Minnesota Comprehensive Assessments-Series III (MCA-III)

Test Specifications

for Science

Minnesota Department of Education

October 10, 2012

Based on the
K–12 Minnesota Academic Standards in Science, 2009 version effective May 24, 2010

MINNESOTA DEPARTMENT OF EDUCATION

MCA-III
Test Specifications
for Science

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The department thanks the Test Specifications Committee, as well as all of the panelists and teachers who reviewed this document in draft form, for their hard work and continued involvement.

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THE MINNESOTA COMPREHENSIVE ASSESSMENTS-SERIES III
Science Test Specifications

Introduction

The test specifications for each grade of the Science Minnesota Comprehensive Assessments-Series III (MCA-III) are presented in this document. The reader is encouraged to read the introductory information carefully because many important concepts are presented, including the purpose of the MCA, a description of the cognitive levels and other information about the format of the test specifications.

Purpose of the Minnesota Comprehensive Assessments

The *No Child Left Behind Act* (NCLB) requires that states implement "a set of high-quality, yearly student academic assessments that include, at a minimum, academic assessments in mathematics, reading or language arts, and science" (*No Child Left Behind Act of 2001*, Pub. L. No. 107-110, §1111, 115 Stat. 1449 [2002]). In science, students must be assessed once in grades 3–5, 6–9 and 10–12. The Minnesota Department of Education (MDE) has selected grades 5 and 8 for assessments in the first two grade bands. The grade 5 MCA assesses the grades 3–5 standards and the grade 8 MCA assesses the grades 6–8 standards. Students in grades 9–12 are expected to take the high school MCA if, in the current academic year, they are enrolled in a life science or biology course and/or have received instruction on all Strand 1 and Strand 4 standards that fulfill the life science credit for graduation.

The *K–12 Minnesota Academic Standards* were adopted in 2003; the Minnesota Comprehensive Assessments-Series II (MCA-II) assessed the 2003 standards. The 2008 Minnesota Legislature approved the 2008 Omnibus Education Policy Act (Minn. Stat. § 120B.023, subd. 2d). This legislation required the revision of the state's academic standards in science in the 2008–2009 school year. The legislation also required that beginning in the 2011–2012 school year, state science tests align with the revised 2009 academic standards in science. The revision to the standards was significant enough that a new series of the MCA assessments was necessary. Thus, the MCA-III are aligned with the 2009 *K–12 Minnesota Academic Standards in Science*.

The purpose of the MCA is to measure Minnesota students' achievement with regard to the Minnesota academic standards. The MCA results can be used to inform curriculum decisions at the district and school level, inform instruction at the classroom level and demonstrate student academic progress from year to year.

Purpose and Overview of the Test Specifications

The primary purpose of test specifications is to help test developers build a test that is consistent over time. The *MCA-III DRAFT Test Specifications for Science* are also meant to serve as a source of information about the test design for teachers and the general public. Test specifications do not indicate what should be taught; the Minnesota academic standards do. Test specifications do not indicate how students should be taught; the classroom teacher does. Test specifications indicate which strands, standards and benchmarks will be assessed on the test and in what proportions. In addition, test specifications provide the types of items to be included, number of items and distribution of cognitive levels. Test specifications also clarify, define and/or limit how test items will be written.

As with any test, the MCA assesses a sampling of student knowledge and does not test every standard or benchmark. There are standards and benchmarks that cannot be assessed with a standardized test. That does not mean that these skills should not be taught or assessed. Teachers need to instruct and assess their students on all of the academic standards. Standards and benchmarks that are not assessed on the MCA are indicated in this document with the phrase "Not assessed on the MCA-III." In addition, not all assessable benchmarks will be included on every assessment each year and some benchmarks are embedded within the assessment of other benchmarks.

The test specifications presented in this document were developed by panels convened for the specific task of constructing these specifications. These panels consisted of members of the Minnesota Academic Standards Committee, as well as other classroom teachers. Many of these classroom teachers were recommended to the Minnesota Department of Education (MDE) by various education organizations, school districts and other stakeholder groups.

Item Specifications

Item specifications are provided for each benchmark. The item specifications clarify, define and limit how items should address each benchmark. The item specifications also list vocabulary that may be used in items. This list is cumulative but not exhaustive in nature. For example, vocabulary listed at grade 3 is eligible for use in all of the grades that follow.

Item Specification Considerations

There are broad item development issues addressed during the development of test items. Each of the following issues is considered for all of the items developed for the Science MCA.

1. Each item will be written to measure primarily one benchmark; however, other benchmarks may also be reflected in the item content.
2. Items will be appropriate for students in terms of grade-level difficulty, expected knowledge of grade-level science vocabulary and life experiences.
3. Item vocabulary is taken from language of the benchmarks and item specifications. Where items commonly depart from the language of the benchmark or use additional vocabulary, the item specifications will include the statement "*Additional vocabulary may include terms such as*". Vocabulary used in the assessment is cumulative in nature. For example, benchmark and additional vocabulary listed in grade 3 is eligible for use in all grades that follow.
4. Many of the benchmarks include examples that clarify the meaning of the benchmark or indicate the level of student understanding. The examples may suggest learning activities or instructional topics. They are NOT intended to be directives for curriculum, assessment or a comprehensive fulfillment of the benchmarks.
5. Items will use clear language based on the work by the U.S. Department of Education: LEP Partnership as outlined in *Linguistic Modification Part I: Language Factors in the Assessment of English Language Learners* and

Linguistic Modification Part II: A Guide to Linguistic Modification[1]. For example, to the extent possible, sentences will: be simple and in standard word order, use active voice, avoid using negatives, avoid proper nouns, avoid using general language terms that have a special meaning in science contexts, reduce written context and be as universal as possible.

6. At a given grade, items will range in difficulty from easy to challenging.
7. Items will not disadvantage or disrespect any segment of the population with regard to age, gender, race, ethnicity, language, religion, socioeconomic status, disability or geographic region.
8. Each item will be written to clearly and unambiguously elicit the desired response.
9. Items will be written according to the MDE *Guidelines for Test Construction*.
10. Advisory Panels will review items as specified in the MDE *Vendor Guide to Advisory Panels*.

Cognitive Complexity

Cognitive complexity refers to the cognitive demand associated with an item. The level of cognitive demand focuses on the type and level of thinking and reasoning required of the student on a particular item. MCA-III levels of cognitive complexity are based on Norman L. Webb's Depth of Knowledge[2] levels. Although certain verbs, such as "recall," "classify" or "reason," are commonly associated with specific cognitive levels, Webb's Depth of Knowledge levels are **not** determined by the verbs that describe them, but rather the contexts in which the verbs are used and the depth of thinking required.

A Level 1 (recall) item requires the recall of information such as a fact, definition, term or simple science process or procedure. A simple science procedure is well-defined and will typically involve only one step. Listing the planets in the solar system would be in this level.

[1] Both papers can be found on the National Clearinghouse for English Language Acquisition and Language Instruction Educational Programs (NCELA) Website at (http://ncela-beta.edstudies.net/files/uploads/10/LingusiticModificationBE024210.pdf)

[2] Webb, N. L. Alignment of science and mathematics standards and assessments in four states (Research Monograph No. 18). Madison: University of Wisconsin – Madison, National Institute for Science Education, 1999.

A Level 2 (skill/concept) item calls for the engagement of some mental processing beyond a habitual response, with students required to make some decisions as to how to approach a problem or activity. Level 2 activities imply more than one mental or cognitive process and may include making observations and collecting data; classifying, organizing and comparing data; and organizing and displaying data in tables, graphs and charts. Reading and interpreting information from a graph is an example of a skill assessed by a level 2 item.

Level 3 (strategic thinking) items require students to reason, plan or use evidence to solve a problem. In most instances, requiring students to explain their thinking is a level 3 activity. A Level 3 item may be solved using routine skills, but the student is not cued or prompted as to which skills to use. Developing a scientific model for a complex situation or forming conclusions from experimental or observational data is considered to be at this level.

Level 4 (extended thinking) items require complex reasoning, planning, developing and thinking, most likely over an extended period of time. Level 4 items are best assessed in the classroom, where the constraints of standardized testing are not a factor.

Using these cognitive complexity levels to categorize items ensures that the complexity of the test items matches the complexity of the content domain assessed. Table 1 indicates the target proportion of test items at each cognitive level included in each test.

TABLE 1. Target Cognitive Level Distribution of Items

Grades	Level 1	Level 2	Level 3
5, 8, and High School	40–60%	35–55%	5–10%

Prioritizing Standards

One of the first steps in the test development process is to determine which standards will be assessed and at what level of detail. In order to provide reliable data about a concept, a test must include several items addressing that concept. This emphasis is not possible for all of the academic standards in science in each grade span within a test of appropriate length. For this reason, MDE, with the advice of teachers and other stakeholders, prioritized the academic standards in science by assigning item totals for each standard that will appear on an operational test.

Test Design by Grade Level

The following tables (tables 2–4) provide the approximate number of points by strand on the operational test for each grade. Multiple-choice (MC) items are each worth 1 point, while other item types are worth 1-3 points. Approximately 40–60 percent of the test will be comprised of multiple-choice items, and other item types will make up the remainder of the test.

TABLE 2. Grade 5 Science MCA-III (Operational Form)

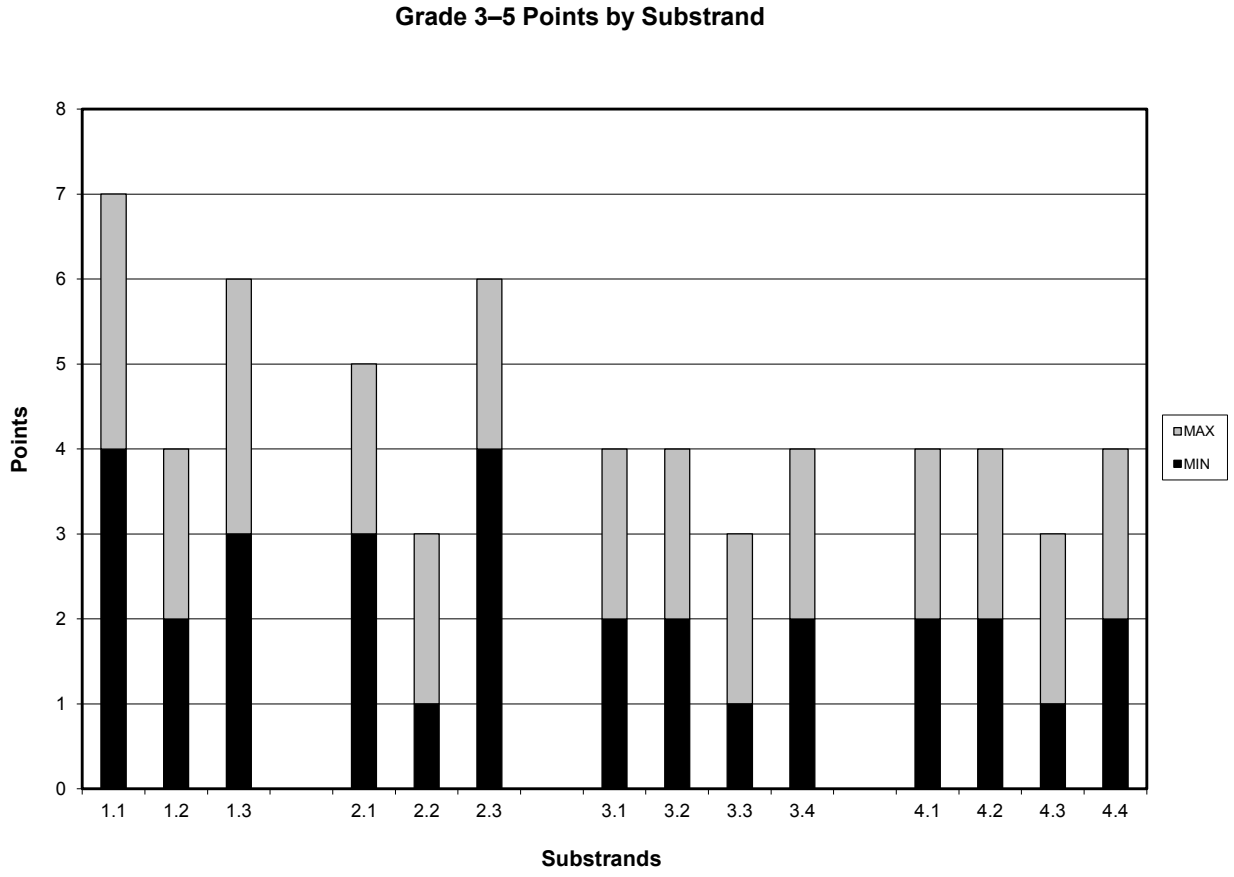
Strand	Approximate Number of Points	Approximate Percent of Points
Nature of Science and Engineering (NSE)	11–13	28
Physical Science (PS)	9–11	24
Earth and Space Science (ESS)	9–11	24
Life Science (LS)	9–11	24
Total	41	100

TABLE 3. Grade 8 Science MCA-III (Operational Form)

Strand	Approximate Number of Points	Approximate Percent of Points
Nature of Science and Engineering (NSE)	13–15	28
Physical Science (PS)	11–13	24
Earth and Space Science (ESS)	11–13	24
Life Science (LS)	11–13	24
Total	51	100

TABLE 4. Grades 9–12 Science MCA-III (Operational Form)

Strand	Approximate Number of Points	Approximate Percent of Points
Nature of Science and Engineering (NSE)	24–28	38
Life Science (LS)	40–44	62
Total	68	100



