesota Department of Education (MDE) has selected grades 5 and 8 for assessments in the first two grade bands. Districts will administer the life sciences assessment to all students in grades 10, 11 or 12. In 2006 and 2007, field administrations of the MCA-IIs in science will give MDE the data needed to build the operational test and will also give schools and districts the opportunity to pilot the delivery of a new test in a new format.

Given the nature of science, MDE will use a web-based format to administer the MCA-IIs in science. This format will allow students to view simulations of experiments and phenomena and manipulate visual representations of relevant materials. It will also allow for faster reporting of test results. Classroom assessments and ancillary materials will be provided for the purpose of familiarizing students and teachers with this web-based format. The classroom assessments will consist of sample scenarios and items and those released from field and operational tests.

MCA test results are used to compare school sites and districts and to provide feedback on curriculum and instruction in the new standards-based system. The test is not designed to assess all aspects of science or even all of the Minnesota Academic Standards in Science. It will assess only those academic standards that can be assessed by the web-based format.

All students, including students in special education who are receiving instruction on grade-level curriculum and students designated with Limited English Proficiency (LEP), must take the MCA-IIs in science. Unlike a graduation assessment where students must earn a minimum score to earn a high school diploma, there is no required minimum MCA score for students.

The test specifications for each grade of the MCA-IIs in science are presented in this document. The reader is encouraged to review the introductory information carefully because many

important concepts are presented including the purpose of the MCA-II, a description of the cognitive levels and information about the format of the test specifications.

The Purpose of the Test Specifications

All tests, from off-the-shelf norm-referenced tests (NRT) to customized, standards-based tests like those given in Minnesota, have test specifications. The primary purpose of a set of test specifications is to help a test developer build a test that stays consistent over time. Test specifications indicate which strands, sub-strands, standards and benchmarks will be assessed on the test and in what proportions. In addition, test specifications provide the number of items, the type of items to be included, constraints on cognitive levels, and content limits. Content limits clarify, define and limit how items should address each benchmark; they are intended to represent essential understandings and are not intended to describe all instruction.

Test specifications do not indicate **what** should be taught: the Academic Standards do. Test specifications do not indicate **how** children should be taught: the classroom teacher does.

Minnesota teachers developed these test specifications over the course of many days. The Minnesota Science Teachers Association and Education Minnesota recommended many of the teachers. The substantive parts of this document are true to their work. MDE thanks these people for their hard work and continued involvement.

The test specifications balance the need for a technically sound test with the goal of minimizing the time students spend taking tests. These test specifications have taken into account the grade and age of the students involved as well as various pedagogical concerns.

As with any test, the MCA-IIs in science collect a sample of student behavior and do not test every standard or benchmark. Even though some science standards and benchmarks cannot be assessed by a standardized test, these skills should be taught and assessed by other means. Teachers need to instruct and assess their students on all of the Academic Standards. The following two examples illustrate benchmarks that are not included in the test specifications for the MCA-IIs in science.

An example from the grades 3–5 span: 4.I.A.2

Strand I: History and Nature of Science

Sub-strand A: Scientific World View

Standard: The student will understand how science is used to investigate interactions between people and the natural world.

Benchmark 2: The student will discuss the responsible use of science.

An example from the grades 6–8 span: 8.I.B.5

Strand I: History and Nature of Science

Sub-strand B: Scientific Inquiry

Standard: The student will use multiple skills to design and conduct scientific investigations.

Benchmark 5: The student will use appropriate technology and mathematics skills to access, gather, store, retrieve and organize data.

In grades 6–8 and 9–12, Historic Perspectives, the test specifications address the development of student understanding of selected episodes in the history of science. To appreciate the significance of these historical episodes, students must (1) know or be able to follow the science involved and (2) be able to grasp the main features of the prevailing view at the time. Assessment of specific people or events in the history of science does not imply that it is inappropriate to have other people or events in the history of science and technology in the curriculum.

Efforts have been made in the test specifications of the historic perspectives substrand to identify selected episodes that have been critical to the development of understanding in a particular area of science. Items may require students to select from a list of historical perspectives, people or events, and provide examples of their understanding.

The Minnesota Academic Standards can be obtained from the Department of Education Web site at: http://education.state.mn.us/html/intro_standards_science.htm

The Purpose of the MCA-II

The purpose of the MCA-II is to measure Minnesota students' achievement with regard to the Minnesota Academic Standards.

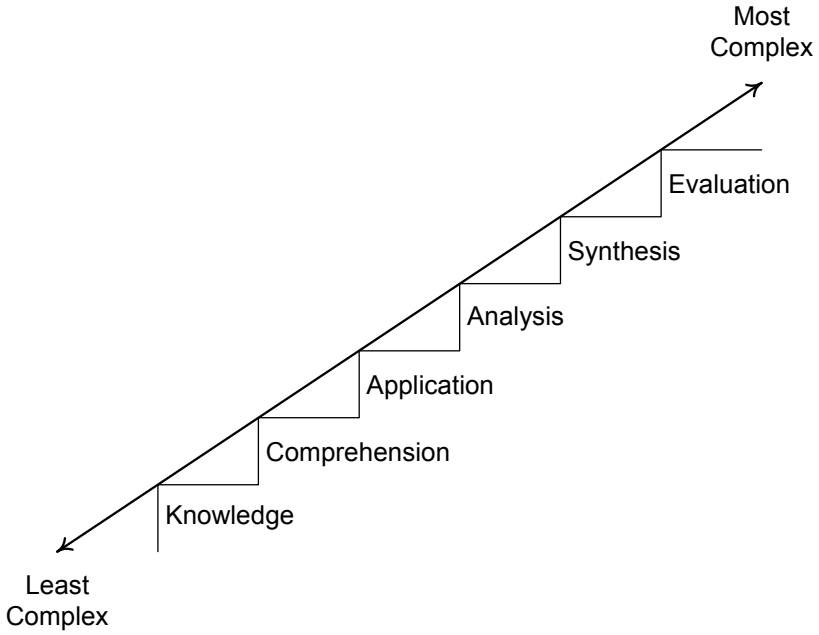
In addition, the MCA-II results can be used to inform curriculum decisions at the district and school level and inform instruction at the classroom level.

Cognitive Levels

Using a taxonomy or framework to classify items and standards helps the test development process and helps teachers understand what students should learn, know and demonstrate at the end of instruction. One such taxonomy is the one developed by Benjamin Bloom[1].

Bloom's classification of the levels of intellectual behavior contained three overlapping domains: cognitive, psychomotor and affective. Within the cognitive domain, Bloom identified six levels of complexity ranging from simple recall or recognition to more complex and abstract operations. Bloom found that over 95% of the test questions he looked at require students to think only at the level of recall. Verbs and examples that represent intellectual activity in science at each level of complexity are provided below.

The following figure depicting Bloom's six levels of cognitive complexity provides a basis for the cognitive levels used in the MCA-II.



[1] Bloom, B., Englehart, M. Furst, E., Hill, W., & Krathwohl, D. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York, Toronto: Longmans, Green.

Knowledge: arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce and state. E.g., label the parts of a cell.

Comprehension (Understanding)[*]: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select and translate. E.g., identify examples of igneous and metamorphic rocks.

Application: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use and write. E.g., construct a graph showing how temperature changes during a thunderstorm.

Analysis: analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question and test. E.g., choose the data needed to determine whether a sample is a mixture or pure substance.

Synthesis: arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up and write. E.g., design an investigation to indicate in which type of soil a particular plant would grow fastest.

Evaluation: appraise, argue, assess, attach, choose, compare, defend, estimate, judge, predict, rate, core, select, support, value and evaluate. E.g., describe a limitation of one model of the atom.

MDE uses the following adaptation of Bloom's taxonomy to align test items with academic standards. It provides teachers and parents with a familiar framework for understanding what students in Minnesota are expected to know and do in reading and mathematics upon the completion of a grade.

Cognitive Level A: consists of Knowledge

Cognitive Level B: consists of Understanding[*]

Cognitive Level C: consists of Application, Analysis, Synthesis and Evaluation

This alignment will provide the most flexibility when developing the MCA-IIs.

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[*] The Test Specifications for the MCA-IIs use *Understanding* in Level B instead of *Comprehension*. The term *comprehension* is a more global skill used at all cognitive levels of reading. *Understanding* is used to avoid confusion with the cognitive skill *comprehension* that is necessary for any level of reading.

Test Design and Development

The test design used in the MCA-IIs in science dictates the development of storyboards, scenarios and test items. The following design elements should be considered for every test component developed for MCA-IIs in science.

Test format

The MCA-IIs in science are scenario-based, computer-delivered tests that present students with realistic representations of classroom experiments and real-world phenomena. Items within a scenario are related by common context in order to more efficiently give students the opportunity to consider science content at a higher cognitive level than would be possible with stand-alone items. Scenarios will include graphic, audio and/or video media. Items will be multiple choice (MC), figural response (FR), short constructed response (SCR) or extended constructed response (ECR). Figural response items require students to manipulate graphic elements of an item, to select a point on a graphic or to complete a graph or diagram. Short and extended constructed response items typically require students to type an answer which can vary from a few words to a few sentences. These item types are not limited to text responses.

Each field and operational test will include a practice items to familiarize students with the types of media, items and expected responses. A tutorial for computer-based testing and item samplers will be available prior to the test administration.

Test length

The MCA-IIs in science do not have a time limit; however, each test will have a target administration time. The following description summarizes the longest administration time expected in a typical classroom. Students who need more time to complete a test should have it. Each test will be segmented so the student will have the option to pause or complete the rest of the test at a later time.

The grade-5 test will consist of nine to eleven operational scenarios and up to 37 operational items. In addition, the test will include practice items and field-test scenario(s). Each scenario will include two to five rooted [2] items. Some of the operational scenarios will also have summary items. Students will have the option of reviewing all of the items in a scenario before moving on to the next scenario. In a typical classroom, the operational test should take between 60 and 105 minutes.

[2] Rooted items are multiple-choice or figural-response items that appear during the scenario.

The grade-8 test will consist of seven to nine operational scenarios, with up to 42 operational items. In addition, the test will include practice items and field-test scenario(s). Each scenario will include three to six rooted items; some scenarios will also include one or two summary items. Students will have the option of reviewing all of the items in a scenario before moving on to the next scenario. In a typical classroom, the operational test should take between 60 and 90 minutes.

The high school test will consist of seven to nine operational scenarios, with up to 52 operational items. In addition, the test will include practice items and field-test scenario(s). Each scenario will include three to eight rooted items; some scenarios will also include one or two summary items. Students will have the option of reviewing all of the items in a scenario before moving on to the next scenario. In a typical classroom, the operational test should take between 75 and 120 minutes.

Prioritizing standards and benchmarks

One of the first steps in the test development process is to determine which standards and benchmarks will be assessed and at what level of detail. In order to provide reliable data about a concept, a test must include several items that address that concept. This emphasis is not possible for all of the academic standards in science in each grade span with a test of appropriate length. Further, some of the standards and benchmarks describe achievement that cannot be measured on a statewide, standardized assessment. For these reasons, the Minnesota Department of Education, with the advice of teachers and other stakeholders, prioritized the academic standards in science into three categories: essential, important and non-assessable. The benchmarks within each standard were then ranked by their relative importance. This prioritization was used to determine the number of items assessing each standard and benchmark that will appear on an operational test.

Writing content limits

The academic standards in science and their respective benchmarks describe skills and concepts that can be accomplished with a variety of curricula and instructional techniques. Specific content limits were written in order to ensure that achievement of each standard and benchmark is assessed in a way that accommodates this variety. These content limits are intended to clarify, define and limit how each benchmark should be assessed. When examples are used within a content limit, they are specified as either open or closed sets of examples. Open sets of examples use the phrasing, “Examples include…” which means there are other examples that may be used that are similar to the ones listed. Closed sets of examples use the phrasing “Examples are limited to…” which means the examples listed are the only

examples that will be used on the assessment. With the advice of teachers and other stakeholders, MDE has written content limits for each assessable benchmark in the academic standards in science.

Storyboard Writing

1. Storyboard writing will begin with a test developer providing design templates to guide authoring of storyboards.
2. Minnesota educators with experience and expertise in science instruction at the appropriate grade levels will use the design templates to write storyboards for every scenario that is field-tested.
3. Storyboards will have the following elements:
    a. A description of the narrative, images, animation and/or video that will be developed for each scenario
    b. Ideas for items that can be developed for the scenario
4. Storyboards will:
    a. Reflect standards in the history and nature of science strand by emphasizing inquiry-based learning theory and hands-on science strategies
    b. Represent significant, recurring issues in science; address examples of scientific issues students encounter; and represent investigations they can relate to
    c. Be necessary but not sufficient for a correct student response. Questions should relate to the storyboard and require students to apply their knowledge and skills.
    d. Describe opportunities for observing a process of science and the results of an investigation or event
    e. Be germane to the standards and provide only information that is necessary for the students to correctly respond to the items
    f. Provide opportunity for assessing more than one strand through natural unforced connections
    g. Have language that is driven by the language of the science standard and benchmark
    h. Have short narratives and descriptions of what the student sees.
    i. Be written at an appropriate grade level, except for technical science terms indicated in the benchmarks and content limits, so that the test measures knowledge of science content, not reading skills.
    j. Use the least complex vocabulary needed to accurately describe a concept (i.e., subcutaneous adipose tissue could be described as fat). Reading level will be targeted for two grades below (e.g., grade 8 test will have a reading level approximately equivalent to grade 6)

   k. Have the potential to have more than one possible item (if ideas for items are indicated).
   l. Be used to develop captions and descriptive text in scenarios, with Universal Design in mind

5. Minnesota educators will review each storyboard before the Minnesota Department of Education will approve it for development as a scenario with media and items.
   a. Review for Content: Minnesota educators with experience and expertise in science instruction at the appropriate grade levels review storyboards for use on the MCA-IIs. During the storyboard review process, Minnesota educators determine the appropriateness of content for the grade level of the test. Each criterion for content is considered during the review.
   b. Review for Potential Bias: Storyboards are also reviewed by groups of Minnesota educators who are representative of Minnesota's regions and culturally diverse population. Storyboards are reviewed for the following kinds of bias: gender, racial/ethnic, linguistic, religious, geographic, socioeconomic and issues related to individuals with disabilities.

Scenario Development

1. Scenario development includes the development of scripts, audio, and graphic media. Graphics may include such items as maps, charts, graphs, line drawings, stills and animations.
2. Scenarios will be developed in a manner consistent with the technical requirements of the test delivery system and the minimum specifications required for computers at test sites.
3. Scenarios will pause to deliver rooted items, with the option of replaying the portion of the scenario that preceded the item. The scenario will also provide a mechanism for tracking rooted items that a student flags for review.
4. Scenarios will function as segments, with the option of reviewing items during the scenario.
5. Visual elements of scenarios will be associated with captions and descriptive text with Universal Design in mind.
6. Scenarios will include static graphics, simple transitions, both 2-D and 3-D animation and graphics, and audio voice-over.

Item Types

1. Multiple Choice (MC)
    a. 1 point each
    b. 4 options
    c. Stem and/or options may be graphics and/or text
2. Figural Response (FR)
    a. 1 or 2 points each. 2-point FR items are to be used sparingly.
    b. Single hot spot: a student responds by selecting a point on a graphic.
    c. Multiple hot spot: a student responds by selecting two or more points on a graphic. Selecting two points may be used to make connections between visual elements in a graphic.
    d. Drag and drop: a student responds by selecting from a number of pictures and then selecting the location in a larger graphic to place the picture. These items should allow students to simply click to pick up and move a graphic and then click again to "drop" the picture, without holding the button to move the picture as well as the more common "click and drag" function.
    e. Graphing: a student responds by constructing or manipulating a graph. These items may require a student to select the type of graph, label axes, and/or plot data on the graph.
3. Short Constructed Response (SCR)
    a. 2 points each
    b. May require text and graphic responses
4. Extended Constructed Response (ECR)
    a. 3 points each
    b. May require text and graphic responses

Item Writing and Selection

1. Each item should be written to measure one benchmark, although other benchmarks may also be reflected in the item content. When items address more than one benchmark, secondary and tertiary coding will be used to identify the additional benchmarks.
2. Items should be appropriate in terms of grade-level difficulty, as well as the life experiences and the reading levels of students.
3. Items should not disadvantage or disrespect any segment of the population with regard to age, gender, race, ethnicity, language, religion, socioeconomic status, disability or geographic region.

4. Each item should clearly and unambiguously elicit the desired response.
5. Items should not ask students to define specific scientific terms unless specifically described to do so in the benchmark's language. However, items may ask students to use their understanding of a specific term in order to choose among examples, compare and contrast to other terms or otherwise apply the term.
6. Figural-response items should limit a student's ability to manipulate a figure beyond the intended purpose.
7. Minnesota educators with experience and expertise in science instruction at the appropriate grade levels review the items for each scenario in terms of content, bias (gender, racial/ethnic, linguistic, religious, geographic, socioeconomic status and issues related to individuals with disabilities) and psychometric data collected from field-testing.