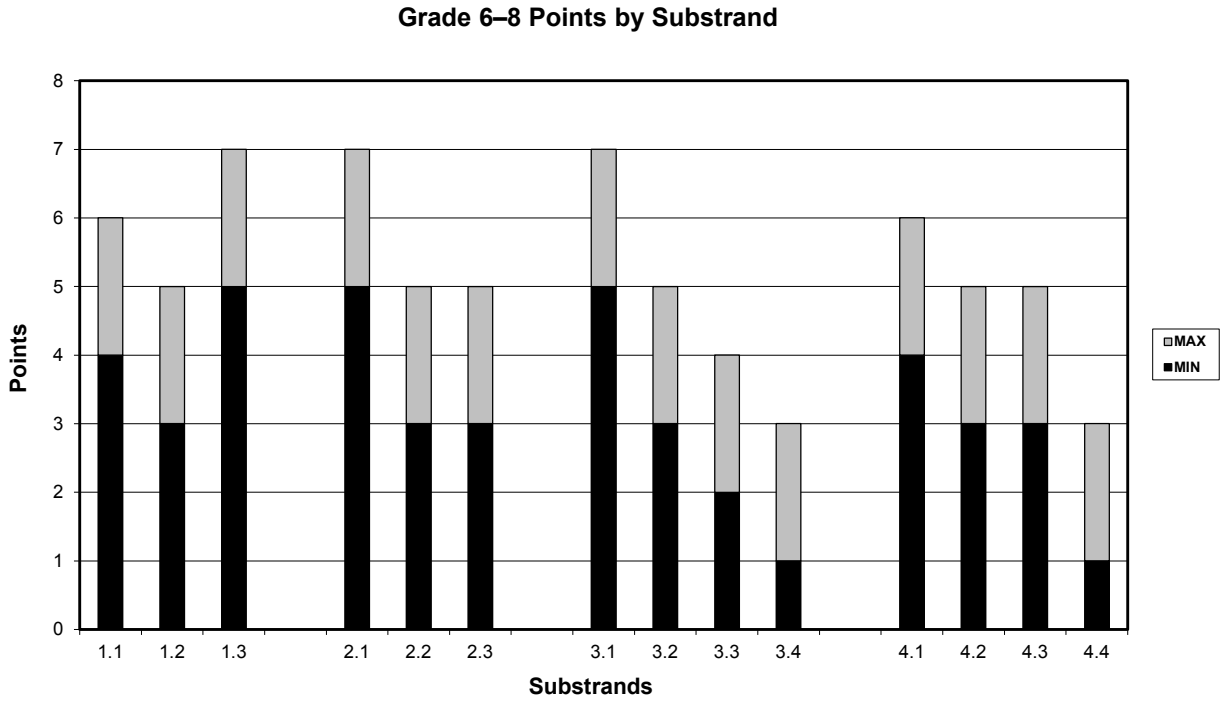
Grades 3–5 Points by Substrand

1. Nature of Science and Engineering (11–13)
1. The Practice of Science (4–7)
2. The Practice of Engineering (2–4)
3. Interactions among Science, Technology, Engineering, Mathematics and Society (3–6)

2. Physical Science (9–11)
1. Matter (3–5)
2. Motion (1–3)
3. Energy (4–6)

3. Earth and Space Science (9–11)
1. Earth Structure and Processes (2–4)
2. Interdependence within the Earth System (2–4)
3. The Universe (1–3)
4. Human Interactions with Earth Systems (2–4)

4. Life Science (9–11)
1. Structure and Function in Living Systems (2–4)
2. Interdependence Among Living Systems (2–4)
3. Evolution in Living Systems (1–3)
4. Human Interactions with Living Systems (2–4)



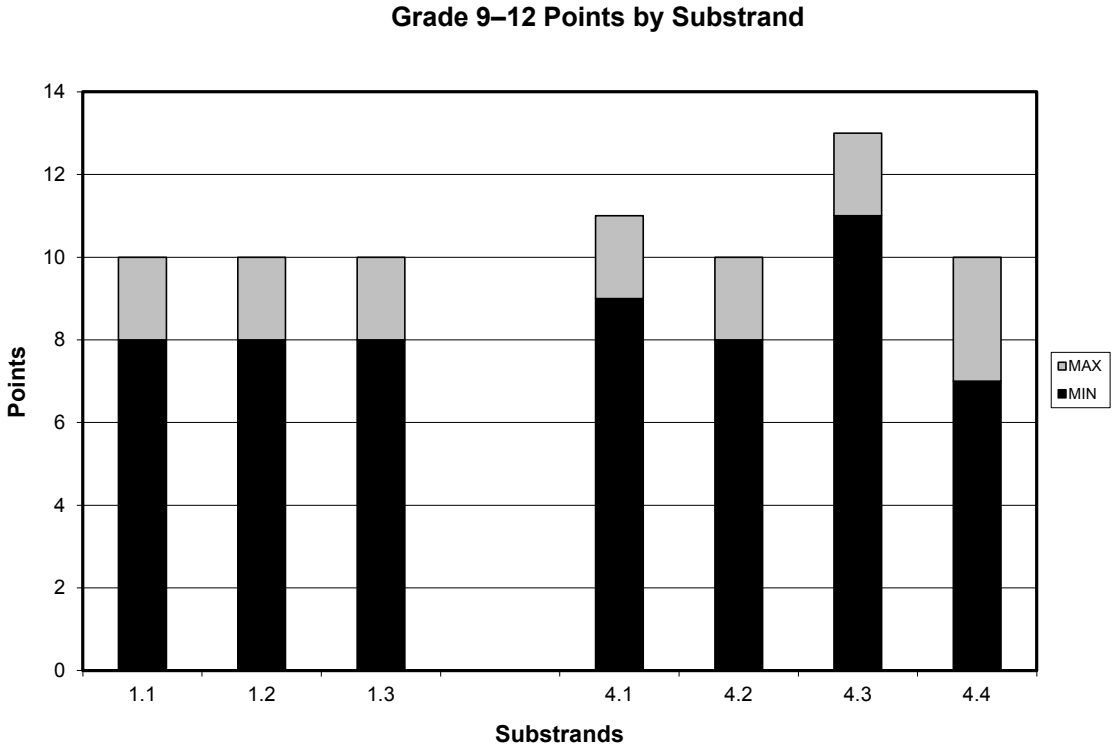
Grades 6–8 Points by Substrand

1. Nature of Science and Engineering (13–15)
1. The Practice of Science (4–6)
2. The Practice of Engineering (3–5)
3. Interactions among Science, Technology, Engineering, Mathematics and Society (5–7)

2. Physical Science (11–13)
1. Matter (5–7)
2. Motion (3–5)
3. Energy (3–5)

3. Earth and Space Science (11–13)
1. Earth Structure and Processes (5–7)
2. Interdependence within the Earth System (3–5)
3. The Universe (2–4)
4. Human Interactions with Earth Systems (1–3)

4. Life Science (11–13)
1. Structure and Function in Living Systems (4–6)
2. Interdependence Among Living Systems (3–5)
3. Evolution in Living Systems (3–5)
4. Human Interactions with Living Systems (1–3)



Grades 9–12 Points by Substrand

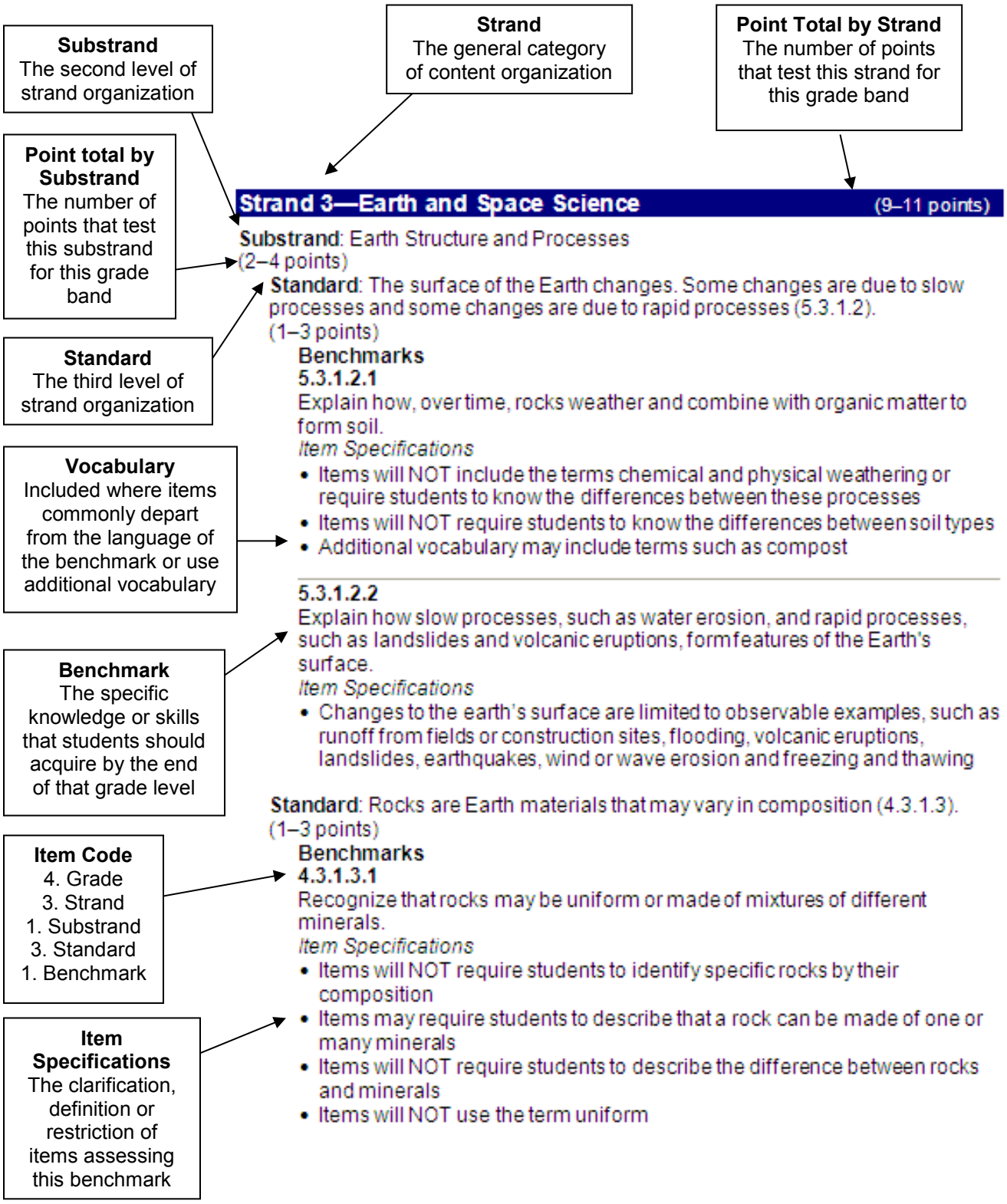
1. Nature of Science and Engineering (24–28)

1. The Practice of Science (8–10)
2. The Practice of Engineering (8–10)
3. Interactions among Science, Technology, Engineering, Mathematics and Society (8–10)

4. Life Science (40–44)

1. Structure and Function in Living Systems (9–11)
2. Interdependence Among Living Systems (8–10)
3. Evolution in Living Systems (11–13)
4. Human Interactions with Living Systems (7–10)

A Guide to Reading the Test Specifications



An Explanation of Terms Related to the Grade-Level Tables

Strand: This is the most general categorization of content in the Minnesota Academic Standards.

Substrand: This is the second level of strand organization. Each strand has three or four substrands.

Standard: Standards describe the expectations in science that all students must satisfy to meet state requirements for credit and graduation.

Benchmark: The purpose of benchmarks is to provide details about "the academic knowledge and skills that schools must offer and students must achieve to satisfactorily complete" the standards (Minn. Stat. § 120B.023 (2008)). Benchmarks are intended to "inform and guide parents, teachers, school districts and other interested persons and for use in developing tests consistent with the benchmarks" (Minn. Stat. § 120B.023 (2008)). Each standard is divided into several benchmarks.

Item Code: Test developers use this code to identify the strand, substrand and benchmark to which a test item is aligned.

Item Specifications: These statements provide more specific clarifications, definitions or restrictions for the benchmark as it is assessed on the MCA-III.

Point Total by Strand: This number is the possible number of points that will be on the operational form from a specific strand.

Point Total by Standard: This number is the total number of points measuring the standard that could be on the test for the indicated standard. For example, in the Grade 5 science test, 11–13 points are from Strand 1. Of those 11–13 Strand 1 points, 1–3 points are from Standard 4.1.2.2.

Science MCA-III Test Specifications Grade-Level Tables

Grades 3–5

Strand 1—The Nature of Science and Engineering (11–13 points)

Substrand: The Practice of Science
(4–7 points)

Standards: Scientists work as individuals and in groups; emphasizing evidence, open communication and skepticism (3.1.1.1); Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review (5.1.1.1).
(1–3 points)

Benchmarks

3.1.1.1.1
Provide evidence to support claims, other than saying "Everyone knows that," or "I just know," and question such reasons when given by others.
Item Specifications

- Evidence is limited to measurable data from an investigation, an observation or historical evidence
- Items may require students to determine the appropriate evidence or data necessary to support a statement or claim

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5.1.1.1.1
Explain why evidence, clear communication, accurate record keeping, replication by others, and openness to scrutiny are essential parts of doing science.
Item Specifications

- Items may require students to recognize whether communication is clear and/or accurate or how clear communication helps others repeat work or conduct further investigations

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5.1.1.1.2
Recognize that when scientific investigations are replicated they generally produce the same results, and when results differ significantly, it is important to investigate what may have caused such differences. For example: Measurement errors, equipment failures, or uncontrolled variables.
Item Specifications

- Items may use the terms investigation or experiment
- Items will NOT include the terms uncontrolled variables
- Variables are referred to as variables that are kept the same, measured or changed by the student
- Items may require students to identify types of variables in an investigation or what caused differences in the results of an investigation

5.1.1.1.3
Understand that different explanations for the same observations usually lead to making more observations and trying to resolve the differences.
Item Specifications
- Not assessed on the MCA-III

5.1.1.1.4
Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain. For example: Different kinds of maps of a region provide different information about the land surface
Item Specifications
- Models may include but are not limited to: Water Cycle, Simple Machines, Solar System and Life Cycle or Food Web

Standards: Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena (3.1.1.2 and 5.1.1.2).
(3–5 points)

Benchmarks

3.1.1.2.1
Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations. For example: Investigate the sounds produced by striking various objects.
Item Specifications
- Scientific or investigable questions have measurable qualities and are testable by students
- Scientific questions are questions that begin with “How can,” “How does,” “What if,” and “I wonder if/how,” but typically NOT “Why”
- Items may require students to identify a testable question
- Items may be placed in a context that addresses an experiment and require students to identify an appropriate question
- Additional vocabulary may include terms such as experimental question, investigable question and testable question

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3.1.1.2.2
Recognize that when a science investigation is done the way it was done before, even in a different place, a similar result is expected.

3.1.1.2.3
Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed. For example: Make a chart comparing observations about the structures of plants and animals.
Item Specifications
- Examples of organizing include placing data in a table
- Examples of analysis may include simple graphing (bar graph and line graph) and using data to make comparisons
- Additional vocabulary may include terms such as notebook and journal

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3.1.1.2.4
Construct reasonable explanations based on evidence collected from observations or experiments.
Item Specifications
- Items may require students to recognize or generate a reasonable conclusion based on evidence

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5.1.1.2.1
Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question.
Item Specifications
- Items may require students to compare and contrast types of investigations and how they are used to answer questions
- Items may require students to identify the appropriateness of a 2- to 3-step procedure or recognize and follow individual steps in a procedure
- Items will NOT test knowledge of specific terms, such as hypothesis
- Items will refer to systematic observations as observations
- Additional vocabulary may include terms such as experimental question, investigable question and testable question

5.1.1.2.2
Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation.
Item Specifications

- Examples of collecting relevant evidence may 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
- Items may require students to identify which variables were changed, kept the same and measured in a given experiment
- Items will NOT use the terms independent variable, dependent variable, manipulated variable or responding variable
- Measurement tools are limited to metric units, except thermometers
- Temperature will be presented in Celsius but may be presented in Fahrenheit in situations where Fahrenheit is commonly used such as weather
- Items assessing this benchmark may also assess benchmark 3.1.3.4.1

5.1.1.2.3
Conduct or critique an experiment, noting when the experiment might not be fair because some of the things that might change the outcome are not kept the same, or that the experiment is not repeated enough times to provide valid results.
Item Specifications

- Items may require students to recognize the variables of an investigation
- Items may require students to recognize when variables are NOT kept the same

Substrand: The Practice of Engineering
(2–4 points)

Standard: Engineers design, create and develop structures, processes and systems that are intended to improve society and may make humans more productive (4.1.2.1).
(0–2 points)

Benchmarks

4.1.2.1.1

Describe the positive and negative impacts that the designed world has on the natural world as more and more engineered products and services are created and used.

Item Specifications

- Items may require students to classify impacts as positive, negative or both
- Designed products and services are limited to those that are familiar to a grade 4 student, such as an aluminum can, plastic bag, plastic bottle or bicycle or sufficient background information will be supplied for the product or service

Standard: Engineering design is the process of identifying problems, developing multiple solutions, selecting the best possible solution, and building the product (4.1.2.2).
(1–3 points)

Benchmarks

4.1.2.2.1

Identify and investigate a design solution and describe how it was used to solve an everyday problem. For example: Investigate different varieties of construction tools.

4.1.2.2.2

Generate ideas and possible constraints for solving a problem through engineering design. For example: Design and build an electromagnet to sort steel and aluminum materials for recycling.

Item Specifications

- Not assessed on the MCA-III

4.1.2.2.3

Test and evaluate solutions, considering advantages and disadvantages of the engineering solution, and communicate the results effectively.

Item Specifications

- Items may require students to identify which actions scientists and engineers take to test and evaluate solutions and communicate results
- Items may require students to evaluate an engineering solution
- Communicating results may include putting results into a data table or graph, publishing results, or discussing conclusions with other scientists

Substrand: Interactions Among Science, Technology, Engineering, Mathematics and Society
(3–6 points)

Standards: Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry (3.1.3.2 and 5.1.3.2).
(1–3 points)

Benchmarks

3.1.3.2.1
Understand that everybody can use evidence to learn about the natural world, identify patterns in nature, and develop tools. For example: Ojibwe and Dakota knowledge and use of patterns in the stars to predict and plan.
Item Specifications
- Items will NOT require students to identify actions of specific individuals or groups

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3.1.3.2.2
Recognize that the practice of science and/or engineering involves many different kinds of work and engages men and women of all ages and backgrounds.
Item Specifications
- Items will NOT require students to identify specific jobs or careers or to make general descriptions that encompass a job or career

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5.1.3.2.1
Describe how science and engineering influence and are influenced by local traditions and beliefs. For example: Substainable agriculture practices used by many cultures.
Item Specifications
- Not assessed on the MCA-III

Standard: The needs of any society influence the technologies that are developed and how they are used (4.1.3.3).
(0–2 points)

Benchmarks

4.1.3.3.1
Describe a situation in which one invention led to other inventions.
Item Specifications
- Inventions are limited to those familiar to grade 4 students or sufficient background information will be supplied for the invention

Standards: Tools and mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish (3.1.3.4 and 5.1.3.4).
(2–4 points)

Benchmarks

3.1.3.4.1

Use tools, including rulers, thermometers, magnifiers and simple balances, to improve observations and keep a record of the observations made.

Item Specifications

- Appropriate measurement tools are limited to rulers, thermometers, simple balances, graduated cylinders, rain gauges, timers and common items that may indicate wind speed or direction, such as a flag or weather vane
- Observational tools are limited to magnifiers or hand lenses, microscopes, binoculars and telescopes
- Measurement tools are limited to metric units
- Metric prefixes are limited to kilo-, centi- and milli-
- Items may require students to choose a tool that is most appropriate for a particular task in a scientific investigation
- Items assessing this benchmark may also assess benchmark 5.1.1.2.2

5.1.3.4.1

Use appropriate tools and techniques in gathering, analyzing and interpreting data. For example: Spring scale, metric measurements, tables, mean/median/range, spreadsheets, and appropriate graphs

Item Specifications

- Measurement tools are limited to metric units
- Metric prefixes are limited to kilo-, centi- and milli-
- Items may require students to choose a tool that is most appropriate to analyze and interpret data, including selecting of a tool that has the appropriate units of measure
- Examples of organizing include placing data in a table
- Examples of analysis include simple graphing (bar graph and line graph) and using data to make comparisons
- Items will NOT require students to make statistical calculations

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5.1.3.4.2

Create and analyze different kinds of maps of the student's community and of Minnesota. For example: Weather maps, city maps, aerial photos, regional maps or online map resources.

Item Specifications

- Analyze and interpret maps using a key or legend
- Evaluate which type of map is most appropriate for informational need
- Identify the features or information included on a map

Strand 2—Physical Science (9–11 points)

Substrand: Matter
(3–5 points)

Standard: Objects have observable properties that can be measured (4.2.1.1).
(0-2 points)

Benchmarks

4.2.1.1.1

Measure temperature, volume, weight and length using appropriate tools and units.

Item Specifications

- Temperature should be measured in Celsius
- Measurements should be in metric units
- Items may use the more familiar term “weight” to represent both weight and mass and will use grams as the base unit for this measurement type
- Items may require students to use a tool by measuring size of an object or reading a volume and temperature from the appropriate tool

Standard: Solids, liquids and gases are states of matter that have unique properties (4.2.1.2).
(1–3 points)

Benchmarks

4.2.1.2.1

Distinguish between solids, liquids and gases in terms of shape and volume. For example: Liquid water changes shape depending on the shape of its container.

Item Specifications

- Items will NOT require students to understand density or changes to the volume of water during phase changes
- Examples of materials used to illustrate concepts include water, a piece of wood, air in a balloon and other common materials

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4.2.1.2.2

Describe how the states of matter change as a result of heating and cooling.

Item Specifications

- Changes of state include changes between solid, liquid and gas
- Examples of materials used to illustrate concepts include water, a piece of wood, air in a balloon and other common materials
- Processes of changing phases are limited to evaporation, condensation, boiling, freezing and melting
- Additional vocabulary may include terms such as water vapor, steam and phase change

Substrand: Motion
(1–3 points)

Standard: An object's motion is affected by forces and can be described by the object's speed and the direction it is moving (5.2.2.1).
(1–3 points)

Benchmarks

5.2.2.1.1

Give examples of simple machines and demonstrate how they change the input and output of forces and motion.

Item Specifications

- Uses of these simple machines are limited to changes in the speed of an object, the distance the object moves and the force on the object
- Simple machines will NOT include pulleys or second or third class levers
- Items will NOT require students to calculate mechanical advantage
- Items will NOT require students to make mathematical calculations
- Items may make comparisons to the human body
- Items will NOT use the terms input or output

5.2.2.1.2

Identify the force that starts something moving or changes its speed or direction of motion. For example: Friction slows down a moving skateboard.

Item Specifications

- Items may require students to identify the force, the location where the force is applied or the part of an object which provides the force
- Items will NOT use the terms balanced or unbalanced force
- Additional vocabulary may include terms such as push or pull

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5.2.2.1.3

Demonstrate that a greater force on an object can produce a greater change in motion.

Item Specifications

- 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 require students to make mathematical calculations
- Items will NOT use the term acceleration
- Items will NOT refer directly to Newton’s laws

Substrand: Energy
(4–6 points)

Standards: Energy appears in different forms, including sound and light (3.2.3.1); Energy appears in different forms, including heat and electromagnetism (4.2.3.1).
(2–4 points)

Benchmarks

3.2.3.1.1
Explain the relationship between the pitch of a sound, the rate of vibration of the source and factors that affect pitch. For example: Changing the length of a string that is plucked changes the pitch.
Item Specifications

- Examples of factors that affect pitch are the size of the object, tension, the type of material, and how fast or slow the object vibrates
- Items will NOT require mathematical calculations

3.2.3.1.2
Explain how shadows form and can change in various ways.
Item Specifications

- Items will use only a single light source
- Items are limited to length and direction of shadow as affected by location of light source
- Items may require students to understand that shadows form when light is blocked by an object
- Items assessing this benchmark may also assess benchmark 3.3.3.1.1

3.2.3.1.3
Describe how light travels in a straight line until it is absorbed, redirected, reflected or allowed to pass through an object. For example: Use a flashlight, mirrors and water to demonstrate reflection and bending of light.
Item Specifications

- Items may require students to recognize examples of these concepts, including reflection of light using solid objects and mirrors, rainbows and the absorption of some light when it passes through dark glasses
- Items will NOT use the terms refract or refraction
- Items that describe interactions of light will include an explicit light source
- Additional vocabulary may include terms such as light rays

4.2.3.1.1
Describe heat transfer when a warm and a cool object are touching or placed near each other.
Item Specifications

- Items will NOT require mathematical calculations

4.2.3.1.2
Describe how magnets can repel or attract each other and how they attract certain metal objects.
Item Specifications
- Metal objects are limited to those made of iron, copper, aluminum and silver
- Items that expect students to distinguish between the magnetic properties of different metal objects will label the type of metal in each object

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4.2.3.1.3
Compare materials that are conductors and insulators of heat and/or electricity. For example: Glass conducts heat well, but is a poor conductor of electricity.
Item Specifications
- 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 NOT use objects that could be both an insulator and a conductor, such as glass, unless its properties are identified either in a label or in data
- 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

Standard: Energy can be transformed within a system or transferred to other systems or the environment (4.2.3.2).
(1–3 points)

Benchmarks

4.2.3.2.1
Identify several ways to generate heat energy. For example: Burning a substance, rubbing hands together, or electricity flowing through wires.

4.2.3.2.2
Construct a simple electrical circuit using wires, batteries, and lightbulbs.
Item Specifications
- Simple electrical circuits will include both open (lightbulb not on) and closed (lightbulb 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
- Items will NOT require students to understand the mechanics and parts of a lightbulb (e.g., tip, threads, globe, filament)
- Additional vocabulary may include terms such as light socket and power source

4.2.3.2.3
Demonstrate how an electric current can produce a magnetic force. For example: Construct an electromagnet to pick up paperclips.
Item Specifications

- Examples include current in a coil of wire wrapped around a nail and electromagnets used to operate devices such as a doorbell
- Items may require students to understand the relationships between the number of turns of wire, the amount of current in the wire and the strength of the magnetic force
- Items may include understanding the magnetic force's effect on a compass

Strand 3—Earth and Space Science (9–11 points)

Substrand: Earth Structure and Processes
(2–4 points)

Standard: The surface of the Earth changes. Some changes are due to slow processes and some changes are due to rapid processes (5.3.1.2).
(1–3 points)

Benchmarks

5.3.1.2.1
Explain how, over time, rocks weather and combine with organic matter to form soil.

Item Specifications

- Items will NOT include the terms chemical and physical weathering or require students to know the differences between these processes
- Items will NOT require students to know the differences between soil types
- Additional vocabulary may include terms such as compost

5.3.1.2.2
Explain how slow processes, such as water erosion, and rapid processes, such as landslides and volcanic eruptions, form features of the Earth's surface.