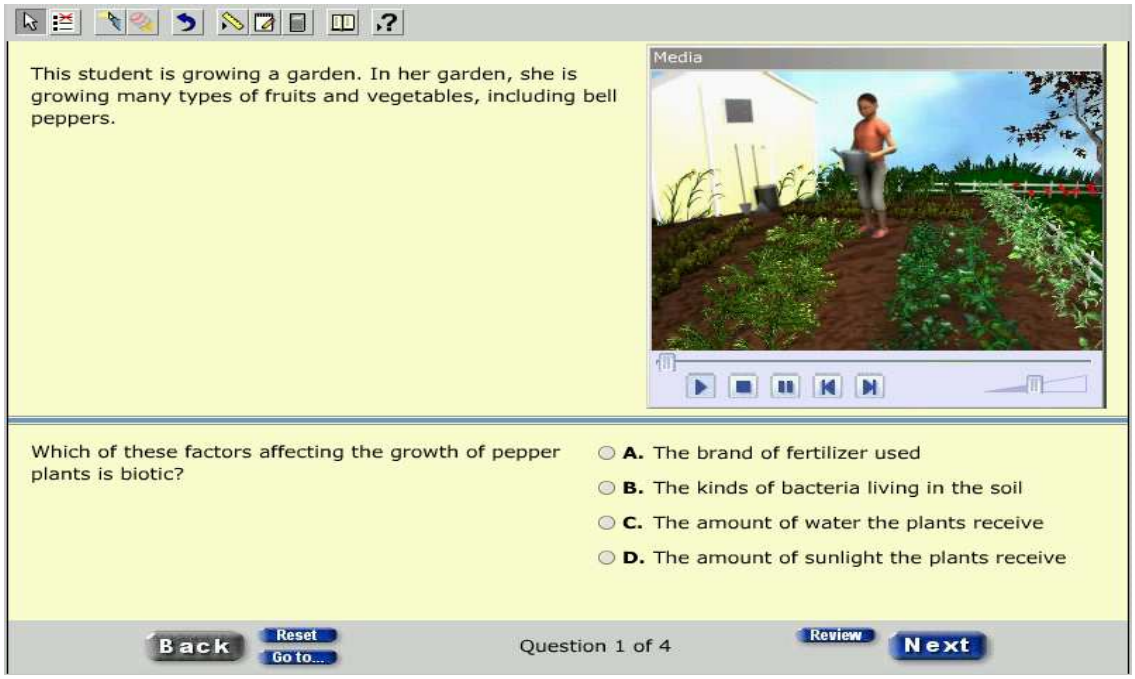
Visual Media

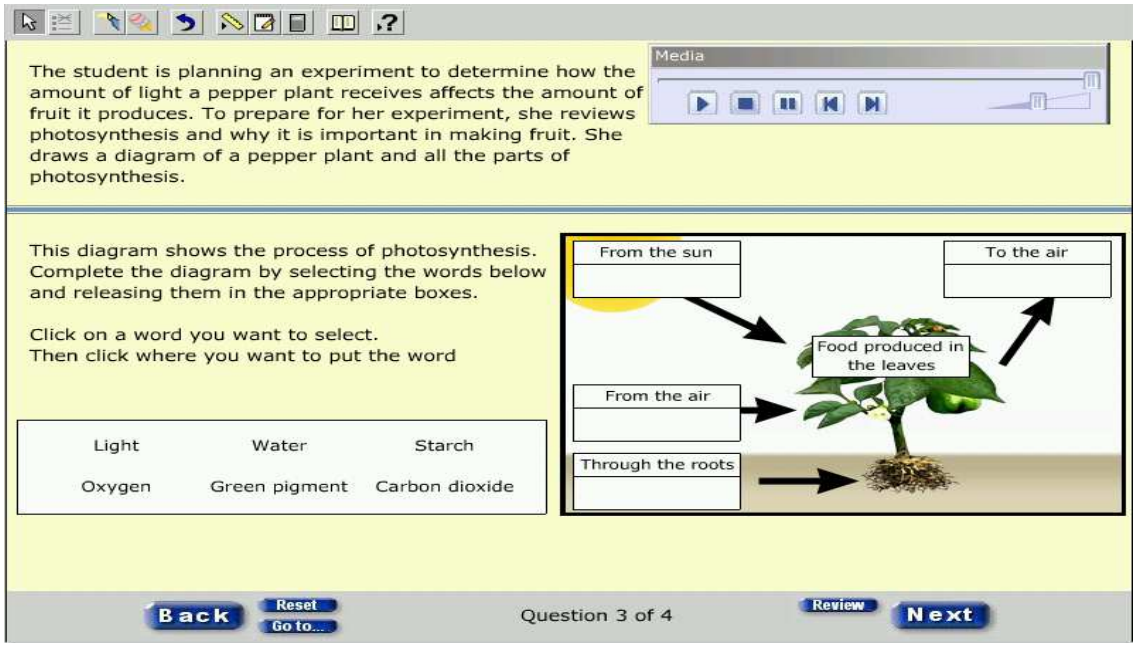
1. Visual media should be accessible by low-vision learners.
2. Visual media should be accessible by learners who cannot easily separate relevant visual information from irrelevant visual detail.
3. Images should be as large, uncluttered and focused on the relevant information as possible.
4. Backgrounds should be plain/empty.
5. A simple black frame should surround the image in order to clearly delineate boundaries and to provide consistency in presentation throughout the test.
6. Images should not be embellished solely for the sake of aesthetics.
7. When possible, limit the number of elements in an image so that there is plenty of empty space. Avoid crowding people and/or objects.
8. Images should not include extraneous 3-D effects, drop shadows, outer glows or other special effects that may be difficult to see as separate from the object.
9. Visual information needed to understand and respond to the prompt should be large and clearly visible.
10. When a prompt addresses a limited section of an image, enlarge that section to fill the display area.
11. Any characters used in visual media should represent the racial, ethnic, and gender diversity of Minnesota.

Sample Scenario

The following is an example of a scenario. Item samplers for all grades can be found at http://education.state.mn.us/MDE/Accountability_Programs/Assessment_and_Testing/Assessments/MCA_II/index.html

Sample scenario for the MCA-II-Science-8





The student tests how the amount of light a pepper plant receives affects the mass of the plants. She sets up 9 pots, each with 1 pepper plant.

The plants are divided into 3 groups with 3 plants in each group. The first group receives 8 hours of light per day. The second group receives 12 hours of light per day. The third group receives 18 hours of light per day.

Media

Click the Next button to go on.

Back Reset Go to... Question 4 of 4 Review Next

The student tests how the amount of light a pepper plant receives affects the mass of the plants. She sets up 9 pots, each with 1 pepper plant.

The plants are divided into 3 groups with 3 plants in each group. The first group receives 8 hours of light per day. The second group receives 12 hours of light per day. The third group receives 18 hours of light per day.

Media

After 10 weeks, the student measures the mass of each plant and averages the results for each group. She notices that the more light her pepper plants received, the more mass they had.

Plot 3 points that show a trend for her results. Click on the graph in 3 places to plot the points.

Back Reset Go to... Question 4 of 4 Review Next

Cognitive Level Distribution

As stated in the introduction of the test specifications, items for the MCA-IIs are written to assess three distinct cognitive levels: A, B and C (see pp. 4–5). Use of these cognitive levels to categorize items helps test developers match the complexity of the test items to the complexity of the content domain. The following table indicates the proportion of test items at each cognitive level.

Cognitive Level Distribution of Items in Science

Grades	Level A	Level B	Level C
5	25-35%	40-50%	20-30%
8	20-30%	40-50%	25-35%
10–12	15-25%	40-50%	30-40%

Test Design by Grade Level

The following tables and charts provide for each grade, strand and sub-strand the number of items on each operational assessment, and for each strand, the number and percent distribution of points.

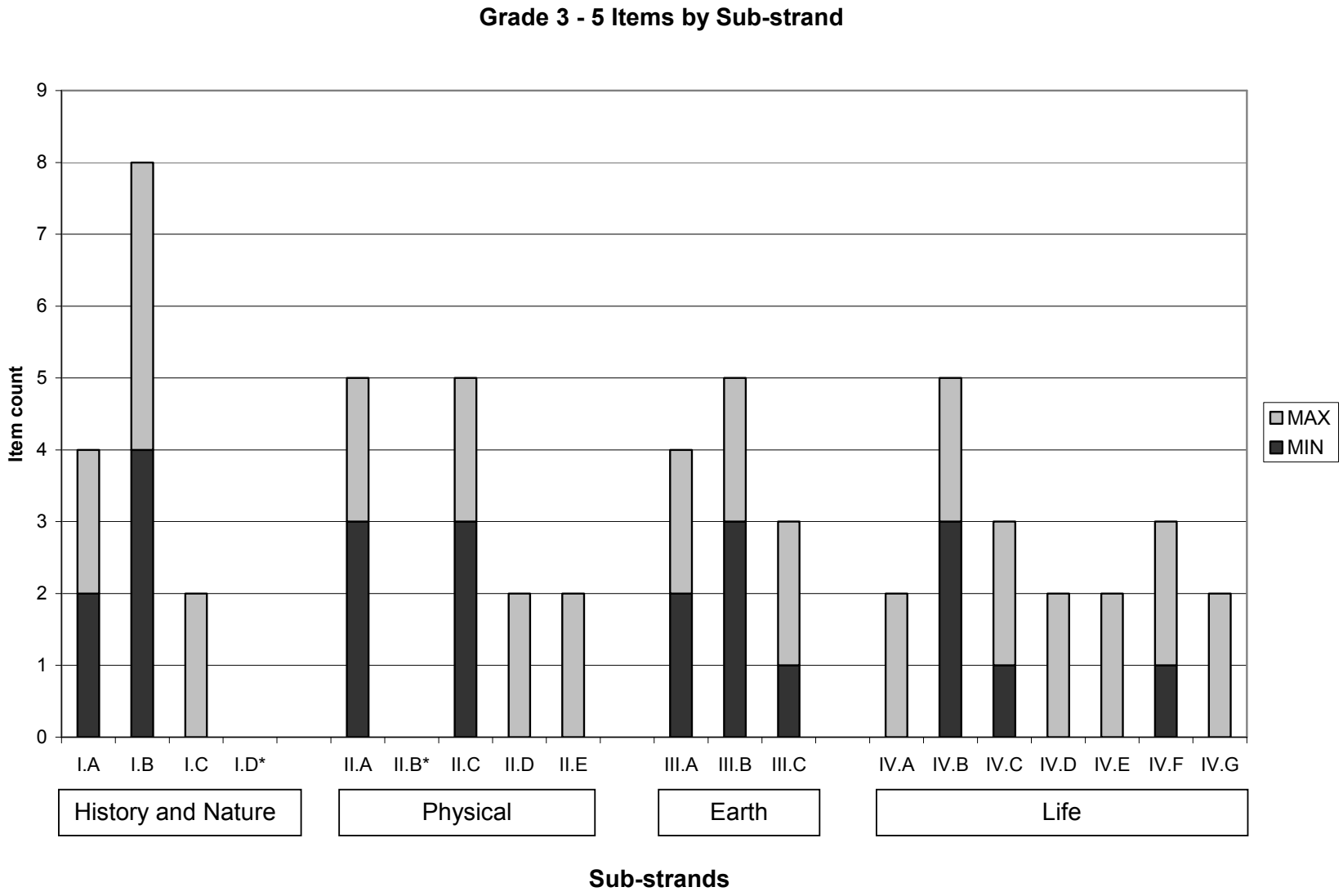
Test Design Science Grade 5

The grade 5 science MCA-II will be a 41-point test with 9–11 scenarios, approximately 34 rooted items (multiple choice (MC) and figural response (FR) items that appear during the scenario), two 2-point short response (SCR) or figural response items, and one 3-point extended response (ECR) items. The number of rooted items may vary if some of the figural response items are more than one point. The total number of points for the rooted items will be 34. The operational test forms will also include embedded field test scenarios

Grade 5 Science MCA-II (Operational Form)						
	Rooted Items	Summary Items				
Strand	MC or FR (1–2 pt)	SCR or FR (2 pts)	ECR (3 pts)	Approximate Items	Approximate Points	Approx % of Points
History and nature of science (HNS)	6-8	2	1	9-11	13-15	34
Physical science (PS)	8-10	0	0	8-10	8-10	22
Earth and space science (ES)	8-10	0	0	8-10	8-10	22
Life science (LS)	8-10	0	0	8-10	8-10	22
Total	30-34	2	1	33-37	41	100

During test form construction, the number of points takes precedence over the number of items.

* There are no benchmarks in grades 3–5 for these sub-strands.



* There are no benchmarks in grades 3-5 for these sub-strands

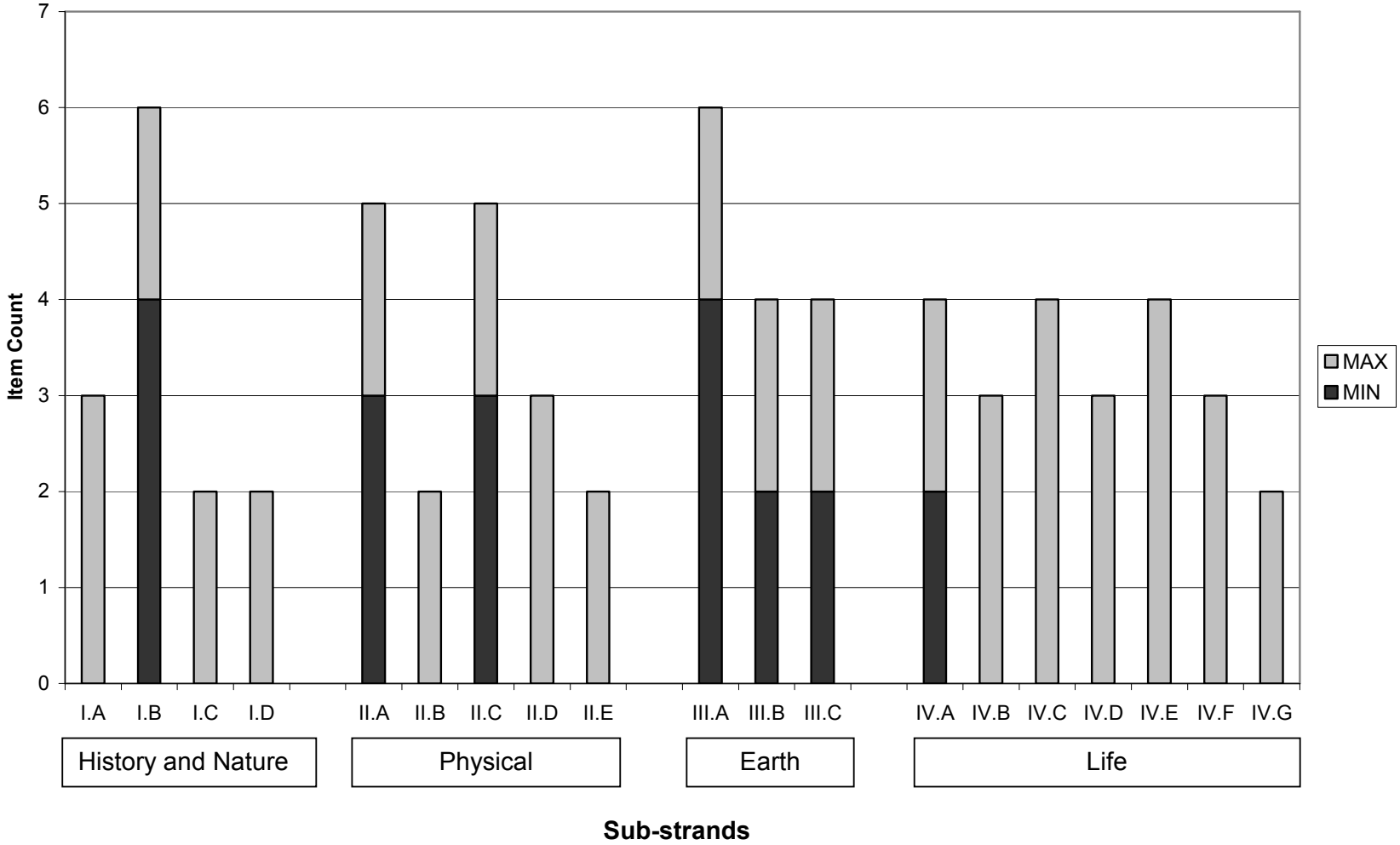
Test Design Science Grade 8

The grade 8 science MCA-II will be a 48-point test with 7–9 scenarios, approximately 37 rooted items (multiple choice (MC) and figural response (FR) items that appear during the scenario), four 2-point short response (SCR) or figural response items, and one 3-point extended response (ECR) items. The number of rooted items may vary if some of the figural response items are more than one point. The total number of points for the rooted items will be 37. The operational test forms will also include embedded field test scenarios.

Grade 8 Science MCA-II (Operational Form)						
	Rooted Items	Summary Items				
Strand	MC or FR (1–2 pt)	SCR or FR (2 pts)	ECR (3 pts)	Approximate Items	Approximate Points	Approx % of Points
History and nature of science (HNS)	6-8	1	1	8-10	11-13	25
Physical science (PS)	9-11	1	0	10-12	11-13	25
Earth and space science (ES)	9-11	1	0	10-12	11-13	25
Life science (LS)	9-11	1	0	10-12	11-13	25
Total	33-37	4	1	38-42	48	100

During test form construction, the number of points takes precedence over the number of items.