Item Specifications

- Changes to the earth's surface are limited to observable examples, such as runoff from fields or construction sites, flooding, volcanic eruptions, landslides, earthquakes, wind or wave erosion and freezing and thawing

Standard: Rocks are Earth materials that may vary in composition (4.3.1.3).
(1–3 points)

Benchmarks

4.3.1.3.1
Recognize that rocks may be uniform or made of mixtures of different minerals.

Item Specifications

- Items will NOT require students to identify specific rocks by their composition
- Items may require students to describe that a rock can be made of one or many minerals
- Items will NOT require students to describe the difference between rocks and minerals
- Items will NOT use the term uniform

4.3.1.3.2
Describe and classify minerals based on their physical properties. For example: Streak, luster, hardness, reaction to vinegar.
Item Specifications

- Items may require students to describe or classify minerals based on mineral properties provided in a table
- Items will NOT require students to compare minerals based on density or fracture
- Items may require students to compare minerals based on relative hardness but will NOT require students to know specific values of an individual scale such as Mohs scale of hardness
- Items will NOT require students to name specific minerals

Substrand: Interdependence within the Earth System
(2–4 points)

Standard: Water circulates through the Earth's crust, oceans and atmosphere in what is known as the water cycle (4.3.2.3).
(2–4 points)

Benchmarks
4.3.2.3.1
Identify where water collects on Earth, including atmosphere, ground and surface water, and describe how water moves through the Earth system using the processes of evaporation, condensation and precipitation.
Item Specifications

- 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
- Items will define the term infiltration if the concept is used
- Additional vocabulary may include terms such as water vapor, water, ice, rain, snow, pond, puddle and collection

Substrand: The Universe
(1–3 points)

Standard: The sun and moon have locations and movements that can be observed and described (3.3.3.1).
(0–2 points)

Benchmarks
3.3.3.1.1
Observe and describe the daily and seasonal changes in the position of the sun and compare observations.
Item Specifications

- All references to the position of the Sun will be from a position on Earth in the Northern Hemisphere
- Items will NOT use the terms rotation, revolution, tilt, axis, equator, angle, spin and circle
- Additional vocabulary may include terms such as spring, summer, fall, winter, day, night

3.3.3.1.2
Recognize the pattern of apparent changes in the moon's shape and position.
Item Specifications
- Items will NOT require students to name the phases of the Moon
- Items will NOT address the causes for changes in the Moon's shape or position
- Items may require students to understand the pattern of changes in both the Moon's daily and monthly position

Standard: Objects in the solar system as seen from Earth have various sizes and distinctive patterns of motion (3.3.3.2).
(0–2 points)

Benchmarks

3.3.3.2.1
Demonstrate how a large light source at a great distance looks like a small light that is much closer. For example: Car headlights at a distance look small compared to when they are close.

3.3.3.2.2
Recognize that the Earth is one of several planets that orbit the sun, and that the moon orbits the Earth.
Item Specifications
- Items will NOT require students to know why the inner and outer planets are different
- Items will NOT require students to name specific planets
- Items will NOT require students to identify planets by their characteristics

Substrand: Human Interactions with Earth Systems
(2–4 points)

Standards: In order to improve their existence, humans interact with and influence Earth systems (4.3.4.1); In order to maintain and improve their existence, humans interact with and influence Earth systems (5.3.4.1).
(2–4 points)

Benchmarks

4.3.4.1.1
Describe how the methods people utilize to obtain and use water in their homes and communities can affect water supply and quality.
Item Specifications
- Items will NOT address chemical testing to determine water quality
- Methods to obtain and use water include both community systems such as building dams, agriculture, manufacturing and water treatment plants along with personal uses of water for washing, cooking and drinking
- Items may require students to identify personal and community water conservation measures such as turning off running water when not in use and fixing leaks in the water delivery system

5.3.4.1.1
Identify renewable and non-renewable energy and material resources that are found in Minnesota and describe how they are used. For example: Water, iron ore, granite, sand and gravel, wind and forests.
Item Specifications
- Renewable resources include water, solar, wind, forest resources and other materials or energy that are inexhaustible or replaceable by new growth
- Nonrenewable resources include iron ore, granite, limestone, clay, sand, gravel and other materials that renew on a long time scale

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5.3.4.1.2
Give examples of how mineral and energy resources are obtained and processed and how that processing modifies their properties to make them more useful. For example: Iron ore, biofuels, or coal.
Item Specifications
- Items will NOT require understanding of the process of raw material refinement
- Items will require students to understand that raw materials must be processed in order to become useable products
- Materials are limited to iron ore, sand and gravel, granite, coal and oil

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5.3.4.1.3
Compare the impact of individual decisions on natural systems. For example: Choosing paper or plastic bags impacts landfills as well as ocean life cycles.
Item Specifications
- Items assessing this benchmark may also assess benchmarks 4.1.2.1.1 and 5.4.4.1.1
- Additional vocabulary may include terms such as recycle, compost

Strand 4—Life Science (9–11 points)

Substrand: Structure and Function in Living Systems
(2–4 points)

Standards: Living things are diverse with many different characteristics that enable them to grow, reproduce and survive (3.4.1.1 and 5.4.1.1).
(2–4 points)

Benchmarks

3.4.1.1.1

Compare how the different structures of plants and animals serve various functions of growth, survival and reproduction. For example: Skeletons in animals and stems in plants provide strength and stability.

Item Specifications

- Structures of plants are limited to roots, stems, leaves/needles/scales, flowers, fruits and seeds
- The function of the entire flower is limited to reproduction; the function of individual parts of the flower are NOT assessed
- Structures of animals are limited to observable physical characteristics such as coverings (skin, fur, hair, scales and feathers), appendages (wings, fins, arms and legs), eyes, ears, mouths and beaks, tails, teeth
- Items will NOT require students to compare the structures of animals and the structures of plants to each other
- Items assessing this benchmark may also assess benchmark 3.4.3.2.2
- Additional vocabulary may include terms such as features and traits

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3.4.1.1.2

Identify common groups of plants and animals using observable physical characteristics, structures and behaviors. For example: Sort animals into groups such as mammals and amphibians based on physical characteristics. Another example: Sort and identify common Minnesota trees based on leaf/needle characteristics.

Item Specifications

- Characteristics of animals include sex, color, size, shape, coverings (skin, fur, hair, scales, feathers), appendages (wings, fins, arms, legs, number of each), eyes, ears, mouths and beaks, tails, teeth
- Characteristics of plants are limited to roots, stems, leaves/needles/scales, flowers, fruits, seeds and functions of the plant (e.g., carrots as a type of taproot)
- The function of the entire flower is limited to reproduction; the function of individual parts of the flower are NOT assessed
- Items will NOT require recall of specific characteristics of organisms
- Items will NOT require students to identify the name of common organisms based on characteristics
- Additional vocabulary may include terms such as feature and trait

5.4.1.1.1

Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system. For example: Compare the physical characteristics of plants or animals from widely different environments, such as desert versus tropical, and explore how each has adapted to its environment.

Item Specifications

- Physical characteristics of animals are limited to those that are observable, such as coloration, body covering, size and strength
- Physical characteristics of plants are limited to roots, stems, leaves/needles/scales, flowers, fruits and seeds
- Items assessing this benchmark may also assess benchmark 3.4.3.2.2
- Additional vocabulary may include terms such as feature and trait

Substrand: Interdependence Among Living Systems
(2–4 points)

Standard: Natural systems have many components that interact to maintain the living system (5.4.2.1).
(2–4 points)

Benchmarks

5.4.2.1.1

Describe a natural system in Minnesota, such as a wetland, prairie, or garden, in terms of the relationships among its living and nonliving parts, as well as inputs and outputs. For example: Design and construct a habitat for a living organism that meets its need for food, air and water.

Item Specifications

- Items may ask students to understand the relationships between producers, consumers and decomposers
- Examples of ways organisms interact include providing food, survival, safety (e.g., herding and schooling behaviors), reproduction, competition for resources and grooming
- Examples of ways organisms interact will NOT include the terms symbiosis, commensalisms, mutualism and parasitism, but these concepts may be addressed
- Nonliving parts of natural systems are limited to water, soil, light, air and temperature
- Items will focus on relationship between living and nonliving parts of system and NOT only identify the sun as a source of energy
- Items may require students to follow the flow of energy between trophic levels but will NOT use the term trophic level
- Items will NOT include the terms primary consumer, secondary consumer or tertiary consumer
- Additional vocabulary may include terms such as protection, shelter, decay, waste, environment, ecosystem, population, predator, prey, food chain and food web

5.4.2.1.2
Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed. For example: Investigate how road salt runoff affects plants, insects and other parts of an ecosystem. Another example: Investigate how an invasive species changes an ecosystem.
Item Specifications

- Examples of changes in a habitat may include changes in rainfall, pollution, catastrophic events, fire and introduced species
- Items may require knowledge that changes in a habitat can be either helpful or harmful to an organism, depending on the organism's niche
- Items will NOT use the terms catastrophic or niche

Substrand: Evolution in Living Systems
(1–3 points)

Standard: Offspring are generally similar to their parents, but may have variations that can be advantageous or disadvantageous in a particular environment (3.4.3.2).
(1–3 points)

Benchmarks

3.4.3.2.1
Give examples of likenesses between adults and offspring in plants and animals that can be inherited or acquired. For example: Collect samples or pictures that show similarities between adults and their young offspring.
Item Specifications

- Items will be limited to physical characteristics and will NOT include behavioral characteristics
- Items may require students to identify similarities and differences based on the inherited and acquired characteristics
- Examples of inherited characteristics in humans may include eye, skin and hair color
- Examples of inherited characteristics in other organisms may include coloration, appendages and body coverings
- Examples of inherited characteristics in plants may include leaf and flower shape and seed and stem type
- Examples of acquired characteristics in humans may include pierced ears, hairstyle, clothing and tattoos
- Examples of acquired characteristics in other organisms may include weight and docked tails
- Examples of acquired characteristics in plants may include leaf damage and total number of leaves
- Items will NOT require recall of specific characteristics of organisms
- Items will NOT use examples of organisms that undergo metamorphosis
- Additional vocabulary may include terms such as feature and trait

3.4.3.2.2
Give examples of differences among individuals that can sometimes give an individual an advantage in survival and reproduction.
Item Specifications
- Items will refer to differences among individuals within a species
- Differences among individual animals include observable characteristics such as coloration, body covering, size and strength and feeding behaviors, nesting and migration
- Differences among individual plants include observable characteristics such as roots, stems, leaves/needles/scales, flowers, fruits and seeds, and responses to stimuli
- Items assessing this benchmark may also assess benchmarks 5.4.1.1.1 and 3.4.1.1.1
- Additional vocabulary may include terms such as adapt, feature and trait

Substrand: Human Interactions with Living Systems
(2–4 points)

Standard: Humans change environments in ways that can be either beneficial or harmful to themselves and other organisms (5.4.4.1).
(1–3 points)

Benchmarks
5.4.4.1.1
Give examples of beneficial and harmful human interaction with natural systems. For example: Recreation, pollution, or wildlife management.
Item Specifications
- Examples of changes in a habitat may include pollution, erosion control, catastrophic events, fire and introduced species
- Items may require students to know that changes in a habitat can be either helpful or harmful to an organism depending on the organism's niche
- Items will NOT use the terms catastrophic or niche

Standard: Microorganisms can get inside one's body and they may keep it from working properly (4.4.4.2).
(0–2 points)

Benchmarks
4.4.4.2.1
Recognize that the body has defense systems against germs, including tears, saliva, skin and blood.
Item Specifications
- Items will NOT ask students to define the terms virus or bacteria or differentiate between them
- Items will NOT address organ systems
- Items may require students to know how germs enter the body
- Items will NOT use the term microorganism

4.4.4.2.2
Give examples of diseases that can be prevented by vaccination.
Item Specifications

- Items will NOT refer to specific diseases but will deal in general terms with disease prevention
- Items will NOT require students to understand how a vaccination works or the mechanisms of the body's response (i.e., dead germs allow the body to prepare a defense against that specific type of germ)
- Additional vocabulary may include terms such as contagious

Grades 6–8

Strand 1—The Nature of Science and Engineering (13–15 points)

Substrand: The Practice of Science
(4–6 points)

Standards: Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review (7.1.1.1 and 8.1.1.1).
(1–3 points)

Benchmarks

7.1.1.1.1
Understand that prior expectations can create bias when conducting scientific investigations. For example: Students often continue to think that air is not matter, even though they have contrary evidence from investigations.
Item Specifications

- Items may address common preconceptions of middle level students
- Items assessing this benchmark may also assess benchmark 7.1.1.2.4

7.1.1.1.2
Understand that when similar investigations give different results, the challenge is to judge whether the differences are significant, and if further studies are required. For example: Use mean and range to analyze the reliability of experimental results.
Item Specifications

- Items may require students to compare statistical data from different investigations
- Items will NOT require students to make statistical calculations
- Statistics provided will be limited to mean, median and range
- Items may include qualitative or quantitative data
- Items may include graphs and tables to represent investigation results
- Items will NOT include the terms reliability and validity

8.1.1.1.1
Evaluate the reasoning in arguments in which fact and opinion are intermingled or when conclusions do not follow logically from the evidence given. For example: Evaluate the use of pH in advertising products related to body care and gardening.
Item Specifications

- Items will address scientific evidence in the context of science content
- Evidence consists of observations and data on which to base scientific explanations
- Items assessing this benchmark may also assess benchmark 7.1.1.2.3

Standards: Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world (7.1.1.2 and 8.1.1.2).