Grade 6 - 8 Items by Sub-strand



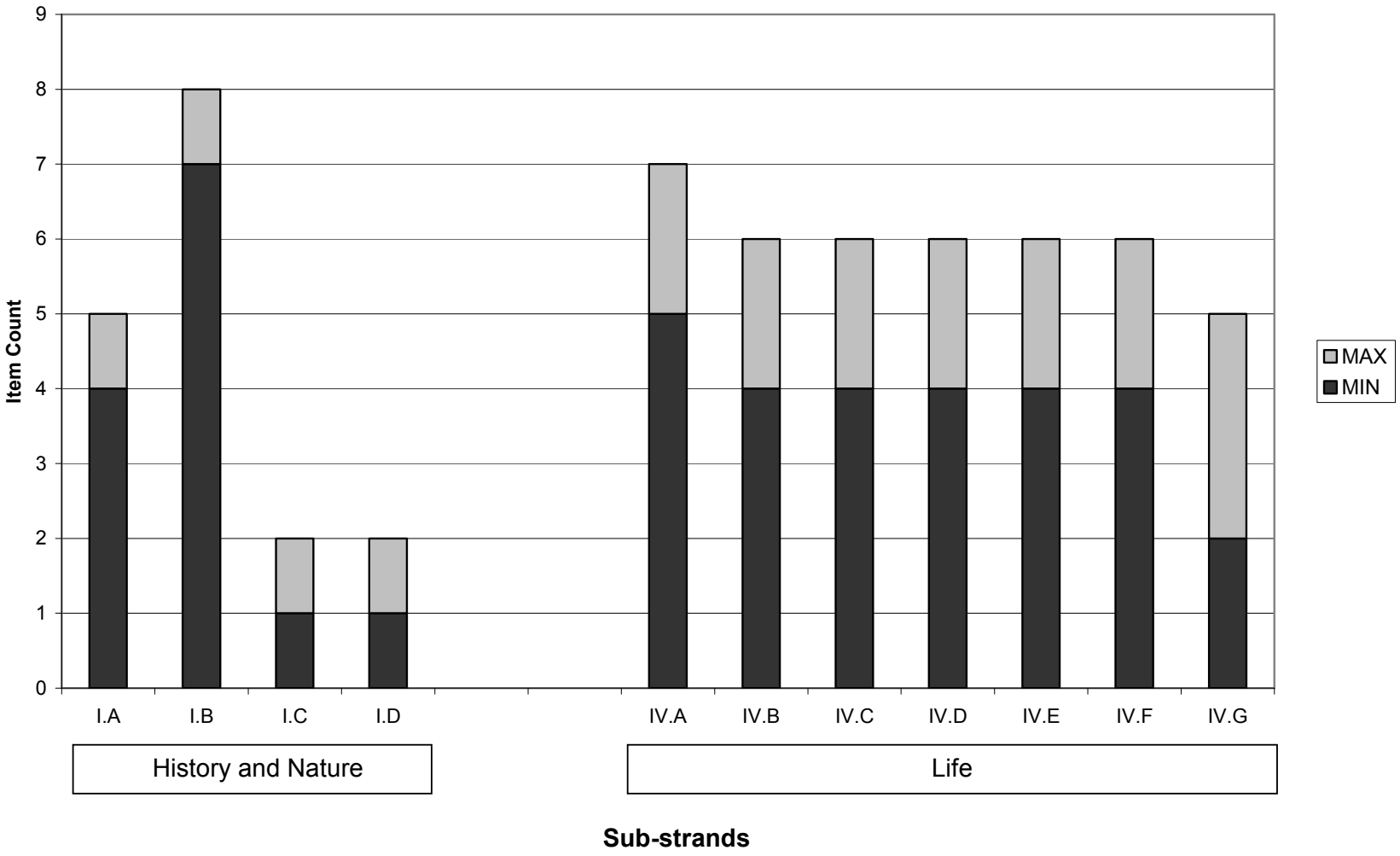
Test Design Science Grades 10–12

The grades 10–12 science MCA-II will be an 62-point test with 7–9 scenarios, approximately 44 rooted items—multiple choice (MC) and figural response (FR) items that appear during the scenario—six 2-point short response (SCR) or figural response items, and two 3-point extended response (ECR) items. The number of rooted items may vary if some of the figural response items are more than one point. The total number of points for the rooted items will be 44. The operational test forms will also include embedded field test scenarios.

Grades 10–12 Science MCA-II (Operational Form)						
	Rooted Items	Summary Items				
Strand	MC or FR (1–2 pt)	SCR or FR (2 pts)	ECR (3 pts)	Approximate Items	Approximate Points	Approx % of Points
History and nature of science (HNS)	11-13	3	1	15-17	20-22	35
Life science (LS)	31-33	3	1	35-37	40-42	65
Total	40-44	6	2	48-52	62	100

During test form construction, the number of points takes precedence over the number of items.

Grade 9 - 12 Items by Sub-strand



A Guide to the Science Grade Level Tables

The Test Specifications that follow provide information about how the academic standards in science will be assessed on the MCA-II. The diagram below explains the format of the Science Test Specifications.

Strand
The subject or content domain in science

Sub-strands
The framework for content within each subject or domain

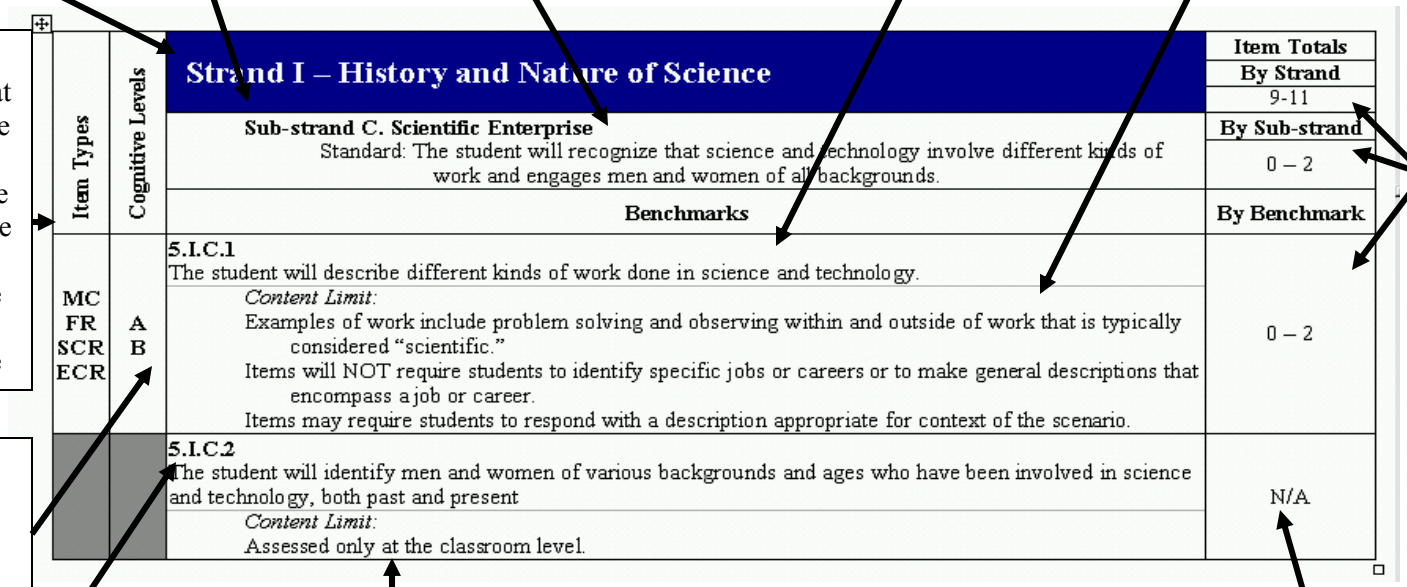
Standards
Descriptions of broad learning goals for each sub-strand

Benchmarks
The specific knowledge or skills that students should acquire by the end of the grade span

Content Limit
The clarification, definition or restriction of items assessing this benchmark

Item Types
The kinds of items that may be used to test the benchmark
MC = Multiple Choice
FR = Figural Response
SCR = Short Constructed Response
ECR = Extended Constructed Response

Item Totals
The number of operational items per form for each strand, sub-strand, and benchmark



Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals
			By Strand: 9-11
		Sub-strand C. Scientific Enterprise Standard: The student will recognize that science and technology involve different kinds of work and engages men and women of all backgrounds.	By Sub-strand: 0 – 2
		Benchmarks	By Benchmark
MC FR SCR ECR	A B	**5.I.C.1** The student will describe different kinds of work done in science and technology. *Content Limit:* Examples of work include problem solving and observing within and outside of work that is typically considered "scientific." Items will NOT require students to identify specific jobs or careers or to make general descriptions that encompass a job or career. Items may require students to respond with a description appropriate for context of the scenario.	0 – 2
		5.I.C.2 The student will identify men and women of various backgrounds and ages who have been involved in science and technology, both past and present *Content Limit:* Assessed only at the classroom level.	N/A

Cognitive Levels
The cognitive complexity of items aligned to the benchmark

Item Code
E.g.,
5. Grade
I. Strand
C. Sub-strand
2. Benchmark

This benchmark is not assessed on the MCA-II. It is assessed in the classroom.

This benchmark is not assessed on the MCA-II. No items on the test are aligned to this benchmark.

An Explanation of Terms on the Science Grade Level Tables

Strand: The most general categorization of content in the Minnesota Academic Standards. Four strands are assessed on the MCA-IIs: History and Nature of Science, Physical Science, Earth Science, and Life Science.

Sub-strand: A subcategory of a strand in the Minnesota Academic Standards. Science has three to seven sub-strands in each strand.

Standard: Explains the general goal of student learning within each sub-strand. One or two standards exist in each sub-strand for each grade. Several standards are grouped in each sub-strand for each grade span.

Benchmark: Each standard is divided into several benchmarks. The benchmark identifies the specific knowledge or skills that students should acquire by the end of that grade level.

Content Limit: Statements that provide more specific clarifications, definitions or restrictions for the benchmark as it is assessed on the MCA-II.

Item Type: The type of item that may be written for a benchmark. The possible formats are multiple choice (MC), figural response (FR), short constructed response (SCR) and extended constructed response (ECR). Multiple-choice items have 4 options, one of them correct. Figural response items require students to manipulate graphic elements, select a point on an image, or complete a diagram, chart, or graph.

Cognitive Level: A measure of the complexity of thinking required by an item. See the introductory text on Cognitive Levels for more information.

Item Code: A code used by test developers to identify the grade, strand, sub-strand and benchmark to which a test item is aligned.

Item Totals

By Strand: The total number of items aligned to benchmarks in the strand that could be on the test. For example, in Grade 5, there will be approximately 37 items on the operational test. Of those 37 items, 9-11 items will be from strand I.

By Sub-strand: The total number of items aligned to benchmarks in a sub-strand that could be on the test. For example, in Grade 8, there will be approximately 42 items on the operational test. Of those 42 items, 10-12 items will be from strand II. Of those 10-12, x–y items will be from sub-strand A.

By Benchmark: The number of items on the operational MCA-II is listed next to each benchmark.

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals By Strand 9-11
		Sub-strand A. Scientific World View Standards: The student will understand the use of science as a tool to examine the natural world (3.I.A); the student will understand how science is used to investigate interactions between people and the natural world (4.I.A); the student will understand that communication is essential to science (5.I.A).	**By Sub-strand** 2 – 4
		Benchmarks	**By Benchmark**
FR **SCR** **ECR**	**B** **C**	**3.I.A.1** The student will explore the use of science as a tool that can help investigate and answer questions about the environment. *Content Limit:* Environment does NOT refer exclusively to environmental science; it is a general term referring to the natural world. The use of science as a tool includes observing, describing, communicating, comparing and contrasting, and sorting. The use of science as a tool does NOT include physical instruments.	0 – 2
FR **SCR** **ECR**	**B** **C**	**4.I.A.1** and **4.I.A.3** The student will explore the uses and effects of science in our interaction with the natural world. The student will recognize the impact of scientific and technological activities on the natural world. *Content Limit:* Interactions with the natural world may have positive or negative effects. Examples of technology include both simple and complex examples, such as simple machines, thermometers, microscopes, hand lenses, balances, rulers, cars, tractors, telephones, televisions, dams, and electricity. Examples of interactions include making and using electricity, using fertilizers, predicting weather, and preventing disease with our choices in clothing, shelter, and hand washing. Examples may include the impact on ground and surface water due to the application of lawn fertilizers; impact of dam building on habitats; impact of flooding on altered land surfaces; impact of making and using electricity on human health. Items which address this benchmark may also address 4.III.A.1, 3.IV.C.2 and 5.III.A.4.	0 –2

		4.I.A.2 The student will discuss the responsible use of science. *Content Limit:* Assessed only at the classroom level.	N/A
MC **FR** **SCR** **ECR**	**A** **B**	**5.I.A.1** The student will know that current scientific knowledge and understanding guide scientific investigation. *Content Limit:* Items may require students to be able to identify the difference between what is known vs. what is unknown at the start of an investigation or determine whether or not a specific example of scientific knowledge is relevant to a specific investigation.	0 –2
MC **FR** **SCR** **ECR**	**A** **B** **C**	**5.I.A.2** The student will recognize that clear communication of methods, findings and critical review is an essential part of doing science. *Content Limit:* Items may require students to recognize whether communication is clear (accurate) or how clear communication helps others repeat work or conduct further investigation.	0 – 3

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals By Strand 9-11
		Sub-strand B. Scientific Inquiry Standards: The student will understand the nature of scientific investigations (3.I.B); the student will participate in a controlled scientific investigation (4.I.B); the student will understand the process of scientific investigations (5.I.B).	**By Sub-strand** 4 – 8
		Benchmarks	**By Benchmark**
FR **SCR** **ECR**	**B** **C**	**3.I.B.1** The student will ask questions about the natural world that can be investigated scientifically. *Content Limit:* Investigating a question scientifically includes making observations, describing, classifying, grouping and sorting, and using rank order. Questions that can be investigated scientifically are limited to those that have measurable qualities and are testable by students. Examples of questions that can be investigated scientifically are questions that begin with "How can," "How does," "What if," "I wonder," but typically NOT "Why." Items may require students to write a measurable, investigable question Items may be placed in scenario that addresses an experiment, and require students to write an appropriate question. Items may supply questions that students evaluate.	0 – 3

MC **FR** **SCR** **ECR**	**A** **B** **C**	**3.I.B.2** and **5.I.B.1** The student will participate in a scientific investigation using appropriate tools. The student will perform a controlled experiment using a specific step-by-step procedure and present conclusions supported by the evidence. *Content Limit:* Appropriate tools are limited to thermometers, microscopes, hand lenses, balances, and rulers. Measurement tools are limited to metric. Items may require students to choose a tool that is most appropriate to a particular task in a scientific investigation. This includes selecting a tool that has the appropriate units of measure. Items may require students to identify whether a 2- to 3-step procedure has been followed, recognize or follow individual steps in a procedure, and/or recognize whether conclusions are based on opinion or evidence. Items may present 2 to 3 steps of a procedure, and require students to identify an appropriate tool for each step. Items will NOT require students to generate a step-by-step procedure.	1 – 3
MC **FR** **SCR** **ECR**	**A** **B** **C**	**3.I.B.3** The student will know that scientists use different kinds of investigations depending on the questions they are trying to answer. *Content Limit:* Examples of different kinds of investigation strategies are making a hypothesis and devising a way to check it, grouping and comparing properties, comparing and contrasting, and observing and collecting data. Items may require students to compare and contrast types of investigations and how they are used to answer questions. Items will NOT require students to recognize types of investigations when given a specific example. Items will NOT test knowledge of specific terms, such as hypothesis.	1 –3
MC **FR** **SCR** **ECR**	**A** **B** **C**	**4.I.B.1** The student will recognize when comparisons might not be fair because some conditions are not kept the same. *Content Limit:* Items may require students to recognize the variables of an investigation. Items may require students to recognize when variables are not controlled. Items will NOT require students to design the controls and variables in an investigation.	1 –3

MC **FR** **SCR** **ECR**	**A** **B** **C**	**4.I.B.2** The student will collect, organize, analyze and present data from a controlled experiment. *Content Limit:* Examples of organizing include placing data in a table. Examples of tools for collecting data include thermometers, microscopes, hand lenses, balances, rulers and rain gauges. Tools also include common items that may indicate wind speed or direction such as a flag or weather vane. Examples of analysis include simple graphing (bar graph, line graph, and histogram) and using data to make comparisons or a summary statement. Examples of analysis do NOT include predictions.	0 – 3
MC **FR** **SCR** **ECR**	**A** **B** **C**	**4.I.B.3** The student will recognize that evidence and logic are necessary to support scientific understandings. *Content Limit:* Evidence is limited to measurable data from an investigation. Examples of logic include those in a systematic investigation—a testable question, a procedure that may be replicated, measurable data that can be reproduced, and a conclusion that reflects the measurable data collected.	0 –2
		5.I.B.2 The student will observe that when a science investigation or experiment is repeated, a similar result is expected. *Content Limit:* Assessed only at the classroom level.	N/A