(3–5 points)

Benchmarks

7.1.1.2.1

Generate and refine a variety of scientific questions and match them with appropriate methods of investigation, such as field studies, controlled experiments, reviews of existing work and development of models.

Item Specifications

- Items may require students to determine if a given question is investigable in the context of science content
- Items may require students to determine if a given question is appropriate for specific methods of investigations
- Examples of controlled experiments may include testing motion using time, speed, mass and location as variables
- Examples of field studies may include sampling populations of living organisms
- Examples of review of existing work may include internet review of climate change
- Examples of development of models may include planetary models

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7.1.1.2.2

Plan and conduct a controlled experiment to test a hypothesis about a relationship between two variables, ensuring that one variable is systematically manipulated, the other is measured and recorded, and any other variables are kept the same (controlled). For example: The effect of various factors on the production of carbon dioxide by plants.

Item Specifications

- Context for items may be from physical science, life science or Earth science areas
- Items may require students to identify a hypothesis, determine materials needed for the experiment or describe a procedure
- Items will NOT require students to identify a specific order of steps in an investigation
- Items may ask students to identify which variables are changed by the investigator, which are kept the same (controlled) and which are measured or observed
- Items will NOT use the terms independent variable, dependent variable, manipulated variable or responding variables
- Information used to specify variables must be provided

7.1.1.2.3

Generate a scientific conclusion from an investigation, clearly distinguishing between results (evidence) and conclusions (explanation).

Item Specifications

- Items may require students to draw conclusions based on evidence
- Results (evidence) consists of observations and data on which to base scientific explanations
- Conclusions (explanations) are based on evidence from a single or a few related experiments that could be performed in a classroom setting
- Items assessing this benchmark may also assess benchmarks 8.1.1.1.1, 7.1.3.4.1 and 8.1.3.4.1

7.1.1.2.4

Evaluate explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, and suggesting alternative explanations.

Item Specifications

- Items may require students to evaluate whether the evidence supports the conclusion when evaluating explanations.
- Items will NOT require students to evaluate the source of the evidence
- Items assessing this benchmark may also assess benchmark 7.1.1.1.1

8.1.1.2.1

Use logical reasoning and imagination to develop descriptions, explanations, predictions and models based on evidence.

Item Specifications

- Items may require students to differentiate among several proposed descriptions, explanations or models to determine which are best supported by the evidence
- Items may require students to develop predictions based on the given evidence
- Evidence consists of observations and data

Substrand: The Practice of Engineering
(3–5 points)

Standard: Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive (6.1.2.1).
(1–3 points)

Benchmarks

6.1.2.1.1

Identify a common engineered system and evaluate its impact on the daily life of humans. For example: Refrigeration, cell phone or automobile.

Item Specifications

- Items are limited to engineered devices, materials, structures, processes and systems that would be equally accessible to middle level students in all socio-economic groups or will provide background information for the technology
- Items may require students to identify the advantages and disadvantages of the engineered system
- Items may require students to identify the effect of the engineered system on different groups of people involved in the use or design of the system

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6.1.2.1.2

Recognize that there is no perfect design and that new technologies have consequences that may increase some risks and decrease others. For example: Seat belts and airbags.

Item Specifications

- Items are limited to engineered devices and materials, structures, processes and systems that would be equally accessible to middle level students in all socio-economic groups or will provide background information for the technology
- Items may require students to identify benefits and risks of new technologies

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6.1.2.1.3

Describe the trade-offs in using manufactured products in terms of features, performance, durability and cost.

Item Specifications

- Items are limited to engineered devices, materials and structures that would be equally accessible to middle level students in all socio-economic groups or will provide background information for the technology
- Items may include differences between two different manufactured products such as an incandescent lightbulb and a compact fluorescent or the differences between using a pen versus a pencil
- Additional vocabulary may include terms such as benefit

6.1.2.1.4
Explain the importance of learning from past failures, in order to inform future designs of similar products or systems. For example: Space shuttle or bridge design.
Item Specifications
- Items will include any necessary background knowledge about the system that failed
- Items may be based on actual case studies of past engineering failures
- Items may provide a flaw or failure and require students to recognize the necessary design changes for a product or system

Standard: Engineering design is the process of devising products, processes and systems that address a need, capitalize on an opportunity, or solve a specific problem (6.1.2.2).
(1–3 points)

Benchmarks

6.1.2.2.1
Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system that solves a problem. For example: Investigate how energy changes from one form to another by designing and constructing a simple roller coaster for a marble.
Item Specifications
- Items may require students to evaluate the feasibility of the representations, recognize the iterative nature of the design process, identify potential design changes or identify criteria and constraints
- Items assessing this benchmark may also assess benchmark 8.1.3.3.3
- Additional vocabulary may include terms such as limitations

Substrand: Interactions Among Science, Technology, Engineering, Mathematics and Society
(5–7 points)

Standard: Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems (6.1.3.1).
(1–3 points)

Benchmarks

6.1.3.1.1
Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.
Item Specifications
- Items are limited to designed or natural systems related to grades 6–8 benchmarks in physical science, life science or Earth science content standards
- Items may require students to label the components of a system
- Items will provide background knowledge needed for knowing the system in order to identify subsystems, parts, inputs, processes and outputs
- Items will NOT require prior knowledge of the system

6.1.3.1.2

Distinguish between open and closed systems. For example: Compare mass before and after a chemical reaction that releases a gas in sealed and open plastic bags.

Item Specifications

- Items will distinguish between open and closed systems in terms of the flow of energy and matter inside or outside of the system
- Items will NOT require students to identify whether a system is open or closed

Standard: Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry (8.1.3.2).
(0–2 points)

Benchmarks

8.1.3.2.1

Describe examples of important contributions to the advancement of science, engineering and technology made by individuals representing different groups and cultures at different times in history.

Item Specifications

- Items will NOT require students to identify specific individuals or groups and their contributions
- Items may provide names of individuals or groups, cultural backgrounds and important associated contributions and expect students to describe the effect of said contributions on the advancement of science, engineering and technology
- Items assessing this benchmark may also assess benchmark 8.1.3.3.2

Standard: Science and engineering operate in the context of society and both influence and are influenced by this context. (8.1.3.3).
(1–3 points)

Benchmarks

8.1.3.3.1

Explain how scientific laws and engineering principles, as well as economic, political, social,and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigations.

Item Specifications

- Items will provide background knowledge needed for an engineering solution or scientific investigation in order to identify possible constraints
- Items may include a list of possible constraints and their potential effects
- Additional vocabulary may include terms such as concern, limitations

8.1.3.3.2
Understand that scientific knowledge is always changing as new technologies and information enhance observations and analysis of data. For example: Analyze how new telescopes have provided new information about the universe.
Item Specifications
- Items assessing this benchmark may also assess benchmark 8.1.3.2.1
- Items will provide background knowledge about the technology
- Items are limited to new technologies related to grades 6–8 benchmarks in physical science, life science or Earth science content standards

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8.1.3.3.3
Provide examples of how advances in technology have impacted the ways in which people live, work and interact.
Item Specifications
- Items will provide background knowledge about the technology
- Items assessing this benchmark may also assess benchmark 6.1.2.1.1

Standards: Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact (6.1.3.4, 7.1.3.4 and 8.1.3.4).
(2–4 points)

Benchmarks

6.1.3.4.1
Determine and use appropriate safe procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in a physical science context.
Item Specifications
- Examples of tools include a Celsius thermometer, metric ruler, timer, electronic balance and graduated cylinder
- Items may require students to determine the tool used to accurately measure a particular quantity
- Items may include constructing and analyzing line graphs from a set of data
- Mathematical analyses are limited to mean, median, range and use of mathematical equations; no algebraic manipulation of equations will be required

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6.1.3.4.2
Demonstrate the conversion of units within the International System of Units (SI, or metric) and estimate the magnitude of common objects and quantities using metric units.
Item Specifications
- Metric prefixes are limited to kilo-, centi- and milli-
- Items are limited to mass, volume, length, time and temperature (in degrees Celsius)

7.1.3.4.1

Use maps, satellite images and other data sets to describe patterns and make predictions about natural systems in a life science context. For example: Use online data sets to compare wildlife populations or water quality in regions of Minnesota.

Item Specifications

- Examples may include graphs of data, predator-prey data sets and maps of population distributions and Minnesota ecosystems
- Items assessing this benchmark may also assess benchmark 7.1.1.2.3

7.1.3.4.2

Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in a life science context.

Item Specifications

- Examples of tools include a Celsius thermometer, metric ruler, timer, electronic balance, microscope, hand lens and graduated cylinder
- Items may require students to determine the tool used to accurately measure a particular quantity
- Items may include constructing and analyzing graphs from a set of data and comparing graphs and data
- Mathematical analyses are limited to mean, median and range and use of mathematical equations; no algebraic manipulation of equations will be required

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8.1.3.4.1

Use maps, satellite images and other data sets to describe patterns and make predictions about local and global systems in Earth science contexts. For example: Use data or satellite images to identify locations of earthquakes and volcanoes, ocean surface temperatures, or weather patterns.

Item Specifications

- Items may address data sets and maps from 8.3.2.2.2 and 8.3.2.2.3
- Items assessing this benchmark may also assess benchmarks 7.1.1.2.3, 8.3.1.1.2 and 8.3.1.1.3

8.1.3.4.2

Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in Earth and physical science contexts.

Item Specifications

- Examples of tools include a Celsius thermometer, metric ruler, timer, electronic balance and graduated cylinder
- Items may require students to determine the tool used to accurately measure a particular quantity
- Items may include constructing and analyzing graphs from a set of data and comparing graphs and data; graphs may include line graphs, scatterplots, circle graphs and histograms
- Mathematical analyses are limited to mean, median, range and use of mathematical equations; no algebraic manipulation of equations will be required

Strand 2—Physical Science (11–13 points)

Substrand: Matter
(5–7 points)

Standards: Pure substances can be identified by properties which are independent of the sample of the substance and the properties can be explained by a model of matter that is composed of small particles (6.2.1.1 and 8.2.1.1); The idea that matter is made up of atoms and molecules provides the basis for understanding the properties of matter (7.2.1.1).
(2–4 points)

Benchmarks

6.2.1.1.1
Explain density, dissolving, compression, diffusion and thermal expansion using the particle model of matter.
Item Specifications

- Diagrams will be limited to common representations of particles (e.g., dots)
- Items may require students to explain common phenomena using the particle model of matter (e.g.,, expansion and contraction of air and solids with temperature changes, dissolving of salt in water)
- Items may require students to explain how the spacing of particles affects density
- Items assessing this benchmark may also assess benchmark 6.2.1.2.3

7.2.1.1.1
Recognize that all substances are composed of one or more of approximately one hundred elements and that the periodic table organizes the elements into groups with similar properties.
Item Specifications

- Groupings will be limited to metals and nonmetals
- Items that refer to the periodic table will include relevant information from the periodic table
- Elements are defined as substances composed of one type of atom
- Items will NOT refer to protons, neutrons or electrons
- Items may require students to know that elements have unique properties but will NOT require students to identify elements by their properties

7.2.1.1.2
Describe the differences between elements and compounds in terms of atoms and molecules.
Item Specifications
- Items will NOT include chemical formulas or equations
- Items will NOT refer to protons, neutrons or electrons
- Elements are defined as a substance that cannot be broken down into any simpler chemical substances and is made of atoms all of the same type
- Compounds are defined as a substance formed by the reaction of two or more chemical elements
- Molecules are defined as the simplest unit of a chemical substance usually a group of two or more atoms
- Items will NOT require students to know the difference between a molecule and a compound

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7.2.1.1.3
Recognize that a chemical equation describes a reaction where pure substances change to produce one or more pure substances whose properties are different from the original substance(s).
Item Specifications
- Chemical equations will be represented by word or graphical representations and will NOT include chemical formulas

---

8.2.1.1.1
Distinguish between a mixture and a pure substance and use physical properties including color, solubility, density, melting point and boiling point to separate mixtures and identify pure substances.
Item Specifications
- Physical properties that can be used to separate mixtures are limited to color, density, melting point, boiling point and solubility
- Items will NOT include quantitative data on solubility
- Items will NOT require students to distinguish between types of mixtures

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8.2.1.1.2
Use physical properties to distinguish between metals and nonmetals.
Item Specifications
- Physical properties that distinguish between a metal and a nonmetal will be limited to electrical and thermal conductivity

Standards: Substances can undergo physical changes which do not change the composition or the total mass of the substance in a closed system (6.2.1.2); Substances can undergo physical and chemical changes which may change the properties of the substance but do not change the total mass in a closed system (8.2.1.2).
(2–4 points)

Benchmarks

6.2.1.2.1
Identify evidence of physical changes, including changing phase or shape, and dissolving in other materials.
Item Specifications
- Evidence is limited to changing phase or shape and dissolving in other materials

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6.2.1.2.2
Describe how mass is conserved during a physical change in a closed system. For example: The mass of an ice cube does not change when it melts.
Item Specifications
- Items will require students to demonstrate a conceptual understanding of physical changes in terms of mass before and after a change
- Items may require students to recognize that when an object's shape changes, its mass remains constant, and the mass of an object is the same as the mass of the sum of the pieces of that object
- Items assessing this benchmark may also assess benchmark 8.2.1.2.3

6.2.1.2.3
Use the relationship between heat and the motion and arrangement of particles in solids, liquids and gases to explain melting, freezing, condensation and evaporation.
Item Specifications
- Particle diagrams are limited to common representations of particles (e.g., dots)
- The motion of particles may be described as farther apart, moving faster, or sliding past one another
- Items will NOT use the terms latent heat or intermolecular forces
- Items will NOT address the expansion of water when it freezes
- Items assessing this benchmark may also assess benchmarks 6.2.1.1.1, 8.3.2.3.1 or 8.3.2.3.2

8.2.1.2.1
Identify evidence of chemical changes, including color change, generation of a gas, solid formation and temperature change.
Item Specifications
- Evidence is limited to color change, generation of a gas, solid formation and temperature change
- More than one piece of evidence is necessary to identify a chemical change

8.2.1.2.2
Distinguish between chemical and physical changes in matter.
Item Specifications
- Evidence for chemical reactions will be limited to a gas produced, heat released, a color change and formation of a solid precipitate
- More than one piece of evidence will be given when possible to identify a chemical change
- Examples of chemical changes may include baking soda and vinegar in a sealed plastic bag and burning a candle in a closed jar
- Evidence for physical changes will be limited to changes in state (phase), shape and dissolving (e.g., salt and water)
- Items will NOT include chemical formulas or equations
- Items will NOT use the term precipitate

8.2.1.2.3
Use the particle model of matter to explain how mass is conserved during physical and chemical changes in a closed system.
Item Specifications
- Examples of physical changes where mass remains constant may include the following: 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
- Examples of chemical changes where mass remains constant may include baking soda and vinegar in a sealed plastic bag and burning a candle in a closed jar
- Items assessing this benchmark may also assess benchmark 6.2.1.2.2

8.2.1.2.4
Recognize that acids are compounds whose properties include a sour taste, characteristic color changes with litmus and other acid/base indicators, and the tendency to react with bases to produce a salt and water.
Item Specifications
- Properties are limited to a sour taste, characteristic color changes with litmus and other acid/base indicators and the tendency to react with bases to produce a salt and water
- Acids and bases are limited to common household materials, such as vinegar, fruit juice, antacids and baking soda solution

Substrand: Motion
(3–5 points)

Standard: The motion of an object can be described in terms of speed, direction and change of position (6.2.2.1).
(1–3 points)

Benchmarks

6.2.2.1.1

Measure and calculate the speed of an object that is traveling in a straight line.

Item Specifications

- Items will use only one reference point(e.g., the ground, a post, a person)
- Items will NOT include velocity or vectors
- No algebraic manipulation of equations will be required
- Items will only require calculating speed from distance and time, NOT distance and time from speed
- Items assessing this benchmark may also assess benchmark 6.1.3.4.1

6.2.2.1.2

For an object traveling in a straight line, graph the object's position as a function of time, and its speed as a function of time. Explain how these graphs describe the object's motion.

Item Specifications

- Graphs are limited to line graphs; items may include constructing and analyzing line graphs from a set of data
- Items that require students to graph the object’s position will provide axes labels on the graph
- Items will NOT include the term acceleration
- Items will NOT require students to make a speed versus time graph from a position versus time graph or make comparisons between those graphs
- Items assessing this benchmark may also assess benchmark 6.1.3.4.1

Standard: Forces have magnitude and direction and affect the motion of objects (6.2.2.2).
(2–4 points)

Benchmarks

6.2.2.2.1

Recognize that when the forces acting on an object are balanced, the object remains at rest or continues to move at a constant speed in a straight line, and that unbalanced forces cause a change in the speed or direction of the motion of an object.

Item Specifications

- Items will describe the action of forces as pushes or pulls
- Items will NOT require the identification of a specific law of motion (e.g., Newton’s Laws)
- Items will NOT include velocity or vectors
- Items will address the concepts qualitatively; items will NOT include the calculation of acceleration or net forces

6.2.2.2.2
Identify the forces acting on an object and describe how the sum of the forces affects the motion of the object. For example: Forces acting on a book on a table or a car on the road.
Item Specifications
- Items will describe the action of forces as pushes or pulls
- Item will NOT require the identification of a specific law of motion (e.g., Newton's Laws)
- Items will address the concepts qualitatively; items will NOT include the calculation of acceleration or net forces
- Items will include forces in a single dimension
- Items may use vectors qualitatively

6.2.2.2.3
Recognize that some forces between objects act when the objects are in direct contact and others, such as magnetic, electrical and gravitational forces can act from a distance.
Item Specifications
- Items will NOT include the cause of electric currents in terms of electrons
- Items will NOT compare how strength of force varies over distance
- Items will NOT address the differences between attraction and repulsion in electrical and magnetic forces

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6.2.2.2.4
Distinguish between mass and weight.
Item Specifications
- Items will NOT require calculations
- Items assessing this benchmark may also assess benchmark 8.3.3.1.3

Substrand: Energy
(3–5 points)

Standards: Waves involve the transfer of energy without the transfer of matter (6.2.3.1 and 8.2.3.1).
(1–3 points)

Benchmarks

6.2.3.1.1
Describe properties of waves, including speed, wavelength, frequency and amplitude.
Item Specifications
- Items are limited to conceptual understandings
- Items may include measurements but will NOT include calculations
- Items may require students to use the terms speed, wavelength, frequency and amplitude to compare and contrast waves

6.2.3.1.2
Explain how the vibration of particles in air and other materials results in the transfer of energy through sound waves.
Item Specifications
- Items may require students to relate the motion of sound to density and the particle nature of matter
- Items will NOT require calculations

6.2.3.1.3
Use wave properties of light to explain reflection, refraction and the color spectrum.
Item Specifications
- Items may require students to apply knowledge of what happens when visible light travels through a prism
- Items will NOT include pigment mixing
- Items will NOT require students to measure angles of refraction

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8.2.3.1.1
Explain how seismic waves transfer energy through the layers of the Earth and across its surface.
Item Specifications
- Layers of the earth are limited to lithosphere, mantle, and inner and outer core
- Items may compare the way different Earth materials affect the propagation of seismic waves
- Items will NOT require calculations
- Items assessing this benchmark may also assess benchmark 8.3.1.1.1

Standard: Energy can be transformed within a system or transferred to other systems or the environment (6.2.3.2).
(1–3 points)

Benchmarks

6.2.3.2.1
Differentiate between kinetic and potential energy and analyze situations where kinetic energy is converted to potential energy and vice versa.
Item Specifications
- Items will NOT require calculations
- Items will disregard the effects of friction

6.2.3.2.2
Trace the changes of energy forms, including thermal, electrical, chemical, mechanical or others as energy is used in devices. For example: A bicycle, lightbulb or automobile.
Item Specifications
- Items are limited to devices that would be familiar to middle level students in all socio-economic groups
- Additional vocabulary may include terms such as energy transformations

6.2.3.2.3
Describe how heat energy is transferred in conduction, convection and radiation.
Item Specifications

- Items may include common interactions in the home such as cooking; cooling or heating of beverages; home heating systems and windows
- Items may require students to apply an understanding of convection in the context of Earth science topics (e.g., weather, crustal plate movement, oceans currents, lake turnover)
- Items may require students to apply an understanding of radiation in the context of Earth science (e.g., Sun and solar system, weather)
- Items assessing this benchmark may also assess benchmark 8.3.2.1.3

Strand 3—Earth and Space Science (11–13 points)

Substrand: Earth Structure and Processes
(5–7 points)

Standard: The movement of tectonic plates results from interactions among the lithosphere, mantle and core (8.3.1.1).
(2–4 points)

Benchmarks

8.3.1.1.1
Recognize that the Earth is composed of layers, and describe the properties of the layers, including the lithosphere, mantle and core.
Item Specifications

- Properties may include composition of lithosphere, mantle, and core, brittle behavior of lithosphere and plastic behavior of mantle
- Layers are limited to lithosphere, mantle, and inner and outer core
- Items will NOT require students to distinguish between crust and lithosphere

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8.3.1.1.2
Correlate the distribution of ocean trenches, mid-ocean ridges and mountain ranges to volcanic and seismic activity.
Item Specifications

- Items assessing this benchmark may also assess benchmarks 8.1.3.4.1 or 8.3.1.1.3

8.3.1.1.3
Recognize that major geological events, such as earthquakes, volcanic eruptions and mountain building, result from the slow movement of tectonic plates.
Item Specifications

- Items assessing this benchmark may also assess benchmarks 8.1.3.4.1 or 8.3.1.1.2
- Items will NOT require students to name tectonic plates
- Items may require students to understand the relative motions that occur at plate boundaries but not name or recognize the names of the boundary types
- Additional vocabulary may include terms such as subduction and fault

Standard: Landforms are the result of the combination of constructive and destructive processes (8.3.1.2).
(1–3 points)

Benchmarks

8.3.1.2.1
Explain how landforms result from the processes of crustal deformation, volcanic eruptions, weathering, erosion and deposition of sediment.
Item Specifications

- Items will NOT require knowledge of specific geographic locations (e.g., 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
- Additional vocabulary may include terms such as uplift, constructive process, and destructive process

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8.3.1.2.2
Explain the role of weathering, erosion, and glacial activity in shaping Minnesota's current landscape.
Item Specifications

- Items will NOT require prior knowledge of specific geographic locations
- Items will provide relevant information about specific geographic locations
- Items may address chemical and physical weathering
- Landscape features may include lakes, river valleys, cliffs, moraines, floodplains and will NOT address specific features such as drumlins, eskers, potholes, and outwash plains

Standard: Rocks and rock formations indicate evidence of the materials and conditions that produced them (8.3.1.3).
(2–4 points)

Benchmarks

8.3.1.3.1
Interpret successive layers of sedimentary rocks and their fossils to infer relative ages of rock sequences, past geologic events, changes in environmental conditions, and the appearance and extinction of life forms.
Item Specifications

- Items may require students to interpret a rock cross-section
- Items may include comparisons of relative age within a rock cross-section
- Additional vocabulary may include terms such as superposition, index fossils, original horizontality, relative dating, and cross cutting

8.3.1.3.2
Classify and identify rocks and minerals using characteristics including, but not limited to, density, hardness and streak for minerals; and texture and composition for rocks.
Item Specifications
- Items will NOT require students to recall the names or properties of specific minerals and rocks
- Mineral characteristics are limited to density, hardness, streak, and luster
- Rock characteristics may include grain size, mineral composition, and texture
- Items may require students to use mineral properties to identify a mineral
- Rock and mineral examples are limited to those common to Minnesota and will be described in the item

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8.3.1.3.3
Relate rock composition and texture to physical conditions at the time of formation of igneous, sedimentary and metamorphic rock.
Item Specifications
- Physical conditions are the major processes that produce each major classification of rock, including melting, cooling, crystallization, recrystallization, erosion, deposition, heat, pressure, and cementation
- Items may require students to describe the environment or physical conditions in which a particular rock type was formed
- Items will NOT require students to identify specific rock names (e.g. quartzite, sandstone)

Substrand: Interdependence within the Earth System
(3–5 points)

Standard: The sun is the principal external energy source for the Earth (8.3.2.1).
(1–3 points)

Benchmarks

8.3.2.1.1
Explain how the combination of the Earth's tilted axis and revolution around the sun causes the progression of seasons.
Item Specifications
- Items may require students to interpret a polar orbit animation or other diagram illustrating the combination of Earth’s tilted axis and revolution around the Sun
- Items will describe or illustrate phenomena as they would be observed in the Northern Hemisphere
- Additional vocabulary may include terms such as equinox and solstice

8.3.2.1.2
Recognize that oceans have a major effect on global climate because water in the oceans holds a large amount of heat.
Item Specifications
- Items will NOT require the students to know the terms heat capacity or specific heat
- Items may require students to compare qualitatively the heat absorption by oceans and the heat absorption by land
- Items assessing this benchmark may also assess benchmarks 8.3.2.1.3 and 8.3.2.2.3

8.3.2.1.3
Explain how heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and hydrosphere producing winds, ocean currents and the water cycle, as well as influencing global climate.
Item Specifications
- Items may require students to explain how wind and temperature differences cause the creation of ocean currents
- Items may require students to explain winds in terms of air moving due to pressure differences in the atmosphere
- Items may require students to explain how density differences in the atmosphere, due to uneven heating of the Earth’s surface, cause wind
- Items will include relevant climatic background information for any specified locations
- Items may assess that the sun is the principal external source of energy for the Earth
- Additional vocabulary may include terms such as prevailing winds
- Items assessing this benchmark may also assess benchmarks 6.2.3.2.3, 8.3.2.1.2, 8.3.2.2.2 and 8.3.2.2.3

Standard: Patterns of atmospheric movement influence global climate and local weather (8.3.2.2).
(1–3 points)

Benchmarks

8.3.2.2.1
Describe how the composition and structure of the Earth's atmosphere affects energy absorption, climate, and the distribution of particulates and gases.
For example: Certain gases contribute to the greenhouse effect.
Item Specifications

- 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
- Composition of the atmosphere may include dust, water vapor and other greenhouse gases
- Structure of the atmosphere may include regions for the ozone layer, the location of most weather phenomena and the jet stream
- Items that reference substances in the atmosphere will use the name rather than the chemical formula
- Items will NOT require students to know the mechanism of the greenhouse effect

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8.3.2.2.2
Analyze changes in wind direction, temperature, humidity and air pressure and relate them to fronts and pressure systems.
Item Specifications

- Items may require students to analyze how a shift in wind direction and change in cloud type are related to the passing of a pressure system
- Items may require students to interpret data but will NOT require students to memorize weather symbols
- Items assessing this benchmark may also assess benchmark 8.3.2.1.3

8.3.2.2.3
Relate global weather patterns to patterns in regional and local weather.
Item Specifications

- Items may include land and sea breezes and global wind patterns
- Items assessing this benchmark may also assess benchmarks 8.3.2.1.2 and 8.3.2.1.3
- Vocabulary may include terms such as jet stream, Coriolis Effect, hurricanes

Standard: Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle. (8.3.2.3).
(1–3 points)

Benchmarks

8.3.2.3.1

Describe the location, composition and use of major water reservoirs on the Earth, and the transfer of water among them.