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals
			By Strand
			9-11
		Sub-strand C. Scientific Enterprise Standard: The student will recognize that science and technology involve different kinds of work and engages men and women of all backgrounds.	By Sub-strand
			0 – 2
		Benchmarks	By Benchmark
MC **FR** **SCR** **ECR**	**A** **B**	**5.I.C.1** The student will describe different kinds of work done in science and technology. *Content Limit:* Examples of work include problem solving and observing within and outside of work that is typically considered "scientific." Items will NOT require students to identify specific jobs or careers or to make general descriptions that encompass a job or career. Items may require students to respond with a description appropriate for context of the scenario.	0 – 2
		5.I.C.2 The student will identify men and women of various backgrounds and ages who have been involved in science and technology, both past and present *Content Limit:* Assessed only at the classroom level.	N/A

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals By Strand
			8 – 10
		Sub-strand A. Structure of Matter Standard: The student will know that heating and cooling may cause changes to the properties of a substance.	**By Sub-strand** 3 – 5
		Benchmarks	**By Benchmark**
MC FR	**A B C**	**4.II.A.1** The student will observe that heating and cooling can causes changes in state. *Content Limit:* Changes in state include changes between solid, liquid and gas. Examples of materials include water, crayons, and oils. Items that address this benchmark may also address benchmark 4.II.A.2	1 – 3
MC FR	**A B C**	**4.II.A.2** The student will describe the changes in the properties of a substance when it is heated or cooled. *Content Limit:* Changes in the properties of substances are limited to changes in shape (e.g., takes the shape of a container, melting), visibility (e.g., can see it, can't see it), size (e.g., bigger, smaller), and color (e.g., an object that is red when heated). Substances will be limited to common substances such as water. Items will NOT address the tendency of substances to expand when heated or to contract when cooled. Items that address this benchmark may also address 4.II.A.1	1 – 3
MC FR	**B C**	**4.II.A.3** The student will compare and contrast the mass, shape and volume of solids, liquids and gases *Content Limit:* Items may require students to understand that mass stays the same during phase changes. Items will NOT require students to understand density or changes to the volume of water. Materials are limited to common materials.	0 –3

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals
			By Strand
			8 – 10
		Sub-strand C. Energy Transformations Standards: The student will explore the characteristics and properties of sound and light (3.II.C); the student will understand basic electricity and its application in everyday life (4.II.C).	By Sub-strand
			3 – 5
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B** **C**	**3.II.C.1** The student will investigate how sounds are made when objects vibrate. *Content Limit:* Properties of objects and sounds are limited to the size of the object, the type of material, how fast or slow it vibrates, as well as pitch, tone and loudness. Examples include how pitch changes when an object vibrates faster or slower.	0 – 2
MC **FR**	**A** **B**	**3.II.C.2** The student will know that light tends to maintain its direction of motion until it is absorbed, refracted, or reflected by an object. *Content Limit:* Items should focus on using examples of these concepts, including reflection of light using solid objects and mirrors, rainbows, and the idea that when we look through dark glasses things are not as bright because some light has been absorbed. Items may require students to understand that seeing involves light from a source reflecting off an object into the eye. Items may require a student to identify whether light in a given example maintains its direction of motion or is refracted, reflected, or absorbed. Items may include the words transparent and/or opaque. Items that describe interactions of light will include an explicit light source.	0 – 2
MC **FR**	**A** **B** **C**	**4.II.C.1** The student will explore simple electrical circuits using components such as wires, batteries and bulbs. *Content Limit:* Simple electrical circuits will include both open (light bulb not on) and closed (light bulb on) circuits with or without switches. Electrical circuits are limited to series circuits. Items may require students to understand the organization and identify the parts of a circuit.	1 – 3

MC **FR**	**A** **B**	**4.II.C.2** The student will investigate static electricity *Content Limit:* Examples of appropriate materials for investigating static electricity include balloons, hair, Styrofoam, plastic rods and combs, tissue, silk scarves, natural fibers. Items may require students to know that a charged object may cause other objects to move without touching them. Items may require students to predict the result of interactions between objects labeled with positive or negative charges. Items will use the terms "push" and "pull" when referring to repulsion and attraction. Items will NOT require students to predict results of interactions based on materials only.	0 –2
MC **FR**	**A** **B** **C**	**4.II.C.3** The student will identify objects and materials that conduct electricity and those that are insulators. *Content Limit:* Examples of appropriate objects and materials include those commonly found in the classroom such as wood, rubber, plastic, craft sticks, metal paper clips, and aluminum foil. Items will include objects that may be either conductors or insulators depending on how they were made only when the items require students to interpret the results of a test. Items may require students to set up tests or use the results of the tests to identify objects and materials that are conductors and insulators.	0 –2

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals
			By Strand
			8 – 10
		Sub-strand D. Motion	By Sub-strand
		Standard: The student will understand that changes in speed or direction of motion are caused by forces.	0 – 2
		Benchmarks	By Benchmark
MC FR	A B C	**5.II.D.1** The student will investigate the use of a lever, inclined plane and wheel and axle to move objects. *Content Limit:* Uses of these simple machines are limited to changes in the speed of an object, the distance it moves, and the force on the object. Items may make comparisons to the human body.	0 – 2
MC FR	B C	**5.II.D.2** The student will demonstrate that the greater the force applied, the greater the change in motion. *Content Limit:* Items may require students to understand the relationship between force and motion, apply this understanding to specific examples, make comparisons, or predict the result of interactions. Items may make comparisons to the human body. Items will NOT use the term "acceleration." Items will NOT refer directly to Newton's laws.	0 – 2

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals
			By Strand
			8 – 10
		Sub-strand E. Forces of Nature Standard: The student will understand that a relationship exists between electricity and magnetism.	By Sub-strand
			0 – 2
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B** **C**	**4.II.E.1** The student will demonstrate how a wire and magnet can be used to generate an electric current. *Content Limit:* Examples include moving a bar magnet near a wire that is connected to an analog meter or wrapped around a compass to show that there is a current, a hand-crank flashlight, generators and alternators. Items that include these examples will provide descriptions, as some students may not have seen all of them.	0 – 2
MC **FR**	**A** **B** **C**	**4.II.E.2** The student will demonstrate how an electric current can make an iron object magnetic. *Content Limit:* Examples include current in a wire wrapped around a nail and electromagnets used to operate devices such as a doorbell or telegraph. Items may require students to understand the relationship among the number of turns of wire, the amount of current in the wire, and the strength of the magnetic force.	0 – 2

Item Types	Cognitive Levels	Strand III – Earth and Space Science	Item Totals
			By Strand
			8-10
		Sub-strand A. Earth Structure and Processes Standards: The student will investigate the impact humans have on the environment (4.III.A); the student will explore the structures and functions of Earth systems (5.III.A).	By Sub-strand
			2 – 4
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**4.III.A.1** The student will identify and investigate environmental issues and potential solutions. *Content Limit:* Examples of appropriate environmental issues may include: pollution of air and water and solid waste issues. Examples of appropriate potential solutions may include: recycling, reducing and reusing. Items may require students to identify potential solutions to an environmental issue provided.	0 – 2
MC **FR**	**A** **B**	**5.III.A.1** The student will recognize the natural processes that cause rocks to break down into smaller pieces and eventually into soil. *Content Limit:* Natural processes are limited to weathering and erosion. Items will NOT include the terms chemical and physical weathering or require differentiation between them. Items will NOT require differentiation between soil types. Items that address this benchmark may also address 5.III.A.2 and 5.III.A.3	0 – 2
MC **FR**	**A** **B** **C**	**5.III.A.2** The student will investigate the formation, composition and properties of soil. *Content Limit:* Soil composition is limited to rocks, organic matter, water and air. Soil properties are limited to color and particle size. Soil formation is limited to origin of soils through weathering and erosion. Items will NOT assess soil horizons. Items that address this benchmark may also address 5.III.A.1 and 5.III.A.3.	0 – 2

MC **FR**	**A** **B**	**5.III.A.3** The student will describe how waves, wind, water and ice shape and reshape the Earth's surface. *Content Limit:* Reshaping of the earth is limited to observable examples of rain, running water, and ice melting that moves material. Examples include runoff from fields or construction sites. Items that address this benchmark may also address 5.III.A.1 and 5.III.A.2.	0 – 2
MC **FR**	**B** **C**	**5.III.A.4** The student will describe the impact of floods, tornadoes, earthquakes and volcanoes on the Earth. *Content Limit:* Examples of descriptions of the impact of these events may include destruction of property, habitat, and changes in shape of landscape.	0 – 2
		5.III.A.5 The student will explore the interaction of the lithosphere, atmosphere, biosphere, hydrosphere and space. *Content Limit:* Assessed by 5.III.A.1–4.	N/A

Item Types	Cognitive Levels	Strand III – Earth and Space Science	Item Totals
			By Strand
			8-10
		Sub-strand B. The Water Cycle, Weather and Climate Standards: The student will investigate weather conditions (3.III.B); the student will recognize that water on Earth cycles and exists in many forms (4.III.B).	By Sub-strand
			3 – 5
		Benchmarks	By Benchmark
MC FR	A B C	**3.III.B.1** and **3.III.B.2** The student will measure, record, and describe weather conditions using common instruments. The student will identify cumulus, cirrus and stratus clouds. *Content Limit:* Common instruments may include thermometer, rain gauge, wind indicator speed and direction using a flag on a flagpole or weather vane. Descriptions of weather conditions that include clouds are limited to cumulus, cirrus, and stratus cloud types. Items may require student to identify weather patterns and changes over time. Patterns and changes over time refer to seasonal changes, NOT pressure regions, fronts, or day-to-day changes. Items may require students to select the appropriate tool for measuring different weather conditions. Items may require students to use recorded measurements to describe weather conditions. Items will NOT require students to know how weather conditions and cloud types are related. Items will NOT include measurements or descriptions of relative humidity.	1 – 2
MC FR	A B C	**4.III.B.1** and **4.III.B.2** The student will describe the water cycle involving the processes of evaporation, condensation, precipitation and collection. The student will identify where water exists on Earth. *Content Limit:* Examples of places where water exists on Earth include rivers, lakes, streams, clouds, the atmosphere, glaciers, groundwater, and oceans. Items may include interpreting or labeling a water cycle diagram. Items will NOT include the process of transpiration.	2 – 3

Item Types	Cognitive Levels	Strand III – Earth and Space Science	Item Totals By Strand 8 – 10
		Sub-strand C. The Universe Standards: The student will understand the characteristics and relationships of objects in the solar system (3.III.C); the student will identify the patterns and movements of celestial objects (4.III.C).	**By Sub-strand** 1 – 3
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**3.III.C.1** The student will recognize the difference between rotation and revolution and their connection to day, night, seasons and the year. *Content Limit:* Examples are limited to the Earth. Examples with models or animations of the Earth rotating may be used to recognize rotation and the connection to day and night. Examples with models or animations of the Earth revolving around the Sun may be used to recognize revolution. Items may require students to recognize the differences between rotation and revolution in examples or models. Items will NOT require recalling the terms or definitions of rotation and revolution.	0 – 2
MC **FR**	**A**	**3.III.C.2** The student will identify the planets in the solar system and their relative sizes, distances and basic characteristics. *Content Limit:* Basic characteristics are limited to relative size and distance from the Sun, special characteristics (e.g., red spot, rings, and moons), rank order, and inner and outer planets. Items will NOT include reasons why the inner and outer planets are different.	0 – 2
MC **FR**	**A** **B**	**3.III.C.3** The student will observe that the sun supplies heat and light to the Earth. *Content Limit:* Examples include using thermometers to observe differences in temperature between areas with and without sunlight or between dark and light fabrics, and the presence of shadows in sunlight. Items that address this standard may also address benchmark 3.II.C.2.	0 – 2

MC **FR**	**A** **B**	**3.III.C.4** and **4.III.C.1** The student will know that planets look like stars, but over time they move differently than stars. The student will recognize that the stars in the sky appear to slowly move from east to west. *Content Limit:* Limit to understanding that planets move at different rates relative to the stars. Examples may include positions of constellations at different times of the year. Stars in the sky that appear to move from east to west are limited to those that appear to move from east to west from the location used in the context of the scenario. (In Minnesota, stars within 43° to 49° of Polaris appear to move counterclockwise about the north celestial pole rather than strictly east to west.)	0 – 2
MC **FR**	**A** **B**	**4.III.C.2** The student will identify the sun as an average-sized star and that the other stars are so far away that they look like points of light. *Content Limit:* Items may require understanding that the Sun is similar to many of the other stars in the sky, and that the other stars would look the same to us as the Sun if they were not so much farther away.	0 – 2
MC **FR**	**A**	**4.III.C.3** The student will know that telescopes magnify distant objects in the sky and dramatically increase the number of stars we can see. *Content Limit:* Distant objects are limited to objects in our solar system. Items may require knowledge that the telescope is a tool used to study the stars. Items will NOT require understanding that the resolving power and aperture of telescopes make more stars visible through a telescope than with the unaided eye.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals By Strand 8 – 10
		Sub-strand A. Cells Standard: The student will know that all organisms are composed of cells, which are the fundamental units of life.	**By Sub-strand** 0 – 2
		Benchmarks	**By Benchmark**
MC **FR**	**A**	**4.IV.A.1** The student will recognize that cells are very small, and that all living things consist of one or more cells. *Content Limit:* Very small is defined as too small to be seen with the naked eye. Items may require students to know the difference between living and non-living things and the terms biotic and abiotic. Items will NOT address knowing that organisms can be single-celled or multi-celled.	0 – 2
MC **FR**	**A**	**4.IV.A.2** The student will recognize that cells need: food, water and air, a way to dispose of waste, and an environment in which they can live. *Content Limit:* Items will use the term "air" to describe components of air such as carbon dioxide and oxygen. Items will NOT assess recognition of the parts of a cell where these needs are met.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			8 – 10
		Sub-strand B. Diversity of Organisms	**By Sub-strand**
		Standards: The student will recognize that plants and animals have different structures that serve various functions (3.IV.B); the student will know that living things can be sorted into groups in many ways according to their varied characteristics, structures and behaviors (4.IV.B).	3 – 5
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**3.IV.B.1** and **3.IV.B.2** The student will describe the structures that serve different functions in growth, survival and reproduction for plants and animals. The student will know that plants have different structures from animals that serve the same necessary functions in growth, survival and reproduction. *Content Limit:* Structures of plants to be described are limited to roots, stems, leaves, flowers, fruits and seeds. Flowers are described as an entire structure with a primary function of being the site for reproduction. Individual parts of the flower are not described. Structures of animals are limited to gross physical characteristics such as coverings (skin, fur, hair, scales, and feathers), appendages (wings, arms, and legs), eyes, ears, mouths, and beaks. Items will NOT require students to make comparisons between the structures of animals and plants and their functions. Items that address this benchmark may also address 4.IV.G.1.	1 – 3

MC **FR**	**A** **B** **C**	**4.IV.B.1** and **4.IV.B.2** The student will classify plants and animals according to their physical characteristics. The student will learn that the characteristics used for grouping depend on the purpose of the grouping. *Content Limit:* Appropriate classification at this age level is grouping and sorting by physical characteristics. Characteristics of animals include sex, color, size, shape, coverings (skin, fur, hair, scales, feathers), appendages (wings, arms, legs, number of each), eyes, ears, and mouths. Characteristics of plants are limited to roots, stems, leaves, flowers, fruits, seeds, and functions of the plant (example: carrots as a type of taproot). Given a set of organisms, items may require students to sort them by one or two characteristics in order to produce sets of organisms with similar characteristics and to assign a unique label to each set. Items may require students to recognize the characteristics used to sort a set of organisms. Items may require students to sort a set of organisms based on physical characteristics within and between a species. Items may require students to infer the reason for grouping based on a particular set of characteristics. For example, grouping birds by beak type in order to answer the question "What types of food do different birds eat?"	2 – 4

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			8 – 10
		Sub-strand C. Interdependence of Life	**By Sub-strand**
		Standard: The student will understand that an organism's patterns of behavior are related to the nature of its environment.	1 – 3
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**3.IV.C.1** The student will know that organisms interact with one another in various ways besides providing food. *Content Limit:* Examples of ways organisms interact other than providing food include survival, safety (e.g., herding and schooling behaviors), reproduction, competition for resources, and grooming. Examples of ways organisms interact other than providing food will NOT include the terms symbiosis, commensalisms, mutualism, and parasitism, but these concepts may be addressed.	0 – 2
MC **FR**	**A** **B** **C**	**3.IV.C.2** The student will know that changes in a habitat can be beneficial or harmful to an organism. *Content Limit:* Examples of changes in a habitat may include pollution, catastrophic events, fire, and new species in the area. Items may require knowledge that changes in a habitat can be either beneficial or harmful to an organism depending on the organism's niche.	0 – 3

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			8 – 10
		Sub-strand D. Heredity Standard: The student will understand that many characteristics of an organism are inherited from its parents, but that other characteristics result from an individual's interactions with the environment.	**By Sub-strand** 0 – 2
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B** **C**	**3.IV.D.1** The student will observe and differentiate between characteristics of organisms that are inherited and characteristics that are acquired. *Content Limit:* Items will be limited to physical characteristics and will NOT include behavioral characteristics. Examples of inherited characteristics in humans include eye, skin, and hair color. Examples of inherited characteristics in other organisms include fur coloration, skin types, number of appendages, and body coverings. Examples of acquired characteristics in humans include pierced ears, hairstyle, weight, clothing, tattoos, and allergies. Examples of acquired characteristics in other organisms include weight and docked tails.	0 – 2
MC **FR**	**B** **C**	**3.IV.D.2** The student will identify similarities and differences between parent and offspring. *Content Limit:* Items will NOT require recall of specific characteristics of organisms. Items will NOT use examples of organisms that undergo metamorphosis.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals By Strand 8 – 10
		Sub-strand E. Biological Populations Change Over Time Standard: The student will know that biological populations change over time.	**By Sub-strand** 0 – 2
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B** **C**	**5.IV.E.1** The student will recognize that individuals of the same species differ in their characteristics and that sometimes the differences give individuals an advantage in surviving and reproducing. *Content Limit:* Characteristics are limited to observable physical characteristics such as coloration, body covering, size, and strength. Examples of behavioral characteristics include reaction time, nesting, and hunting behaviors.	0 – 2
MC **FR**	**A** **B** **C**	**5.IV.E.2** The student will recognize that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. *Content Limit:* Characteristics are limited to observable physical characteristics such as coloration, body covering, size, and strength. Items will address the concept of a population adapting over time, NOT an individual adapting to a changing environment.	0 – 2
MC **FR**	**B** **C**	**5.IV.E.3** The student will compare the structure of fossils to one another and to living organisms. *Content Limit:* Fossils include the mineralized or otherwise preserved remains or traces (such as footprints) of animals, plants, and other organisms. Examples of fossils are limited to those common to classroom experience. Comparing the structure of fossils is limited to gross physical characteristics including teeth, skulls, body covering, and appendages. Comparing the structure of fossils does NOT include comparing the process of fossilization. Comparisons may be made between two fossils or between a fossil and a living organism. Fossil representations are limited to photos, sketches or drawings or illustrations and museum or similar dioramas.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			8 – 10
		Sub-strand F. Flow of Matter and Energy Standard: The student will know that matter and energy flow into, out of, and within a biological system.	**By Sub-strand**
			1 – 3
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**5.IV.F.1** The student will recognize that organisms need energy to stay alive and grow, and that this energy originates from the sun. *Content Limit:* Items may require students to recognize that plants capture energy from the Sun for growth and reproduction. Items will NOT require understanding the photosynthetic process of capturing the Sun's energy. Items may refer to the energy flow into, through and out of a biological system.	0 – 3
MC **FR**	**B** **C**	**5.IV.F.2** The student will use food webs to describe the relationships among producers, consumers, and decomposers in an ecosystem in Minnesota. *Content Limit:* Examples of ecosystems include, but are not limited to, prairie, forest, and wetland. Items may require students to describe the roles of organisms and the relationships, including the transfer of energy among producers, consumers and decomposers in a particular ecosystem in Minnesota. Items will not require students to generate specific examples of the producers, consumers and decomposers in a particular ecosystem.	0 – 2
MC **FR**	**A** **B**	**5.IV.F.3** The student will recognize that organisms are growing, dying and decaying, and that their matter is recycled. *Content Limit:* Examples of organisms may include plants or animals. Items may require students to recognize that matter cycles within a system. Items will NOT describe matter as flowing into or out of a system. Items will NOT require students to know specific cycles such as the carbon or nitrogen cycle.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			8 – 10
		Sub-strand G. Human Organism Standard: The student will know the structures that serve various functions in the human body, including protection from disease.	By Sub-strand 0 – 2
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**4.IV.G.1** The student will understand that humans have structures that serve functions in growth, survival and reproduction. *Content Limit:* Structures are limited to organs and organ systems. Examples include heart, lungs, skeletal system, skin, digestive tract, reproductive organs, eyes, nose, ears, and mouth. Items that address this benchmark may also address benchmark 3.IV.B.1.	0 – 2
MC **FR**	**A** **B** **C**	**4.IV.G.2** The student will know that germs entering the body can cause disease, and that the body has defenses against these germs. *Content Limit:* Items will NOT use the terms virus or bacteria. Items include how germs enter the body and ways that lifestyle choices such as personal hygiene prevent germs from entering the body.	0 – 2
MC **FR**	**A** **B**	**4.IV.G.3** The student will know that there are many diseases that can be prevented by vaccination. *Content Limit:* Items will NOT refer to specific diseases but will deal in general terms with disease prevention. Items will NOT require understanding what is in a vaccination and how it works (i.e., dead germs allow the body to prepare a defense against that specific type of germ).	0 – 2

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals
			By Strand
			8 – **10**
		Sub-strand A. Scientific World View Standard: The student will understand that science is a way of knowing about the world that is characterized by empirical criteria, logical argument and skeptical review.	By Sub-strand 0 – 3
		Benchmarks	**By Benchmark**
MC **FR** **SCR** **ECR**	**B** **C**	**6.I.A.1** and **6.I.A.4** The student will distinguish between scientific evidence and personal opinion. The student will define scientific facts, laws and theories. *Content Limit:* Items will address scientific evidence in the context of science content. Items will address understandings of these terms and how the terms are related. Items may require understanding that theories explain, and that laws state relationships. Items may require understanding that facts can be used to support laws and theories. Evidence consists of observations and data on which to base scientific explanations. (National Research Council, *National Science Education Standards,* [National Academy Press, 1996], 117) A fact is defined as an observation that has been repeatedly confirmed. (National Academy of Sciences, *Teaching About Evolution and the Nature of Science*, [National Academy Press, 1998], 5) A law is defined as a descriptive generalization about how some aspect of the natural world behaves under stated circumstances and that carries the weight of scientific evidence. (*Ibid.*) A theory is defined as a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses (A hypothesis is defined as a testable statement about the natural world). (*Ibid.*)	0 – 3
MC **FR** **SCR** **ECR**	**A** **B** **C**	**6.I.A.2** The student will explain why scientists often repeat investigations to be sure of the results. *Content Limit:* Items may address the accuracy of results or looking for interfering variables. Items will be placed in scenarios that address variables and investigation design.	0 – 2

MC FR SCR ECR	**A B C**	**6.I.A.3** The student will recognize that scientists assume that the laws of nature are the same everywhere and that they are understandable and predictable. *Content Limit:* Examples are limited to natural events that middle-level students are likely to directly observe outside the classroom and then be able to confirm for themselves in a science class. Examples of laws of nature include Mendel's laws, law of gravity, and laws of motion.	0 – 2
MC FR SCR ECR	**A B C**	**7.I.A.1** The student will recognize how scientific knowledge is subject to change as new evidence becomes available, or as new theories cause scientists to look at old observations differently. *Content Limit:* Examples of theories that have changed over time include evolution, germ theory, plate tectonics, structure of the solar system, and early atomic theory (matter is composed of atoms).	0 – 2
MC FR SCR ECR	**A B C**	**7.I.A.2** The student will explain natural phenomena by using appropriate physical, conceptual and mathematical models. *Content Limit:* Examples include graphs of data, models of the atom, cell models, planet/Earth/Moon models, phases of the Moon, convection, transfer of energy, weather forecasting, and extinction/predicted extinction of species over time. Mathematical models are limited to simple formulas. Physical models include cells and the solar system. Items that address this benchmark may also address 6.I.B.4	0 – 2
		8.I.A.1 The student will explain and give examples of how science can be used to make informed ethical decisions by identifying likely consequences of particular actions. *Content Limit:* Assessed only at the classroom level.	N/A
MC FR SCR ECR	**A B C**	**8.I.A.2** The student will explain the development, usefulness and limitations of scientific models in the explanation and prediction of natural phenomena. *Content Limit:* Examples of the limitations of models include scales of time, distance, and size, and artificial control of variables. Items may require students to compare the model to the object, organism, or phenomenon being modeled.	0 – 2

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals By Strand: 8 – 10
		Sub-strand B. Scientific Inquiry Standards: The student will understand that scientific inquiry is used in systematic ways to investigate the natural world (6.I.B); the student will design and conduct scientific investigations (7.I.B); the student will understand that scientific inquiry is used by scientists to investigate the natural world in systematic ways (8.I.B); the student will use multiple skills to design and conduct scientific investigations (8.I.B).	**By Sub-strand**: 4 – 6
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**A B C**	**6.I.B.1** and **7.I.B.1** The student will identify questions that can be answered through scientific investigation and those that cannot. The student will formulate a testable hypothesis based on prior knowledge. *Content Limit:* Items will require students to determine if a given question is investigable or generate investigable questions, in the context of science content. Investigable questions are observable (measurable), identify variables, and do not simply ask why. Prior knowledge must be information provided in the scenario and be related to benchmarks in one of the other strands. Examples include testing motion using time, speed, mass and location as variables; testing weather using wind patterns, pressure, temperature, and humidity as variables; and testing seed germination using temperature, time, moisture, and air as variables. Examples of questions that cannot be answered through scientific investigation include questions relating to personal values, emotions, folk-lore, and mythology.	0 – 2
MC FR SCR ECR	**A B C**	**6.I.B.2** The student will distinguish among observation, prediction and inference. *Content Limit:* An observation is defined as using one or more of the five senses to gather information, and may include the use of equipment. (Karen L. Ostlund, *Science Process Skills: Assessing Hands-On Student Performance,* [Addison-Wesley, 1992], iv) A prediction is defined as the use of knowledge to identify and explain observations, or changes, in advance. (National Research Council, *National Science Education Standards,* [National Academy Press, 1996], 116) An inference is defined as the development of ideas based on observations. (Ostlund, *Science Process Skills*, iv)	1 – 3

MC FR SCR ECR	**A B C**	**6.I.B.3** The student will use appropriate tools and Système International (SI) units for measuring length, time, mass, volume and temperature with suitable precision and accuracy. *Content Limit:* Tools are limited to a Celsius thermometer, a barometer, a metric ruler, a clock, a mechanical balance (not electronic), and a graduated cylinder. Examples include requiring students to determine the tool used to most accurately measure a particular volume of liquid, or to determine the tool used to most accurately measure the mass of a particular object.	0 – 2
MC FR SCR ECR	**B C**	**6.I.B.4** The student will present and explain data and findings from controlled experiments using multiple representations including tables, graphs, physical models and demonstrations. *Content Limit:* Items will be placed in scenarios that describe controlled experiments that students conduct in middle-level science. Items may require students to compare supplied graphs or tables to data provided and determine if they match. Examples of sources for these graphs, tables and data include measurements of plant growth, speed, distance and time, the relative abundance of materials, diffusion rates, and population counts. Items that address this benchmark may also address 7.I.A.2	0 – 2
MC FR SCR ECR	**A B C**	**7.I.B.2 and 8.1.B.3** The student will recognize that a variable is a condition that may influence the outcome of an investigation and know the importance of manipulating one variable at a time. The student will specify variables to be changed, controlled and measured. *Content Limit:* Items that address this benchmark may also address benchmark 7.I.B.1. For example, based on a given hypothesis, which variables must be kept constant? Knowledge used to specify variables must be information provided in the scenario and be related to benchmarks in one of the other strands. Examples include testing motion using time, speed, mass and location as variables, testing weather using wind patterns, pressure, temperature, and humidity as variables, and testing seed germination using temperature, time, moisture, and air as variables. Items may require students to identify which variables were changed, kept the same, and measured in a given experiment. Items will NOT require knowledge of the terms "independent" and "dependent."	1 – 3

		7.I.B.3 The student will write a specific step-by-step procedure for a scientific investigation. *Content Limit:* Assessed only at the classroom level.	N/A
MC **FR** **SCR** **ECR**	**B** **C**	**7.I.B.4** The student will explain how classroom scientific investigations relate to established scientific principles. *Content Limit:* Examples of scientific principles include requirements for plant growth. Examples of classroom investigations include angle of ramp and speed or germination rate in seeds. Items may require students to compare investigations to known facts, laws and theories. For example, a good scientific investigation would not include the color of a pendulum or the amount of light on a seed as variables to be changed; such experimental designs would not reflect scientific facts, laws or theories.	0 – 2
MC **FR** **SCR** **ECR**	**A** **B** **C**	**8.I.B.1** The student will know that scientific investigations involve the common elements of systematic observations, the careful collection of relevant evidence, logical reasoning and innovation in developing hypotheses and explanations. *Content Limit:* Examples of scientific investigations that involve these common elements include gathering evidence that shows that continents have and are moving (such as continental coastlines, fossil records, matching landforms, and glacial evidence), and Mendel's work resulting in predictable relationships for characteristics of offspring and parents. An example of logical reasoning is using evidence to change the focus of scientific investigation from how could continents move to determining what was driving their motion.	0 – 2
MC **FR** **SCR** **ECR**	**B** **C**	**8.I.B.2** The student will describe how scientists can conduct investigations in a simple system and make generalizations to more complex systems. *Content Limit:* Investigations include using observations of the impact of penicillin on bacteria to generalization of penicillin can cure certain illnesses, and using observations of convection to study weather patterns. Simple systems have only one variable or factor, complex systems have multiple factors involved.	0 – 2

MC **FR** **SCR** **ECR**	**B** **C**	**8.I.B.4** The student will use sufficient trials and adequate sample size to ensure reliable data. *Content Limit:* Examples include comparison of data sets. Examples may include pooling class data to increase the sample size or number of trials. Sufficient trials will be addressed by comparing investigations where more trials are better or by comparing investigations where at least 3 trials are needed to see a pattern. Reliable data will be addressed by examples where multiple trials are needed to ensure reliable data. Items will NOT address differences due to experimental error. Items will NOT address investigations where there are more than two independent variables.	0 – 2
		8.I.B.5 The student will use appropriate technology and mathematics skills to access, gather, store, retrieve and organize data. *Content Limit:* Assessed only at the classroom level.	N/A

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals
			By Strand
			8 – 10
		Sub-strand C. Scientific Enterprise Standard: The student will know that science and technology are human efforts that both influence and are influenced by society (6, 7.I.C); the student will know that science and technology are human efforts that both influence and are influenced by civilizations and cultures worldwide (8.I.C).	**By Sub-strand** 0 – 2
		Benchmarks	**By Benchmark**
MC **FR** **SCR** **ECR**	**B** **C**	**6.I.C.1** The student will describe the types of questions asked, the products, and the methods of investigation used to distinguish science from technology. *Content Limit:* The purposes of science investigations include knowing something about the natural world as opposed to developing technology or creating a process or product for human use. Items may require students to know that design is technology and scientific inquiry is science. Items may require students to know that inventions, processes and systems are products of technology while facts, laws and theories are products of science.	0 – 2
MC **FR** **SCR** **ECR**	**B** **C**	**6.I.C.2** The student will explain why scientists may work in teams or work alone, can collaborate and, at times, compete. *Content Limit:* Examples of collaboration include monitoring earthquakes. Examples of competition should include the eventual sharing of ideas, stimulating new ideas and increasing the pace of development.	0 – 2

FR **SCR** **ECR**	**B** **C**	**7.I.C.1** The student will give examples of the development of technology influencing scientific knowledge, and investigation and scientific knowledge influencing the development of technology. *Content Limit:* Examples of the generation of a tool and the resulting ability to collect a new kind of data include the microscope—cells, radio balloons—weather patterns, and seismographs—earthquakes, telescopes—solar system. Examples of scientific knowledge and the resulting technology include the structure of the eye—glasses, light and lenses—microscopes, animal life science cycle—pesticides, plant life cycle—herbicides, functions of body systems—medical advances, radiation energy—medical cures (cancer), germ theory—pasteurization. Examples of research and advances of communication include: internet—knowledge distribution, calculator—computation of scientific data.	0 – 2
MC **FR** **SCR** **ECR**	**B** **C**	**8.I.C.1** The student will evaluate the credibility and validity of scientific and technological information from various sources. *Content Limit:* Items may require students to evaluate the qualifications of authors of a publication and the methods they used to gather information.	0 – 2

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals By Strand 8 – 10
		Sub-strand D. Historic Perspectives[3] Standard: The student will understand how scientific discovery, culture, societal norms and technology have influenced one another in different time periods.	**By Sub-strand** 0 – 2
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**A B**	**7.I.D.1** The student will cite examples of individuals throughout history who made discoveries and contributions in science and technology. *Content Limit:* Examples of individuals (and some of their discoveries or contributions) are limited to Rachel Carson—*Silent Spring*, George Washington Carver—agricultural products, technology, Nicolas Copernicus—Copernican revolution, Charles Darwin—classification, ecology and natural selection, Galileo Galilei—gravity and telescopes, Jane Goodall—primate research, James Hutton—geology, Anton van Leeuwenhoek and Robert Hooke—microscopy, Johann Gregor Mendel—genetics, Isaac Newton—gravity, mechanics, light and telescopes, Louis Pasteur—pasteurization, and Alfred Wegener—plate tectonics. Examples include discoveries and contributions made by a group of people, such as the Lakota or Ojibwa and their discoveries in and contributions to astronomy and medicine. Items may require students to cite an example and/or describe a relevant discovery or contribution based on the context of a scenario. Items may require students to identify a criterion for grouping individuals and/or their contributions. Such criteria include whether individuals are scientists, whether individuals contributed to our current understanding of a particular topic, or whether individuals or contributions can be grouped by discipline.	0 – 2
MC FR SCR ECR	**A B C**	**7.I.D.2** and **8.I.D.2** The student will cite examples of how culture influences scientific and technological advances. The student will cite examples of how science and technology contributed to changes in agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing or communication. *Content Limit:* Items may require students to supply an example or describe the relevant advancement or contribution based on the context of a scenario.	0 – 2

[3] See page 3 for additional notes.