Item Specifications

- Composition is limited to fresh water and salt water
- Transfer of water may include precipitation, evaporation, condensation, runoff, infiltration and transpiration
- Items may relate changes of phase to particle actions
- Items assessing this benchmark may also assess benchmark 6.2.1.2.3

8.3.2.3.2

Describe how the water cycle distributes materials and purifies water. For example: Dissolved gases in rain can change the chemical composition of substances on Earth. Another example: Waterborne disease.

Item Specifications

- Items may include transportation and deposition of sediment and pollutants
- Purification may include evaporation, aeration and filtration
- Items assessing this benchmark may also assess benchmark 6.2.1.2.3

Substrand: The Universe
(2–4 points)

Standard: The Earth is the third planet from the sun in a system that includes the moon, the sun, seven other planets and their moons, and smaller objects (8.3.3.1).
(2–4 points)

Benchmarks

8.3.3.1.1

Recognize that the sun is a medium-sized star, one of billions of stars in the Milky Way galaxy, and the closest star to Earth.

Item Specifications

- Items will NOT include Hertzsprung-Russell (H-R) diagrams

8.3.3.1.2

Describe how gravity and inertia keep most objects in the solar system in regular and predictable motion.

Item Specifications

- Items will NOT require calculations

8.3.3.1.3
Recognize that gravitational force exists between any two objects and describe how the masses of the objects and distance between them affect the force.
Item Specifications
- Items will NOT require calculations
- Items assessing this benchmark may also assess benchmark 6.2.2.2.4

8.3.3.1.4
Compare and contrast the sizes, locations and compositions of the planets and moons in our solar system.
Item Specifications
- Items will provide numerical information about mass, distance and size as needed
- Distance is given in astronomical units (AU)
- Items may require students to compare inner planets and outer planets as groups

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8.3.3.1.5
Use the predictable motions of the Earth around its own axis and around the sun, and of the moon around the Earth, to explain day length, the phases of the moon, and eclipses.
Item Specifications
- Items may require students to interpret a polar orbit animation or other diagram illustrating the combination of Earth's tilted axis and revolution around the Sun
- Items will describe or illustrate phenomena as they would be observed in the Northern Hemisphere
- Items may require students to identify relative positions of the Earth, Sun and Moon in their explanations
- Additional vocabulary may include terms such as rotate, revolve and orbit

Substrand: Human Interactions with Earth Systems
(1–3 points)

Standard: In order to maintain and improve their existence humans interact with and influence Earth systems (8.3.4.1).
(1–3 points)

Benchmarks

8.3.4.1.1
Describe how mineral and fossil fuel resources have formed over millions of years, and explain why these resources are finite and non-renewable over human time frames.
Item Specifications
- Items will provide relevant background information

8.3.4.1.2

Recognize that land and water use practices affect natural processes and that natural processes interfere and interact with human systems. For example: Levees change the natural flooding process of a river. Another example: Agricultural runoff influences natural systems far from the source.

Item Specifications

- Items will provide relevant background information
- Land and water use practices may include practices in systems common in Minnesota such as mining, agriculture, forestry, dam building and water treatment

Strand 4—Life Science (11–13 points)

Substrand: Structure and Function in Living Systems
(4–6 points)

Standard: Tissues, organs and organ systems are composed of cells and function to serve the needs of all cells for food, air and waste removal (7.4.1.1).
(2–4 points)

7.4.1.1.1

Recognize that all cells do not look alike and that specialized cells in multicellular organisms are organized into tissues and organs that perform specialized functions. For example: Nerve cells and skin cells do not look the same because they are part of different organs and have different functions.

Item Specifications

- 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 and blood cells carry gases
- Tissues are limited to muscle, nerve and skin tissues
- Organs and organ systems are limited to respiratory, circulatory, digestive, nervous, skin and urinary systems
- Items assessing this benchmark may also assess benchmark 7.4.1.1.2
- Items are limited to examples in humans

7.4.1.1.2

Describe how the organs in the respiratory, circulatory, digestive, nervous, skin and urinary systems interact to serve the needs of vertebrate organisms.

Item Specifications

- Items will NOT require students to identify the structure or function of individual systems outside the context of system interaction
- Items assessing this benchmark may also assess benchmark 7.4.1.1.1

Standard: All living organisms are composed of one or more cells which carry on the many functions needed to sustain life (7.4.1.2).
(2–4 points)

Benchmarks

7.4.1.2.1

Recognize that cells carry out life functions, and that these functions are carried out in a similar way in all organisms, including, animals, plants, fungi, bacteria and protists.

Item Specifications

- Life functions include obtaining and using energy
- Items will NOT require students to have specific knowledge about respiration, such as the Krebs cycle, or equations that describe respiration or photosynthesis
- Items may require students to make comparisons of the life functions of different organisms
- Items assessing this benchmark may also assess benchmarks 7.4.1.2.2 or 7.4.1.2.3

7.4.1.2.2
Recognize that cells repeatedly divide to make more cells for growth and repair.
Item Specifications
- Items may require students to understand how cells are replaced in an organism 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
- Additional vocabulary may include terms such as cell division
- Items assessing this benchmark may also assess benchmarks 7.4.1.2.1 or 7.4.1.2.3

7.4.1.2.3
Use the presence of the cell wall and chloroplasts to distinguish between plant and animal cells. For example: Compare microscopic views of plant cells and animal cells.
Item Specifications
- Items may require students to know that plant and animal cells can be distinguished by the presence of cell wall and chloroplast but cannot only be distinguished by the presence of a cell membrane, mitochondria, nucleus or ribosomes
- Items assessing this benchmark may also assess benchmarks 7.4.1.2.1 or 7.4.1.2.2

Substrand: Interdependence Among Living Systems
(3–5 points)

Standard: Natural systems include a variety of organisms that interact with one another in several ways (7.4.2.1).
(1–3 points)

Benchmarks

7.4.2.1.1
Identify a variety of populations and communities in an ecosystem and describe the relationships among the populations and communities in a stable ecosystem.
Item Specifications
- Items may require students to distinguish between a population and a community
- Items may require students to identify population trends based on a relationship
- Items may describe non-food related relationships such as mutualism and competition but will NOT use the terms mutualism, commensalism or symbiosis
- Populations, communities and organisms are limited to those commonly recognizable in Minnesota
- Additional vocabulary may include terms such as niche, biome

7.4.2.1.2
Compare and contrast the roles of organisms with the following relationships: predator/prey, parasite/host, and producer/consumer/decomposer.
Item Specifications
- Items may require students to identify the roles in a relationship such as producers and consumers, predator and prey
- Organisms are limited to those commonly recognizable in Minnesota
- Predator-prey relationships may include owls and mice, and wolves and deer
- Parasite-host relationships may include wood ticks and humans, deer ticks and humans, deer ticks and dogs, and tapeworms and dogs
- Producer-consumer-decomposer relationships may include relationships such as grass and rabbits, and deer and fungi

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7.4.2.1.3
Explain how the number of populations an ecosystem can support depends on the biotic resources available as well as abiotic factors such as amount of light and water, temperature range and soil composition.
Item Specifications
- Ecosystems are limited to Minnesota ecosystems such as forests, prairies, streams and lakes
- Items will use the terms living and non-living factors and will NOT use the terms biotic and abiotic
- Additional vocabulary may include terms such as niche, shelter and habitat

Standard: The flow of energy and the recycling of matter are essential to a stable ecosystem (7.4.2.2).
(1–3 points)

Benchmarks

7.4.2.2.1
Recognize that producers use the energy from sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.
Item Specifications
- 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

7.4.2.2.2
Describe the roles and relationships among producers, consumers and decomposers in changing energy from one form to another in a food web within an ecosystem.
Item Specifications
- Organisms in food webs are limited to those commonly recognizable in Minnesota
- If organisms are listed or labeled, broad terms such as owl, eagle, fish, snake, mouse, fox, plant, worm, frog or insect must be used
- 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
- Additional vocabulary may include terms such as producer, primary consumer, secondary consumer, tertiary consumer and decomposer

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7.4.2.2.3
Explain that the total amount of matter in an ecosystem remains the same as it is transferred between organisms and their physical environment, even though its form and location change. For example: Construct a food web to trace the flow of matter in an ecosystem.
Item Specifications
- Organisms are limited to those commonly recognizable in Minnesota
- Ecosystems are limited to Minnesota ecosystems, such as forests, prairies, streams and lakes
- Organisms may include producers, consumers and decomposers

Substrand: Evolution in Living Systems
(3–5 points)

Standard: Reproduction is a characteristic of all organisms and is essential for the continuation of a species. Hereditary information is contained in genes which are inherited through asexual or sexual reproduction (7.4.3.1).
(1–3 points)

Benchmarks

7.4.3.1.1
Recognize that cells contain genes and that each gene carries a single unit of information that either alone, or with other genes, determines the inherited traits of an organism.
Item Specifications
- Items will NOT use the terms chromosome, phenotype, genotype, dominant or recessive
- Items will NOT require students to understand or use a Punnett square

7.4.3.1.2
Recognize that in asexually reproducing organisms all the genes come from a single parent, and that in sexually reproducing organisms about half of the genes come from each parent.
Item Specifications
- Items will NOT require students to understand the process of meiosis
- Items may require students to know that sex cells contain half the total genetic information
- Items will NOT use the term chromosome

7.4.3.1.3
Distinguish between characteristics of organisms that are inherited and those acquired through environmental influences.
Item Specifications
- Items will provide relevant background information
- Items may address how some inherited traits can also be affected by the environment. For example mutations caused by pollution, organism height, leaf number, leaf color
- Additional vocabulary may include terms such as instinctive, behavioral and learned characteristics

Standard: Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring (7.4.3.2).
(1–3 points)

Benchmarks

7.4.3.2.1
Explain how the fossil record documents the appearance, diversification and extinction of many life forms.
Item Specifications
- Items will NOT require students to recall specific fossils, geologic time periods or absolute ages

7.4.3.2.2
Use internal and external anatomical structures to compare and infer relationships between living organisms as well as those in the fossil record.
Item Specifications
- Items may require students to interpret cladograms but will not use this term
- Items will NOT use the terms DNA, phylogeny, homologous structures, analogous structures
- Additional vocabulary may include terms such as common ancestor

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7.4.3.2.3
Recognize that variation exists in every population and describe how a variation can help or hinder an organism’s ability to survive.
Item Specifications
- Additional vocabulary may include terms such as adaptation, genetic diversity

7.4.3.2.4
Recognize that extinction is a common event and it can occur when the environment changes and a population's ability to adapt is insufficient to allow its survival.
Item Specifications
- Items may require students to use evidence from the fossil record to show extinction as a common event throughout Earth's history
- Items will NOT require students to understand that a population's ability to adapt can result in an increase in the population

Substrand: Human Interactions with Living Systems
(1–3 points)

Standard: Human activity can change living organisms and ecosystems (7.4.4.1).
(0–2 points)

Benchmarks
7.4.4.1.1
Describe examples where selective breeding has resulted in new varieties of cultivated plants and particular traits in domesticated animals.
Item Specifications
- Items will provide relevant background information on traits found in the plants and animals

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7.4.4.1.2
Describe ways that human activities can change the populations and communities in an ecosystem.
Item Specifications
- Change as a result of human activities may include chemicals in the environment, bacterial resistance, pollution, deforestation, over-hunting and urban development
- Items may require students to describe the effects of human activity when given an example

Standard: Human beings are constantly interacting with other organisms that cause disease (7.4.4.2).
(0–2 points)

Benchmarks
7.4.4.2.1
Explain how viruses, bacteria, fungi and parasites may infect the human body and interfere with normal body functions.
Item Specifications
- Items will provide relevant background information regarding the biological agent
- Items will NOT require students to understand the cellular processes of infection

7.4.4.2.2
Recognize that a microorganism can cause specific diseases and that there are a variety of medicines available that can be used to combat a given microorganism.
Item Specifications
- Items may require students to differentiate between treatments for different biological agents
- Items will NOT reference specific drugs used for specific diseases (e.g., amoxicillin for treating strep throat)

7.4.4.2.3
Recognize that vaccines induce the body to build immunity to a disease without actually causing the disease itself.

7.4.4.2.4
Recognize that the human immune system protects against microscopic organisms and foreign substances that enter from outside the body and against some cancer cells that arise from within.
Item Specifications
- Items will NOT require students to understand the mechanisms of the immune response
- Items will NOT require students to know specific organs, tissues or cells in the immune system

Grades 9–12

Strand 1—The Nature of Science and Engineering (24–28 points)

Substrand: The Practice of Science
(8–10 points)

Standard: Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
(9.1.1.1)
(2–4 points)

Benchmarks

9.1.1.1.1

Explain the implications of the assumption that the rules of the universe are the same everywhere and these rules can be discovered by careful and systematic investigation.

Item Specifications

- Rules of the universe are things and events in the universe that "occur in consistent patterns that are comprehensible through careful systematic study"; scientific theories and natural laws are the result of that systematic study (Project 2061, Atlas of Science Literacy, Volume 2, [American Association for the Advancement of Science, 2007], 5)
- 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" (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 (National Academy of Sciences, Teaching About Evolution and the Nature of Science, [National Academy Press, 1998], 5)
- Items may require students to apply their knowledge of scientific theories and natural laws to a context
- Items will NOT require students to define scientific theory or natural law

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9.1.1.1.2

Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.

9.1.1.1.3

Explain how the traditions and norms of science define the bounds of professional scientific practice and reveal instances of scientific error or misconduct. For example: the use of peer review, publications and presentations.