		8.I.D.1 The student will relate personal experiences in scientific investigation to the experiences of scientists throughout history. *Content Limit:* Assessed only at the classroom level.	N/A

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals By Strand 10 – 12
		Sub-strand A. Structure of Matter Standard: The student will understand that matter is made of small particles and this explains the properties of matter.	**By Sub-strand** 3 – 5
		Benchmarks	**By Benchmark**
MC **FR** **SCR**	**A** **B**	**6.II.A.1** and **6.II.A.7** The student will know that there are more than 100 different elements with unique properties. The student will know that atoms are the smallest unit of an element that maintains the characteristics of the element. *Content Limit:* Elements are defined as substances composed of one type of atom. Items will NOT require use of the periodic table. Items will NOT refer to protons, neutrons and electrons. Items will NOT address the difference between molecules and atoms.	1 – 3
MC **FR** **SCR**	**B** **C**	**6.II.A.2** The student will use evidence to explain that matter is made of small particles called atoms or molecules, which are too small to see. *Content Limit:* Evidence includes examples of particles moving (food coloring in water, perfume in air), and examples of empty space between particles (expansion and contraction with temperature changes, including when these changes lead to convection).	1 – 3
MC **FR**	**A** **B** **C**	**6.II.A.3** The student will know that the mass of a substance remains constant whether it is together, in parts or in a different state. *Content Limit:* Items will require a conceptual understanding of physical changes in terms of mass. Items will NOT use the term “conservation of mass”. Examples where mass remains constant include: • A ball of clay has the same mass if you change its shape. • The mass of an ice cube is the same as the mass of the liquid formed by melting the ice cube. • The mass of an object is the same as the mass of sum of the pieces of that object.	0 – 2

MC FR SCR	**B C**	**6.II.A.4** The student will describe the states of matter in terms of the space between particles. *Content Limit:* Examples include particle models of solids, liquids and gasses. Items may relate to density.	0 – 2
MC FR	**A B C**	**6.II.A.5** The student will distinguish between volume, mass and density. *Content Limit:* Items should address the conceptual understanding of volume, mass and density.	0 – 2
MC FR	**A B C**	**6.II.A.6** The student will use the characteristic properties of density, melting point, boiling point and solubility to identify and distinguish mixtures and pure substances. *Content Limit:* Properties are limited to density, melting point, boiling point and solubility. Items will NOT address the difference between compounds and elements. Items will NOT include quantitative data on solubility. Items that address this benchmark may also address 6.II.B.3	0 – 2

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals By Strand
			10 – 12
		Sub-strand B. Chemical Reactions Standard: The student will differentiate between chemical and physical changes.	**By Sub-strand** 0 – 2
		Benchmarks	**By Benchmark**
MC **FR** **SCR**	**A** **B** **C**	**6.II.B.1** and **6.II.B.2** The student will define chemical and physical changes. The student will observe that substances react chemically with other substances to form new substances with different characteristic properties. *Content Limit:* A chemical change produces a new substance with different characteristic properties; a physical change does not produce a new substance. Evidence for chemical changes is limited to: a gas produced, heat released, light or sound produced, a color change and formation of a solid. No single piece of evidence should be considered sufficient to identify a chemical change because many physical changes can also produce the above results. Examples of physical changes include changes in state (phase), size, and dissolving (e.g., salt and water) Items will require students to apply or demonstrate their understanding of these definitions. Items will NOT include chemical formulas or equations.	0 – 2
MC **FR**	**A** **B**	**6.II.B.3** The student will give examples and classify substances as mixtures or pure substances. *Content Limit:* Classification is limited to mixtures and pure substances, NOT distinguishing between elements and compounds, and NOT distinguishing between heterogeneous and homogeneous mixtures. Limit the definition of pure substance to materials with a single set of properties. Limit the definition of mixture to materials with more than one set of properties that can be separated by physical means. Examples should include common materials but exclude water because it is by definition a pure substance, although it is almost always impure. Items that address this benchmark may also address benchmarks 6.II.A.6, 6.II.B.1 or 6.II.B.2.	0 – 2

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals By Strand: 10 – 12
		Sub-strand C. Energy Transformations Standard: The student will understand that energy exists in many forms and can be transferred in many ways.	**By Sub-strand**: 3 – 5
		Benchmarks	**By Benchmark**
MC FR SCR	**B C**	**6.II.C.1** The student will compare and contrast heat, chemical, mechanical and electrical energy and identify transformations of energy from one form to another in everyday situations. *Content Limit:* Items may require students to supply energy transformations as steps in a larger process. Items will NOT require a distinction between potential and kinetic energy. Items will NOT require understanding that the kinetic energy of particles may be described as heat or mechanical energy, and will NOT include stems that are ambiguous regarding heat and mechanical energy. Examples of transformations include combustion, friction, electrical systems (such as DC circuits, motors and generators), chemical interactions and moving objects.	1 – 3
MC FR SCR	**A B C**	**6.II.C.2** The student will recognize that heat is transferred by convection, conduction and radiation from warmer objects to cooler ones until both reach the same temperature. *Content Limit:* Items may include common interactions in the home such as cooking, cooling or heating of beverages, home heating systems, and windows. Items may address convection in the context of earth science topics (weather, crustal plate movement, oceans currents, and lake turnover). Items may address radiation in an earth science context (Sun and solar system, weather). Items that address this benchmark may also address benchmark 8.III.B.1.	1 – 3

MC **FR**	**B** **C**	**6.II.C.3** The student will demonstrate that visible light from the sun or reflected by objects may be made up of a mixture of many different colors of light. *Content Limit:* Items may require students to apply knowledge of what happens when light is shined through a prism. Items will NOT include pigment mixing.	0 – 2
MC **FR**	**A** **B**	**6.II.C.4** The student will recognize the relationship between light and heat. *Content Limit:* Examples include observing that dark colored things absorb heat better than light colored things, and observing that temperatures differ in full sunlight and shade.	0 – 2
MC **FR**	**A** **B** **C**	**6.II.C.5** The student will describe waves in terms of speed, frequency and wavelength. *Content Limit:* Items should focus on conceptual understandings. Items may include measurements but should exclude algebraic manipulations. Items will require students to use the terms to compare and contrast wave movement.	0 – 2
MC **FR**	**A** **B**	**6.II.C.6** The student will recognize that vibrations such as sound and earthquakes move in waves and that waves move at different speeds in different materials. *Content Limit:* "Vibrations such as … earthquakes," refers to seismic waves. Items may relate the motion of sound and seismic waves to density and the particle nature of matter. Items that address this benchmark may also address benchmark 6.II.A.2. Items will NOT require calculations.	0 – 2

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals
			By Strand
			10 – 12
		Sub-strand D. Motion Standard: The student will describe the motion of objects.	**By Sub-strand**
			0 – 3
		Benchmarks	**By Benchmark**
MC **FR**	**B** **C**	**6.II.D.1** The student will use a frame of reference to describe the position, speed, and acceleration of an object. *Content Limit:* Items are limited to one frame of reference (e.g., the ground, a post, or a person). Acceleration is limited to changes in speed. Items will NOT include velocity or vectors.	0 – 2
MC **FR** **SCR**	**B** **C**	**6.II.D.2** The student will measure and graph the positions and speed of an object. *Content Limit:* Items will provide formulas for speed in words and variables, where needed. Items will only require calculating speed from distance and time, NOT distance and time from speed. Items that require calculations will provide an on-screen calculator. Items that require constructing a graph will provide labels on the x-axis (time) and y-axis (distance). Items that address this benchmark may also address benchmark 6.I.B.4.	0 – 2
MC **FR**	**A** **B**	**6.II.D.3** The student will recognize that unbalanced forces acting on an object change the object's speed and/or direction. *Content Limit:* Items will describe forces as pushes or pulls Item will NOT require the identification of a specific law of motion (i.e., Newton's Laws).	0 – 2

Item Types	Cognitive Levels	Strand II – Physical Science	Item Totals By Strand
			10 – 12
		Sub-strand E. Forces of Nature Standard: The student will understand that a variety of forces govern the structure and motion of objects in the universe.	**By Sub-strand** 0 – 2
		Benchmarks	**By Benchmark**
MC **FR** **SCR**	**A** **B**	**6.II.E.1** The student will know that electric currents and magnets can exert a force on certain objects and each other. *Content Limit:* Items will NOT include the cause of electric currents, in terms of electrons.	0 – 2
MC **FR** **SCR**	**A** **B** **C**	**6.II.E.2** The student will know that there are positive and negative charges and that like charges repel one another and opposite charges attract. *Content Limit:* Descriptions of positive and negative charges are limited to those in static electricity examples. Items will NOT address the transfer of electrons as the cause of static electricity.	0 – 2

Item Types	Cognitive Levels	Strand III – Earth and Space Science	Item Totals
			By Strand
			10 – 12
		Sub-strand A. Earth Structure and Processes Standards: The student will identify Earth's composition, structure and processes (8.III.A); the student will investigate the impact humans have on the environment (8.III.A).	By Sub-strand
			4 – 6
		Benchmarks	**By Benchmark**
MC FR SCR	**B C**	**8.III.A.1** The student will explain how earthquakes, volcanoes, sea-floor spreading and mountain building are evidence of the movement of crustal plates. *Content Limit:* Items may require students to use earthquakes, volcanoes, sea-floor spreading and mountain building to support the theory of plate tectonics.	0 – 3
MC FR SCR	**B C**	**8.III.A.2** The student will describe how features on the Earth's surface are created and constantly changing through a combination of slow and rapid processes of weathering, erosion, sediment deposition, landslides, volcanic eruptions and earthquakes. *Content Limit:* Items will not require knowledge of specific geographic locations. For example, riverbank erosion as a process is assessable, but specific knowledge of the Mississippi River is not to be assessed. Items may address chemical and physical weathering. Items will NOT address the formation of different types of soil.	1 – 3
MC FR	**A B C**	**8.III.A.3** The student will describe the various processes and interactions of the rock cycle. *Content Limit:* Examples include major processes that produce each major classification of rock, including crystallization, metamorphism, deposition and cementation. Major classifications of rock are defined as igneous, metamorphic, and sedimentary. Items may require students to interpret or construct portions of the rock cycle.	0 – 2

MC **FR**	**B** **C**	**8.III.A.4** The student will interpret successive layers of sedimentary rocks and their fossils to document the age and history of the Earth. *Content Limit:* Items may include interpretation of a rock cross-section. Items may include comparisons of relative age within a rock cross-section. Rock cross-sections may include rock types other than sedimentary. Items may include the terms superposition, index fossils, horizontality, relative dating, and cross cutting.	1 – 3
MC **FR**	**A** **B** **C**	**8.III.A.5** The student will recognize that constructive and destructive Earth processes can affect the evidence of Earth's history. *Content Limit:* Examples of evidence of the Earth's history include changes to rock layers, landmasses, and shape/structure of the land. Examples of Earth processes include the movement of tectonic plates, weathering, continental glaciation, and volcanic activity.	0 – 2
MC **FR**	**A** **B** **C**	**8.III.A.6** The student will classify and identify rocks and minerals using characteristics including but not limited to density, hardness and streak. *Content Limit:* Items will NOT require students to recall the names of specific minerals. Characteristics are limited to color, hardness, cleavage, streak, and luster. Items may include using mineral properties to identify a mineral from a key.	0 – 2
MC **FR** **SCR**	**B** **C**	**8.III.A.7** The student will identify and research an environmental issue and evaluate its impact. *Content Limit:* Items may require students to predict possible outcomes of a specific environmental accident or event, including the impact humans have on the environment. Examples of positive and negative environmental issues and human impacts include global climate change, water quality, energy use, acid precipitation, ozone, establishment of parks, agricultural practices, and forestry. Items that address this benchmark may also address 7.IV.C.1.	0 – 2

Item Types	Cognitive Levels	Strand III – Earth and Space Science	Item Totals
			By Strand
			10 – 12
		Sub-strand B. The Water Cycle, Weather and Climate Standard: The student will investigate how the atmosphere interacts with the Earth system.	By Sub-strand
			2 – 4
		Benchmarks	By Benchmark
MC **FR** **SCR**	**A** **B** **C**	**8.III.B.1** The student will define radiation, conduction and convection and explain their effects on weather and climate. *Content Limit:* Items may require students to explain how these three processes work together to heat the atmosphere. Conduction is the transfer of heat between objects in direct contact with each other. Convection is the transfer of heat by movement of fluid, including air and water. Radiation is the transfer of energy via electromagnetic waves such as light waves, radio waves, microwaves, etc.	0 – 3
MC **FR**	**A** **B**	**8.III.B.2** The student will identify the forces that create currents and layers in the Earth's atmosphere and water systems. *Content Limit:* Examples of forces that create currents in the ocean include wind and salinity/temperature differences. Examples of forces that create currents and layers in the atmosphere include unequal heating of surface air, which creates density differences that cause convection currents in the troposphere.	0 – 2
MC **FR**	**B** **C**	**8.III.B.3** The student will describe the effect of Earth's rotation on the winds and ocean currents. *Content Limit:* Items will NOT require explanations of the physics of the Coriolis effect, but may use the term. A description of the Coriolis Effect created by the Earth's rotation includes the deflection of wind and water in both hemispheres but in opposite directions.	0 – 2

MC **FR** **SCR**	**B** **C**	**8.III.B.4** The student will collect and use data to predict the weather. *Content Limit:* Examples of the use of data include understanding how trends in variables can be used to predict the immediate (12–24 hour) weather. Variables are limited to barometric pressure, dewpoint, wind direction, temperature, precipitation, and cloud type. Items will require students to interpret data but will NOT require students to memorize weather symbols.	0 – 3
MC **FR**	**A** **B**	**8.III.B.5** The student will identify the composition and structures of the atmosphere. *Content Limit:* Items will NOT require students to recall the name of layers. Items may require students to recognize the presence of variations in temperature, pressure and compositions among the layers of the atmosphere. Examples of composition and structures in the atmosphere may include identification of regions for the ozone layer, most weather phenomena, and the jet stream.	0 – 2
MC **FR** **SCR**	**B** **C**	**8.III.B.6** The student will describe climate changes that have occurred over time. *Content Limit:* Examples of evidence of the existence of different climates in Minnesota include the current topographies, landforms, and rock layers found throughout the state. Items may require students to use evidence of continental glaciation in Minnesota to describe climate changes that have occurred.	0 – 2

Item Types	Cognitive Levels	Strand III – Earth and Space Science	Item Totals
			By Strand
			10 – 12
		Sub-strand C. The Universe Standards: The student will compare objects in the solar system and explain their interactions with the Earth (8.III.C); the student will describe the composition and structure of the universe (8.III.C).	**By Sub-strand** 2 – 4
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**8.III.C.1** The student will recognize that the sun is the principal energy source for the solar system and that this energy is transferred in the form of radiation. *Content Limit:* Items may include the terms electromagnetic spectrum and visible light. Interactions of solar energy include those described in physical, earth or life science.	0 – 2
MC **FR** **SCR**	**B** **C**	**8.III.C.2** and **8.III.C.4** The student will explain how the combination of the Earth's tilted axis and revolution around the sun causes the progression of seasons and weather patterns. The student will use the predictability of the motions of the Earth and Sun to explain the length of day, length of year, phases of the moon, eclipses, tides and shadows. *Content Limit:* Items may require students to interpret a polar orbit animation or other diagram that illustrates the combination of Earth's tilted axis and revolution around the Sun. Explanations of the seasons emphasize that they are not caused by differences in distance from the Sun, and that the tilt of the Earth does not change as the Earth revolves around the Sun. Examples of phenomena will be described or illustrated, as they would be observed in the Northern Hemisphere.	0 – 3
MC **FR** **SCR**	**B** **C**	**8.III.C.3** The student will compare and contrast the planets, taking into account their composition, mass and distance from the sun and recognize the conditions that have allowed life to flourish on Earth. *Content Limit:* Items may require students to recognize those conditions that limit the development of life as known on Earth when given certain characteristics of a planet. Conditions that have allowed life to flourish on Earth include Earth's distance from the Sun, composition of the atmosphere, and the presence of liquid water.	0 – 3

MC **FR**	**A** **B**	**8.III.C.5** The student will recognize that the universe consists of many billions of galaxies, each containing many billions of stars and that there are vast distances that separate these galaxies and stars from one another. *Content Limit:* Items may refer to distances in light years. Items will NOT use scientific notation. Items may require students to understand the relationship between distance and time, evidence for an expanding universe, and Big Bang Theory. Item may require students to understand that the large distances in space currently limit space travel.	0 – 2
MC **FR**	**A** **B**	**8.III.C.6** The student will recognize that the sun is a medium-sized star and is the closest star to Earth. It is the central and largest body in the solar system and is one of billions of stars in the Milky Way Galaxy. *Content Limit:* Items may require students to recognize the Sun's relationship to the solar system and Milky Way Galaxy. Items will NOT include H-R diagrams.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			10 – 12
		Sub-strand A. Cells Standard: The student will understand that all organisms are composed of cells that carry on the many functions needed to sustain life.	**By Sub-strand** 2 – 4
		Benchmarks	**By Benchmark**
		7.IV.A.1 The student will know that cells are the fundamental units of life. *Content Limit:* Assessed by 7.IV.A.2-6.	N/A
MC **FR**	**A** **B**	**7.IV.A.2 and 7.IV.A.3** The student will distinguish between single-cellular and multi-cellular organisms. The student will distinguish between plant and animal cells. *Content Limit:* Examples of single-cellular organisms are limited to Protists, such as amoeba and paramecia. Examples of multi-cellular organisms are limited to plants and animals. Differences are limited to the presence and functions of the cell wall, chloroplasts, and central vacuole in plant cells and the absence of these structures and functions in animal cells.	0 – 2

MC **FR**	**A** **B**	**7.IV.A.4** The student will recognize that cells repeatedly divide for growth and repair. *Content Limit:* Items may require students to understand how cells are replaced in the body and how an organism gets larger. Items will NOT require understanding the specific processes of mitosis and meiosis, although the term mitosis may be used.	0 – 2
MC **FR**	**B**	**7.IV.A.5** The student will recognize that cells convert energy from food for the production of molecules necessary for life, and for life processes including cell growth and cell division. *Content Limit:* Items will require students to understand that cells take in food to provide energy for work and other products need by the cell. Items may require students to understand the difference between food and its converted form when it enters the cell. Items will NOT require specific knowledge about respiration, such as the Krebs cycle, or equations that describe respiration or photosynthesis. Items that address this benchmark may also address 7.IV.F.1.	0 – 2
MC **FR**	**A** **B**	**7.IV.A.6** The student will recognize that specialized cells in multi-cellular organisms perform specialized functions. *Content Limit:* Examples of the functions of specialized cells are limited to recognition that nerve cells receive and transmit signals, muscle cells contract and relax, skin cells provide protection, bone cells provide support, and blood cells carry gases. Items that address this benchmark may also address 7.IV.B.1.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			10 – 12
		Sub-strand B. Diversity of Organisms Standard: The student will understand that living systems, at every level of organization, demonstrate the complementary nature of structure and function.	By Sub-strand 0 – 3
		Benchmarks	By Benchmark
FR **SCR**	**B** **C**	**7.IV.B.1** The student will explain that individuals are composed of specialized cells, tissues, organs and organ systems that perform specialized functions. *Content Limit:* Items are limited to examples in humans. Items may allow students to describe their own example. Items may include the differences and relationships among cells, tissues, organs, and organ systems. Examples of the functions of specialized cells include nerve cells receive and transmit signals, muscle cells contract and change shape, skin cells provide protection, bone cells provide support, and blood cells carry gases. Examples of tissues are limited to muscle, nerve, skin, bone tissues. Examples of organs and organ systems are limited to muscular system, nervous system, skeletal system, circulatory system and excretory system. Items that address this benchmark may also address 7.IV.A.6 or 7.IV.G.3.	0 – 2
MC **FR** **SCR**	**A** **B**	**7.IV.B.2** The student will recognize that an organism's body plan and its ability to regulate its internal environment enable it to make or find food, grow and reproduce in a constantly changing environment. *Content Limit:* Items may address how an organism is adapted to the environment. Items will include familiar organisms, or allow students to describe their own example. Items may include the terms endothermic and ectothermic. Items will NOT include single-cell organisms.	0 – 2

MC FR	**A B**	**7.IV.B.3** The student will recognize that behavioral responses of organisms may be determined by heredity and past experience. *Content Limit:* Examples are limited to stimulus and response, innate and learned responses, and imprinting.	0 – 2
MC FR SCR	**B C**	**7.IV.B.4** The student will use and create dichotomous keys. *Content Limit:* Dichotomous keys used in items will be limited to no more than four steps and enable students to identify organisms using easily observed physical traits. Items will include pictures of the organisms.	0 – 2
MC FR	**B**	**7.IV.B.5** The student will use the characteristics of an organism to identify the kingdom to which it belongs. *Content Limit:* Examples of kingdoms are limited to the animal, plant, and Protist kingdoms.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			10 – 12
		Sub-strand C. Interdependence of Life Standard: The student will understand that within ecosystems, complex interactions exist between organisms and the physical environment.	**By Sub-strand** 0 – 4
		Benchmarks	**By Benchmark**
MC **FR** **SCR**	**B** **C**	**7.IV.C.1** The student will provide examples of the potentially irreversible effects of human activity on ecosystems. *Content Limit:* Examples of human activity include chemicals in the environment, bacterial resistance, pollution, deforestation, over-hunting, and urban sprawl. Items may require students to describe the effects of human activity given an example of human activity in the context of a scenario.	0 – 3
MC **FR**	**A**	**7.IV.C.2** The student will define a population as all individuals of a species that exist together at a given place and time. *Content Limit:* Examples of species are limited to commonly recognizable species in Minnesota.	0 – 2
MC **FR**	**A** **B**	**7.IV.C.3** The student will define an ecosystem as all populations living together and the physical factors with which they interact. *Content Limit:* Physical factors are limited to soil, water, temperature, and light.	0 – 2
MC **FR**	**A** **B** **C**	**7.IV.C.4** The student will explain the factors that affect the number and types of organisms an ecosystem can support, including available resources, abiotic and biotic factors and disease. *Content Limit:* Items may require students to define factors within a sample ecosystem using vocabulary. Items may use the terms living and non-living, or descriptions of these terms, but NOT the terms biotic and abiotic. Examples of ecosystems are limited to Minnesota ecosystems such as temperate forest, prairie, stream, or lake. Items may require that students know how a change in a factor, such as rainfall, would affect the number and types of organisms that can be supported by an ecosystem.	0 – 3

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals By Strand 10 – 12
		Sub-strand D. Heredity Standard: The student will understand that heredity information is contained in genes, which are inherited through both sexual and asexual reproduction.	**By Sub-strand** 0 – 3
		Benchmarks	**By Benchmark**
MC **FR** **SCR**	**A** **B**	**7.IV.D.1, 7.IV.D.2,** and **7.IV.D.3** The student will recognize that inherited traits result from information contained in genes, which are located on chromosomes of each cell. The student will recognize that each gene carries a single unit of information and can influence more than one trait. The student will explain how inherited traits can be determined by one or many genes. *Content Limit:* Examples of organisms include humans and angiosperms. Inheritance is limited to basic Mendelian inheritance. Inheritance will be limited to dominant and recessive genes only. Examples of inherited traits include flower color, seed texture, and plant height. Items will NOT require students to understand the process of meiosis. Items may require students to know that the sex cells contain half the total genetic information. Items may include the use of monohybrid crosses and Punnett squares. Items will NOT require students to construct or complete a Punnett square.	0 – 2
MC **FR**	**B**	**7.IV.D.4** The student will comprehend that interactions with the environment affect some inherited traits. *Content Limit:* Examples include the effect of malnutrition, the effects of diet and nutrition on wellness and disease, and the effect of the amount of light and water on plants.	0 – 2

MC FR	**B**	**7.IV.D.5** The student will comprehend that reproduction is essential for the continuation of a species. *Content Limit:* Examples of requirements for the continuation of a species include sufficient genetic diversity and a sufficient number of organisms. Increased genetic diversity results in an increased chance that some individuals will have traits that will help them survive an environmental change. Items that address this benchmark may also address 7.IV.E.3 or 7.IV.D.6.	0 – 2
MC FR SCR	**C**	**7.IV.D.6** The student will compare and contrast the advantages and disadvantages of sexual and asexual reproduction. *Content Limit:* Examples of advantages to sexual reproduction include genetic diversity. Examples of disadvantages to sexual reproduction include expending increased energy and time. Examples of advantages to asexual reproduction include no requirement for a mate, and the organism may reproduce more rapidly. Examples of disadvantage to asexual reproduction include decreased genetic variation. Items that address this benchmark may also address benchmark 7.IV.D.5.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			10 – 12
		Sub-strand E. Biological Populations Change Over Time Standard: The student will understand how biological evolution provides a scientific explanation for the fossil record of ancient life forms, as well as for the striking similarities observed among the diverse species of living organisms.	**By Sub-strand** 0 – 4
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**7.IV.E.1** The student will recognize extinction is a common event. *Content Limit:* Items may require students to use evidence from the fossil record to show extinction as a common event.	0 – 2
MC **FR**	**B**	**7.IV.E.2** The student will describe how the fossil record documents the appearance and diversification of many life forms. *Content Limit:* Items will require students to describe only general concepts about the fossil record, including that it shows examples of organisms that lived during various times, allowing scientists to learn how organisms have changed over time.	0 – 2
MC **FR** **SCR**	**B** **C**	**7.IV.E.3** The student will explain how biological adaptations in structure, function and behavior enhance the reproductive success and survival of a species in a particular environment. *Content Limit:* Examples of biological adaptation include horses and Darwin's finches. The process of natural selection is defined as changes in characteristics within a population that lead to survival. Items may include the term natural selection and may use the term biological evolution to indicate change over time. Items that address this benchmark may also address 7.IV.D.5	0 – 3

MC **FR**	**A** **B**	**7.IV.E.4** The student will recognize that scientific evidence can be used to infer common ancestry among some organisms. *Content Limit:* Evidence is limited to fossil records and homologous structures. Items will not use the terms DNA or phylogeny.	0 – 2
MC **FR**	**B** **C**	**7.IV.E.5** The student will explain how diversity of species develops through gradual processes over generations. *Content Limit:* Examples include Darwin's finches, horses, and the Grand Canyon squirrel populations. Examples of gradual processes include differences in food sources, changes in climate, and isolation of populations through geographic separation. Items may use the term biological evolution to indicate change over time.	0 – 3

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			10 – 12
		Sub-strand F. Flow of Matter and Energy Standard: The student will understand how the flow of energy and the recycling of matter contribute to a stable ecosystem.	**By Sub-strand** 0 – 3
		Benchmarks	**By Benchmark**
MC **FR**	**A**	**7.IV.F.1** The student will know that plants use the energy in light to make sugars out of carbon dioxide and water. *Content Limit:* Descriptions of photosynthesis are limited to words and graphic representations NOT chemical reactions with formulas. Items may include the terms carbon dioxide and oxygen. Items will NOT use the terms chlorophyll or glucose. Items that address this benchmark may also address 7.IV.A.5.	0 – 2
MC **FR**	**B** **C**	**7.IV.F.2** and **7.IV.F.3** The student will explain how energy is transferred through food chains and food webs in an ecosystem. The student will explain how the amount of useable energy available to organisms decreases as it passes through a food chain and/or food web. *Content Limit:* Examples of organisms in food chains or webs are limited to commonly recognizable organisms in Minnesota. Items will list or label organisms with broad terms such as owl, eagle, fish, snake, mouse, fox, plants, worms, frog, or insects. Items may require students to interpret a food chain or web with organisms. Items will NOT assess specific percentages of energy transferred between trophic levels. Items may require students to understand energy pyramids and that only a very small fraction of the available energy is transferred. Items may include the following vocabulary: producer, primary consumer, secondary consumer, tertiary consumer, and decomposer. Items may only require students to build a food chain or web using the terms producer, primary consumer, secondary consumer, tertiary consumer and decomposer. Items that address this benchmark may also address 7.IV.F.5.	0 – 2

MC **FR**	**A** **B**	**7.IV.F.4** The student will know that the total amount of matter in a closed system remains the same as it is transferred between organisms and the physical environment even though its location or form changes. *Content Limit:* Examples of organisms are limited to commonly recognizable organisms in Minnesota. Examples of ecosystems are limited to Minnesota ecosystems such as temperate forest, prairie, stream, or lake. Organisms include producers, consumers, and decomposers.	0 – 2
MC **FR**	**B**	**7.IV.F.5** The student will compare and contrast predator/prey, parasite/host and producer/consumer/decomposer relationships. *Content Limit:* Examples of organisms are limited to commonly recognizable organisms in Minnesota. Examples of predator-prey relationships include owls and mice, and wolves and deer. Examples of parasite-host relationships include wood ticks and humans, deer ticks and humans, deer ticks and dogs, and tapeworms and dogs. Examples of producer-consumer-decomposer relationships include grass—rabbits and deer—fungi. Items that address this benchmark may also address 7.IV.F.2.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			10 – 12
		Sub-strand G. Human Organism Standard: The student will understand human body systems and their relationship to disease.	**By Sub-strand**
			0 – 3
		Benchmarks	**By Benchmark**
MC **FR**	**A** **B**	**7.IV.G.1** and **7.IV.G.2** The student will recognize that disease can be caused by genetics, infection by other organisms, exposure to environmental factors or a combination of these. The student will identify risks associated with natural, chemical and biological hazards. *Content Limit:* Diseases caused by biological agents are limited to those caused by viruses and bacteria.	0 – 3
MC **FR** **SCR**	**A** **B** **C**	**7.IV.G.3** The student will describe the structure and function of systems for digestion, respiration, reproduction, circulation, excretion, movement, control and coordination and for protection from disease, in the human organism. *Content Limit:* Items will be limited to how the structure and function of the above systems maintain a healthy body. Items may require students to recognize or describe the reasons that a system is important to maintaining a healthy body and will NOT simply require students to identify the structure and function of systems. Items may address personal decision-making related to maintaining a healthy body. Items that address this benchmark may also address 7.IV.B.1.	0 – 3

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals
			By Strand
			15 – 17
		Sub-strand A. Scientific World View Standard: The student will understand the nature of scientific ways of thinking and that scientific knowledge changes and accumulates over time.	**By Sub-strand** 4 – 5
		Benchmarks	**By Benchmark**
MC **FR** **SCR** **ECR**	**B** **C**	**9-12.I.A.1** The student will be able to distinguish among hypothesis, theory and law as scientific terms and how they are used to answer a specific question. *Content Limit:* Items will address understanding of the scientific terms in reference to a specific investigation of a common scientific concept including Mendel's Laws of Genetics, Cell Theory, Theory of Evolution, or the Germ Theory of Disease. A fact is defined as an observation that has been repeatedly confirmed. (National Academy of Sciences, *Teaching About Evolution and the Nature of Science*, [National Academy Press, 1998], 5) A law is defined as a descriptive generalization about how some aspect of the natural world behaves under stated circumstances and that carries the weight of scientific evidence. (*Ibid.*) A hypothesis is defined as a testable statement about the natural world. (*Ibid.*) A theory is defined as a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses. (*Ibid.*)	1 – 3

MC **FR** **SCR** **ECR**	**B** **C**	**9-12.I.A.2** and **9-12.I.A.3** The student will be able to explain how scientific and technological innovations as well as new evidence can challenge portions of or entire accepted theories and models including but not limited to cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease and big bang theory. The student will recognize that in order to be valid, scientific knowledge must meet certain criteria including that it: be consistent with experimental, observational and inferential evidence about nature; follow rules of logic and reporting both methods and procedures; and, be falsifiable and open to criticism. *Content Limit:* Items will address theories, models and the validity of scientific knowledge in the context of life science content including cell theory, theory of evolution, and germ theory. Criticism is defined as peer review. Falsifiable is defined as the ability to determine the relevant null hypothesis for a given hypothesis, with the goal of determining whether to reject the null hypothesis; items may address this concept or provide examples, but will NOT require students to determine the null hypothesis and will NOT use these terms.	2 – 4
		9-12.I.A.4 The student will explain how traditions of ethics, peer review, conflict and general consensus influences the conduct of science. *Content Limit:* Assessed only at the classroom level.	N/A
MC **FR** **SCR** **ECR**	**B** **C**	**9-12.I.A.5** The student will recognize that some scientific ideas are incomplete, and opportunity exists in these areas for new advances. *Content Limit:* Examples include historical examples of incomplete scientific ideas that have advances associated with them, including the role of DNA in the genetic transfer of information, germ theory, and spontaneous generation and contemporary examples that are set in the context of the scenario Items will address ideas and opportunities in the context of life science content. Items may require students to comment on a specific viewpoint and how it has affected the direction of the research.	0 – 1

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals By Strand 15 – 17
		Sub-strand B. Scientific Inquiry Standard: The student will design and conduct a scientific investigation.	By Sub-strand 7 – 8
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**B C**	**9-12.I.B.1** The student will design and complete a scientific experiment using scientific methods by determining a testable question, making a hypothesis, designing a scientific investigation with appropriate controls, analyzing data, making conclusions based on evidence and comparing conclusions to the original hypothesis and prior knowledge. *Content Limit:* Context should demonstrate all appropriate safety considerations. Items may address part or all of the benchmark. Items will be placed in an investigation scenario. When addressing types of variables, items will use the following language: • variable that is changed by scientist or student • variable that is kept the same • variable that changes as a result of the investigation	0 – 2
MC FR SCR ECR	**A B C**	**9-12.I.B.2** The student will distinguish between qualitative and quantitative data. *Content Limit:* Items will address the use of qualitative and quantitative data, or fit examples of data to these terms. Items may expect students to understand the differences between qualitative and quantitative data, including differences in the purposes of using each type of data and extent of inferences that can be made in a particular setting with each type. Items will be placed in an investigation or data analysis scenario.	0 – 2

MC FR SCR ECR	**B C**	**9-12.I.B.3** The student will apply mathematics and models to analyze data and support conclusions. *Content Limit:* Mathematics will be limited to 8th grade math or below, per Minnesota Academic Standards in Mathematics, and includes the concepts of percent, mean, median, mode and line of best fit. Examples of models include physical models, conceptual models, and mathematical models such as population growth, bacterial growth, and probability in genetics. Items will address scientific applications of mathematics, NOT pure math.	1 – 3
MC FR SCR ECR	**B C**	**9-12.I.B.4** The student will identify possible sources of error and their effects on results. *Content Limit:* Examples of error include uncontrolled variables, operator error, and measurement error. Items will be placed in an investigation scenario. Items may make limited use of negative stems.	1 – 3
		9-12.I.B.5 The student will know that professional scientists and engineers have ethical codes. *Content Limit:* Assessed only at the classroom level.	N/A
MC FR SCR ECR	**B C**	**9-12.I.B.6** The student will give examples of how different domains of science use different bodies of scientific knowledge and employ different methods to investigate questions. *Content Limit:* Examples of domains are limited to fields within the life sciences, e.g., cell biology, botany, and medicine. Items will NOT assess how different domains of science use different bodies of knowledge. Bodies of knowledge are defined as the major fields of science: life, physical and earth. Comparisons include: observational vs. controlled experiments and animal behavior vs. field studies.	0 – 1

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals By Strand 15 – 17
		Sub-strand C. Scientific Enterprise Standard: The student will understand the relationship between science and technology and how both are used.	**By Sub-strand** 1 – 2
		Benchmarks	**By Benchmark**
		9-12.I.C.1 The student will compare and contrast the purposes and career opportunities of engineering, technology and science. *Content Limit:* Assessed only at the classroom level.	N/A
FR **SCR** **ECR**	**B** **C**	**9-12.I.C.2** The student will provide an example of a need or problem identified by science and solved by engineering or technology. *Content Limit:* Examples include curing or identifying diseases through medical technology, preventing disease through food safety or pasteurization, germ theory discoveries and non-medical examples such as energy needs and resources, environmental remediation.	0 – 2
FR **SCR** **ECR**	**B** **C**	**9-12.I.C.3** The student will provide an example of how technology facilitates new discoveries and the development of scientific knowledge. *Content Limit:* Examples include microscopy (electron and light microscopes), organism culturing techniques, use of Global Positioning System (GPS) technology.	0 – 2
		9-12.I.C.4 The student will know that technological changes and scientific advances are often accompanied by social, political, environmental and economic changes. *Content Limit:* Assessed only at the classroom level.	N/A

		9-12.I.C.5 The student will recognize that science and technology are influenced by cultural backgrounds and beliefs and by social needs, attitudes, values and limitations. *Content Limit:* Assessed only at the classroom level.	N/A

Item Types	Cognitive Levels	Strand I – History and Nature of Science	Item Totals By Strand 15 – 17
		Sub-strand D. Historic Perspectives [4] Standard: The student will recognize the historical and cultural context of scientific endeavors and how they influence each other.	**By Sub-strand** 1 – 2
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**A B C**	**9-12.I.D.1** The student will be able to trace the development of a scientific advancement, invention or theory and its impact on society. *Content Limit:* Examples include cell theory, microscopes, DNA structure, Mendel's laws of genetics, theory of evolution, and germ theory. Development of a scientific advancement includes understanding that several areas of research come together to make it possible to discover a new idea.	1 – 2
MC FR SCR ECR	**A B C**	**9-12.I.D.2** The student will provide examples of scientific advancements contributed by other civilizations and cultures. *Content Limit:* Scientific advances are defined as facts, laws, and theories that have become incorporated into the contemporary scientific knowledge base. Items will address ideas discovered by other cultures and civilizations that have become a part of the contemporary scientific knowledge base in areas such as genetics, agriculture, and medicine.	N/A
		9-12.I.D.3 The student will compare and contrast the differences between scientific theories and theories from other bodies of knowledge, and the importance of each in a science discussion. *Content Limit:* Assessed only at the classroom level.	N/A

[4] See page 3 for additional notes.

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			35 – 37
		Sub-strand A. Cells Standard: The student will comprehend that all living things are composed of cells, and that the life processes in a cell are based on molecular interactions.	By Sub-strand 5 – 7
		Benchmarks	By Benchmark
MC FR SCR ECR	**A B C**	**9-12.IV.A.1** The student will relate cellular structures to their functions. *Content Limit:* Structures (and functions) are limited to the nucleus (holds genetic material), nuclear membrane (selective barrier), cell wall (support and protect the cell), cell membrane (selective barrier), cytoplasm (internal environment of cell), vacuoles (storage), lysosomes (decomposition), ribosomes (protein synthesis), endoplasmic reticulum (transport), Golgi apparatus (package materials), mitochondria (transforms energy to a usable form for the cell), cytoskeleton (support), centrioles (cell division) and chloroplasts (convert light energy). Items may address prokaryotic and eukaryotic cells, but will not address viruses.	0 – 2
MC FR SCR ECR	**A B**	**9-12.IV.A.2** The student will compare and contrast the structures found in typical plant, animal and bacterial cells. *Content Limit:* Examples of structures found in most cells are limited to cell membranes, cytoplasm, DNA and ribosomes. Examples of structures found in plant cells are limited to central vacuoles, chloroplasts, and cell walls. Examples of structures found in animal cells are limited to cytoskeleton and centrioles. Examples of differences between eukaryotic and prokaryotic cells are limited to typical sizes, nuclei, the presence of other organelles, and that multi-cellular organisms are composed of eukaryotic cells.	0 – 1
MC FR SCR ECR	**A B C**	**9-12.IV.A.3** The student will explain the role of the cell membrane as a highly selective barrier in diffusion, osmosis and active transport. *Content Limit:* Items may require students to understand the similarities and differences between passive and active transport processes. Active transport is limited to pumps (e.g. sodium/potassium, proton, etc), endocytosis, and exocytosis. Passive transport is limited to diffusion, osmosis, and facilitated transport.	0 – 2

MC FR SCR ECR	**B C**	**9-12.IV.A.4** The student will describe the role of enzymes as catalysts in metabolism and cellular synthesis of new molecules. *Content Limit:* Items may be placed in scenarios with a laboratory context. Characteristics of enzymes that serve as catalysts include specificity to particular molecules and not being consumed in the reaction. Examples of enzymes that may be used to describe the role of enzymes as catalysts include amylase, catalase, lactase, pepsin, trypsin, and polymerase. Items will NOT address the role of environmental variables, such as pH and temperature, in enzyme function. Items will NOT assess the roles of specific enzymes.	0 – 2
MC FR SCR ECR	**A B C**	**9-12.IV.A.5** The student will differentiate between the processes of photosynthesis and respiration in terms of energy flow, reactants and products. *Content Limit:* Items describing reactants and products of processes will be limited to words and will NOT use formulas. E.g., carbon dioxide + water in the presence of light/chlorophyll produce glucose (sugar) + oxygen + ATP. Items will not require students to understand absorption spectra. Items that address this benchmark may also address benchmark 9-12.IV.F.1.	0 – 2
MC FR SCR ECR	**A B C**	**9-12.IV.A.6** The student will describe and compare the processes of mitosis and meiosis and their roles in the cell cycle. *Content Limit:* The products of mitosis are defined as identical cells with a full set of genetic information. The products of meiosis are defined as sex cells that are unique with a half set of genetic information. Items that address the processes of mitosis and meiosis are limited to knowing the sequence of events. Items will NOT assess the terms haploid, diploid, prophase, metaphase, anaphase and telophase. Items will NOT assess mitosis in the context of bacteria.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals By Strand 35 – 37
		Sub-strand B. Diversity of Organisms Standard: The student will classify, compare and contrast the diversity of organisms on Earth and their modes of accommodating the requirements for life.	**By Sub-strand** 4 – 6
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**A B C**	**9-12.IV.B.1** The student will relate the structure, complexity and organization of organ systems to the methods of obtaining, transforming, releasing and eliminating the matter and energy used to sustain the organism. *Content Limit:* Examples of organ systems are limited to digestive, respiratory and circulatory systems in animals and nutrient uptake, gas exchange, and material transport in plants.	2 – 4
MC FR	**A B**	**9-12.IV.B.2** The student will recognize that organisms have both innate and learned behavioral responses to internal and external stimuli, including the tropic responses in plants. *Content Limit:* Examples include geotropism, phototropism, geotaxis, or phototaxis.	0 – 1
MC FR SCR ECR	**B C**	**9-12.IV.B.3** The student will use scientific evidence, including the fossil record, homologous structures, embryological development or biochemical similarities, to classify organisms in order to show probable evolutionary relationships and common ancestry. *Content Limit:* Items will NOT use analogous structures. Items will NOT use specific terms associated with dendrograms, such as phylogenetic tree and cladogram, but may require understanding such a graphical illustration of the relationships between organisms.	2 – 4

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			35 – 37
		Sub-strand C. Interdependence of Life	By Sub-strand
		Standard: The student will describe how the environment and interactions between organisms can affect the number of species and the diversity of species in an ecosystem.	4 – 6
		Benchmarks	By Benchmark
MC FR SCR ECR	A B C	**9-12.IV.C.1** The student will describe the factors related to matter and energy in an ecosystem that both influence fluctuations in population size and determine the carrying capacity of a population. *Content Limit:* Examples of factors include food availability, predation, competition, population density, and waste removal.	1 – 3
MC FR SCR ECR	B C	**9-12.IV.C.2** The student will explain how adaptations of species and co-evolution with other species are related to success in an ecosystem. *Content Limit:* Examples of adaptations include behavioral, morphological, and physiological adaptations.	1 – 3
MC FR SCR ECR	A B	**9-12.IV.C.3** The student will identify examples of mutualism, commensalism, and parasitism in a stable ecosystem. *Content Limit:* Items will focus on the relationships between organisms.	0 – 1
MC FR SCR ECR	B C	**9-12.IV.C.4** The student will predict and analyze how a change in an ecosystem, resulting from natural causes, changes in climate, human activity or introduction of invasive species, can affect both the number of organisms in a population and the biodiversity of species in the ecosystem. *Content Limit:* Scenarios will use examples of Minnesota ecosystems when appropriate. Items may require students to predict, analyze and reflect on global issues.	1 – 3

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals By Strand 35 – 37
		Sub-strand D. Heredity Standard: The student will explain how inherited characteristics are encoded by genes.	**By Sub-strand** 4 – 6
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**A B**	**9-12.IV.D.1** The student will explain that the instructions for the characteristics of all organisms are carried in nucleic acids. *Content Limit:* Items will NOT make reference to specific human genetic disorders.	0 – 1
MC FR	**A**	**9-12.IV.D.2** The student will define the relationship between DNA, genes and chromosomes. *Content Limit:* Items will NOT make reference to specific human genetic disorders. Items will NOT include the term chromatin.	0 – 2
MC FR	**A B**	**9-12.IV.D.3** The student will describe the structure and function of DNA and distinguish between replication, transcription and translation. *Content Limit:* Structure of DNA is defined as complementary base pairs A=T and C=G. Items may include the following terms: mRNA, tRNA, amino acids, Uracil in RNA, and ribosomes. Items may include the location of replication, transcription, and translation in addition to the role of DNA, mRNA and proteins (amino acids) in these processes. Items will NOT make reference to specific human genetic disorders.	0 – 2
MC FR	**A B**	**9-12.IV.D.4** The student will know that different species of multicellular organisms have a characteristic number of chromosomes, and that in typical humans there are 22 autosomal pairs and 2 sex chromosomes. *Content Limit:* Items will NOT require recall of the number of chromosomes in cells other than human cells. Items may require students to understand that the number of chromosomes within a species is similar and between species is different. Examples will NOT include polyploid organisms and will be limited to animals.	0 – 1

MC **FR**	**A** **B**	**9-12.IV.D.5** The student will describe how genetic information is transmitted from parents to offspring through the processes of meiosis and fertilization as they relate to chromosome recombination and sexual reproduction. *Content Limit:* Items will NOT make reference to specific human genetic disorders. Items may use the terms egg and sperm. Items may require students to recognize crossing over during the processes of meiosis and fertilization.	0 – 2
MC **FR**	**B** **C**	**9-12.IV.D.6** The student will use Mendel's laws of segregation and independent assortment to determine the genotype and phenotype of a monohybrid cross. *Content Limit:* Items will NOT discuss linked genes or use the term allele. Items may include the understanding of a Punnett square. Items will NOT make reference to specific human genetic disorders. Items that address this benchmark may also address 9-12.IV.D.7. Items will NOT assess independent assortment in a dihybrid cross.	0 –2
MC **FR**	**A** **B** **C**	**9-12.IV.D.7** The student will differentiate between dominant, recessive, co- dominant, incompletely dominant, polygenic and sex-linked traits. *Content Limit:* Items may use the terms heterozygous and homozygous. Items may include pedigrees. Items that address this benchmark may also address benchmark 9-12.IV.D.6. Items will NOT make reference to specific human genetic disorders.	0 – 2

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals By Strand 35 – 37
		Sub-strand E. Biological Populations Change Over Time Standard: The student will understand how biological evolution provides a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.	**By Sub-strand** 4 – 6
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**A B C**	**9-12.IV.E.1 and 9-12.IV.E.4** The student will understand that species change over time and the term biological evolution is used to describe this process. The student will use biological evolution to explain the diversity of species. *Content Limit:* Items will NOT use specific terms involved in geological time scales. Diversity of species or speciation may address the following processes: divergence, convergence, adaptive radiation, and co-evolution. Items may require understanding a graphical illustration of the relationships between organisms.	1 – 3
MC FR SCR ECR	**B C**	**9-12.IV.E.2** The student will use the principles of natural selection to explain the differential survival of groups of organisms as a consequence of: • The potential for a species to increase its numbers; • The genetic variability of offspring due to mutation and recombination of genes; • A finite supply of the resources required for life; and, • The ensuing selection based on environmental factors of those offspring better able to survive and produce reproductively successful offspring. *Content Limit:* Items will NOT refer to the terms directional, disruptive, or stabilizing selection.	1 – 3

MC **FR** **SCR** **ECR**	**B** **C**	**9-12.IV.E.3** The student will describe how genetic variation between populations is due to different selective pressures acting on each population, which can lead to a new species. *Content Limit:* Items may include the process of selective breeding and artificial selection. Items will NOT address the concept of bottlenecks, founder effects, and genetic drift. Items may require understanding that selective pressures on a population can lead to speciation, but are NOT limited to examples where selective pressures result in speciation.	1 – 3

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals By Strand 35 – 37
		Sub-strand F. Flow of Matter and Energy Standard: The student will describe and explain the cycling of matter and flow of energy through an ecosystem's living and non-living components.	**By Sub-strand** 4 – 6
		Benchmarks	**By Benchmark**
MC FR SCR ECR	**A B**	**9-12.IV.F.1** The student will explain the relationship between abiotic and biotic components of an ecosystem in terms of the cycling of water, carbon, oxygen and nitrogen. *Content Limit:* Items that address this benchmark may also address benchmark 9-12.IV.A.5 Items that address this benchmark are limited to reactants and products in the cycling of matter.	1 – 3
MC FR SCR ECR	**A B C**	**9-12.IV.F.2 and 9-12.IV.F.5** The student will know that all matter tends to become more disorganized over time, and that living systems require a continuous input of energy in order to maintain their chemical and physical organizations and prevent death. The student will understand that matter and energy flow through different levels of organization of living systems, from cells to communities, as well as between living systems and the physical environment as chemical elements are recombined in different ways. Each recombination results in both storage and dissipation of energy. *Content Limit:* Items are limited to the flow of energy and the energy needs of a living system. Items will NOT focus on thermodynamics, entropy or Chaos theory. Items will address the flow of matter and energy between cells, organisms, or within a community. Items will address the processes of photosynthesis, respiration and decomposition in recycling matter. Items are limited to the following terms and concepts: trophic structure and associated terminology, and energy pyramids. Items may include the disruption of a food chain and food web.	2 – 4

MC **FR** **SCR** **ECR**	**A** **B** **C**	**9-12.IV.F.3** and **9-12.IV.F.4** The student will explain that sunlight is transformed into chemical energy by photosynthetic organisms. The student will explain that respiration releases chemical energy through the breakdown of molecules. *Content Limit:* Items will NOT require students to recognize the light reactions and the Calvin cycle. Items will NOT include glycolysis, Krebs cycle, electron transport system or fermentation. Items that address this benchmark may also address 9-12.IV.A.5 and 9-12.IV.F.2 and F.5.	0 – 1

Item Types	Cognitive Levels	Strand IV – Life Science	Item Totals
			By Strand
			35 – 37
		Sub-strand G. Human Organism Standard: The student will understand how all organ systems, including the nervous system, interact to maintain homeostasis.	By Sub-strand 2 – 5
		Benchmarks	By Benchmark
MC **FR** **SCR** **ECR**	**B** **C**	**9-12.IV.G.1** The student will understand and describe the basic anatomy and physiology of the nervous system and sense organs. *Content Limit:* Functions of sense organs are limited to how signals are received, transmitted, interpreted, and responded to. Parts of the central nervous system are limited to cerebrum, cerebellum, brain stem, and spinal cord. Parts of the peripheral nervous system are limited to sensory and motor neurons. Parts of a neuron are limited to cell body, dendrite, and axon. The physiology of the nervous system is limited to synapses and neurotransmitters.	1 – 3
MC **FR** **SCR** **ECR**	**B** **C**	**9-12.IV.G.2** The student will describe how the functions of individual organ systems are integrated to maintain a homeostatic balance in the body. *Content Limit:* Items are limited to those which require both hormonal and nervous regulation. Items will be placed in scenarios that refer to body temperature, breathing, and pulse rate as homeostatic disruptions of the human body, or any scenario that addresses symptoms or disruptions of homeostasis. Items will provide opportunities for students to describe examples they supply. Items will NOT address positive feedback.	1 – 3

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