Item Specifications

- Items will NOT require students to make ethical decisions

9.1.1.1.4
Explain how societal and scientific ethics impact research practices.
For example: Research involving human subjects may be conducted only with the informed consent of the subjects.
Item Specifications
- Not assessed on the MCA-III

9.1.1.1.5
Identify sources of bias, and explain how bias might influence the direction of research and the interpretation of data. For example: How funding of research can influence questions studied, procedures used, analysis of data and communication of results.
Item Specifications
- Items will NOT require students to make ethical decisions
- Sources of bias may include gender bias, misconception, cultural bias, funding bias, procedural bias, individual bias based on prior experience with the subject and political bias

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9.1.1.1.6
Describe how changes in scientific knowledge generally occur in incremental steps that include and build on earlier knowledge.
Item Specifications
- Items may require students to show how one scientific understanding leads to another (e.g., show how new evidence or analysis led to further development of the theory of evolution, germ theory or theory of inheritance)
- Items assessing this benchmark may also assess benchmarks 9.1.3.2.1 and 9.4.4.1.3

9.1.1.1.7
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 the big bang theory.
Item Specifications
- Items will address theories, models and the validity of scientific knowledge in the context of life science
- Technological innovations may include microscopy, global positioning system (GPS), genetic engineering and molecular engineering

Standard: Scientific inquiry uses multiple interrelated processes to investigate and explain the natural world. (9.1.1.2)
(4–6 points)

Benchmarks

9.1.1.2.1

Formulate a testable hypothesis, design and conduct an experiment to test the hypothesis, analyze the data, consider alternative explanations and draw conclusions supported by evidence from the investigation.

Item Specifications

- Context of items should demonstrate all appropriate safety considerations
- Items may address part or all of the benchmark
- Hypothesis is defined as "a testable statement about the natural world that can be used to build more complex inferences and explanations" (National Academy of Sciences, Teaching About Evolution and the Nature of Science, [National Academy Press, 1998], 5)
- Items will NOT require students to define the term hypothesis
- Items may require students to evaluate or draw an accurate conclusion based on presented evidence
- Items may require students to identify which variables were changed, kept the same and measured in a given experiment
- Items will NOT use the terms independent variable, dependent variable, manipulated variable or responding variables

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9.1.1.2.2

Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.

Item Specifications

- Items may require students to evaluate a set of data to formulate possible conclusions

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9.1.1.2.3

Identify the critical assumptions and logic used in a line of reasoning to judge the validity of a claim.

Item Specifications

- Items may include product claims, pseudoscience and unsupported conclusions

9.1.1.2.4
Use primary sources or scientific writings to identify and explain how different types of questions and their associated methodologies are used by scientists for investigations in different disciplines.
Item Specifications
- Items may require students to identify the different types of questions or methodologies of scientists in different disciplines
- Disciplines are limited to zoology, botany, microbiology, evolutionary biology, ecology, genetics, cell biology, anatomy and physiology
- Methodologies may include observation, gathering data, organizing information, analysis, experimentation and computer modeling

Substrand: The Practice of Engineering
(8–10 points)

Standard: Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes, and systems. (9.1.2.1)
(5–7 points)

Benchmarks

9.1.2.1.1
Understand that engineering designs and products are often continually checked and critiqued for alternatives, risks, costs and benefits, so that subsequent designs are refined and improved. For example: If the price of an essential raw material changes, the product design may need to be changed.
Item Specifications
- Items will NOT require students to know details of specific technologies
- Items will be placed in contexts that give sufficient background information
- Items are limited to environmental effects on natural and artificial ecosystems and their physical and biological components

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9.1.2.1.2
Recognize that risk analysis is used to determine the potential positive and negative consequences of using a new technology or design, including the evaluation of causes and effects of failures. For example: Risks and benefits associated with using lithium batteries.
Item Specifications
- Items will NOT require students to know details of specific technologies
- Items will be placed in contexts that give sufficient background information
- Items are limited to environmental effects on natural and artificial ecosystems and their physical and biological components
- Items may require students to identify risks and benefits of a new technology or design

9.1.2.1.3
Explain and give examples of how, in the design of a device, engineers consider how it is to be manufactured, operated, maintained, replaced and disposed of.
Item Specifications
- Items will NOT require students to know details of specific technologies
- Items will be placed in contexts that provide sufficient background information
- Items are limited to environmental effects on natural and artificial ecosystems and their physical and biological components

Standard: Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem. (9.1.2.2)
(1–3 points)

Benchmarks

9.1.2.2.1
Identify a problem and the associated constraints on possible design solutions. For example: Constraints can include time, money, scientific knowledge and available technology.
Item Specifications
- Vocabulary may include terms such as limitations or problems

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9.1.2.2.2
Develop possible solutions to an engineering problem and evaluate them using conceptual, physical and mathematical models to determine the extent to which the solutions meet the design specifications. For example: Develop a prototype to test the quality, efficiency and productivity of a product.
Item Specifications
- Items may require students to evaluate conceptual, physical or mathematical prototypes to identify solutions to an engineering problem

Substrand: Interactions Among Science, Technology, Engineering, Mathematics and Society
(8–10 points)

Standard: Natural and designed systems are made up of components that act within a system and interact with other systems. (9.1.3.1)
(2–4 points)

Benchmarks

9.1.3.1.1
Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs. For example: A power plant or ecosystem.
Item Specifications
- Items may use either natural or designed systems
- Items will be placed in contexts that give sufficient background information
- Items may require students to identify common reactants and products in a life science context as inputs and outputs

9.1.3.1.2
Identify properties of a system that are different from those of its parts but appear because of the interaction of those parts.
Item Specifications
- Items may use either natural or designed systems
- Examples of systems include ecosystems, organ systems, power plants and water treatment systems

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9.1.3.1.3
Describe how positive and/or negative feedback occur in systems.
For example: The greenhouse effect
Item Specifications
- Items may use either natural or designed systems
- Items may require students to analyze positive and negative feedback from a set of data or information
- Items will NOT require students to know specific feedback mechanisms within an organism
- Additional examples may include ecosystem and population dynamics, greenhouses and aquaculture
- Items will NOT address organ systems
- Positive feedback is the response of the system to a change of a variable that results in an amplified change in the system; negative feedback reduces changes in a system and tends to keep a system in stable equilibriums

Standard: Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry. (9.1.3.2)
(0–2 points)

Benchmarks

9.1.3.2.1
Provide examples of how diverse cultures, including natives from all of the Americas, have contributed scientific and mathematical ideas and technological inventions. For example: Native American understanding of ecology; Lisa Meitner's contribution to understanding radioactivity; Tesla's ideas and inventions relating to electricity; Watson, Crick and Franklin's discovery of the structure of DNA; or how George Washington Carver's ideas changed land use.
Item Specifications
- Items assessing this benchmark may also assess benchmarks 9.1.1.1.6 and 9.4.4.1.3
- Items will be placed in contexts that give sufficient background information
- Items will NOT require students to match an individual to a specific idea or invention
- Items may require students to recognize how an idea or invention has contributed to the field of science

9.1.3.2.2
Analyze possible careers in science and engineering in terms of education requirements, working practices, and rewards.
Item Specifications
- Not assessed on the MCA-III

Standard: Science and engineering operate in the context of society and both influence and are influenced by this context. (9.1.3.3)
(0–2 points)

Benchmarks

9.1.3.3.1
Describe how values and constraints affect science and engineering.
For example: Economic, environmental, social, political, ethical, health, safety, and sustainability issues.
Item Specifications
- Not assessed on the MCA-III

9.1.3.3.2
Communicate, justify, and defend the procedures and results of a scientific inquiry or engineering design project using verbal, graphic, quantitative, virtual or written means.
Item Specifications
- Items may require students to justify or defend procedures and results based on data, observations, or other evidence
- Items may require students to interpret or create a graphic in order to communicate procedures and results
- Items may require students to analyze or produce quantitative information in order to communicate procedures and results

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9.1.3.3.3
Describe how scientific investigations and engineering processes require multi-disciplinary contributions and efforts. For example: Nanotechnology, climate change, agriculture, or biotechnology.
Item Specifications
- Items may require students to identify appropriate disciplines that contribute to or collaborate in a given scientific investigation or engineering effort
- Items may require students to evaluate the contributions of a discipline or group of disciplines
- Examples of disciplines are limited to zoology, botany, microbiology, evolutionary biology, ecology, genetics, cell biology, anatomy and physiology
- Items will provide context with sufficient background information

Standard: Science, technology, engineering and mathematics rely on each other to enhance knowledge and understanding. (9.1.3.4)
(4–6 points)

Benchmarks

9.1.3.4.1
Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics and new technologies.
Item Specifications
- Not assessed on the MCA-III

9.1.3.4.2
Determine and use appropriate safety procedures, tools, computers and measurement instruments in science and engineering contexts. For example: Consideration of chemical and biological hazards in the lab.
Item Specifications
- All measurements will use the International System of Units (SI)
- Appropriate tools and measurement instruments include tools such as thermometer, pipette, test tube, beaker, balance, graduated cylinder, microscope
- Appropriate safety procedures include using equipment such as goggles, apron, protective gloves, closed-toe shoes, fume hood, eye wash, fire extinguisher
- Vocabulary may include terms such as hazardous chemicals

9.1.3.4.3
Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results.
Item Specifications
- All measurements will use the International System of Units (SI)
- Items may require students to place appropriate variables on graph axes
- Items may require students to determine appropriate increments on graphs
- Items may require students to use one of the representations to describe a phenomena, evaluate results or the identify the best way to represent a set of data

9.1.3.4.4

Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve the data collection and analysis. For example: Use statistical analysis or error analysis to make judgments about the validity of results

Item Specifications

- Examples of error include uncontrolled variables, operator error and measurement error
- Mathematics will be limited to grade 8 mathematics or below, per the Minnesota Academic Standards in Mathematics, and can include the concepts of percent, mean, median, mode and line of best fit
- Items will NOT require students to do mathematics without using the results to evaluate data
- All measurements will use the International System of Units (SI)
- Items that require students to do calculations will provide a calculator tool

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9.1.3.4.5

Demonstrate how unit consistency and dimensional analysis can guide the calculation of quantitative solutions and verification of results.

Item Specifications

- Mathematics will be limited to grade 8 mathematics or below, per the Minnesota Academic Standards in Mathematics
- All measurements will use the International System of Units (SI)
- Items that require students to do calculations will provide a scientific calculator tool

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9.1.3.4.6

Analyze the strengths and limitations of physical, conceptual, mathematical and computer models used by scientists and engineers.

Item Specifications

- Examples of models include population growth, bacterial growth and probability in genetics

Strand 4—Life Science (40–44 points)

Substrand: Structure and Function in Living Systems
(9–11 points)

Standard: Organisms use the interaction of cellular processes as well as tissues and organ systems to maintain homeostasis. (9.4.1.1)
(2–4 points)

Benchmarks

9.4.1.1.1

Explain how cell processes are influenced by internal and external factors, such as pH and temperature, and how cells and organisms respond to changes in their environment to maintain homeostasis.

Item Specifications

- Internal and external factors or stimuli include pH, temperature, light, gravity and concentration
- A cell's response to maintain homeostasis may include single-celled organisms or individual cells of organisms
- An organism's response to maintain homeostasis may include responses such as gravitropism and phototropism in plants and shivering or sweating in animals
- Items may address both voluntary and involuntary responses.
- Items will NOT address the mechanisms of specific organ systems
- Items will NOT require students to distinguish between innate and learned behaviors

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9.4.1.1.2

Describe how the functions of individual organ systems are integrated to maintain homeostasis in an organism.

Item Specifications

- Items may be placed in contexts referring to body temperature, breathing and pulse rate as homeostatic disruptions of the human body or any context that addresses symptoms or disruptions of homeostasis
- Organ systems in animals are limited to digestive, respiratory, circulatory and nervous systems
- Organ systems in plants may include the function of vascular tissue and leaves
- The functions of individual organ systems in plants include nutrient uptake, gas exchange and material transport
- Items will NOT require students to identify specific plant structures, such as xylem or stoma, but may require students to understand their function
- Items will NOT address positive feedback in homeostasis

Standard: Cells and cell structures have specific functions that allow an organism to grow, survive and reproduce. (9.4.1.2)
(6–8 points)

Benchmarks

9.4.1.2.1
Recognize that cells are composed primarily of a few elements (carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur), and describe the basic molecular structures and the primary functions of carbohydrates, lipids, proteins and nucleic acids.
Item Specifications
- Items may require students to know the elemental symbols for carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur

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9.4.1.2.2
Recognize that the work of the cell is carried out primarily by proteins, most of which are enzymes, and that protein function depends on the amino acid sequence and the shape it takes as a consequence of the interactions between those amino acids.
Item Specifications
- Items may require students to analyze the effect of a change in the amino acid sequence on protein shape and resulting function
- Items addressing enzymes are limited to understanding that enzymes are catalysts in reactions, are specific to particular molecules and are affected by pH and temperature
- Items will NOT assess the roles of specific enzymes
- Items will NOT use the term activation energy
- Items assessing this benchmark may also assess 9.4.3.1.3

9.4.1.2.3
Describe how viruses, prokaryotic cells and eukaryotic cells differ in relative size, complexity and general structure.
Item Specifications
- Viral structures are limited to genetic material and protein coat
- Examples of differences between viruses, eukaryotic cells and prokaryotic cells are limited to relative sizes, the presence of nuclei, the presence of other organelles, and that multi-cellular organisms are composed of eukaryotic cells
- Items will use the terms cell parts for general structures

9.4.1.2.4
Explain the function and importance of cell organelles for prokaryotic and/or eukaryotic cells as related to the basic cell processes of respiration, photosynthesis, protein synthesis and cell reproduction.
Item Specifications
- Cell organelles will be referred to in test items as cell parts
- The cell part related to respiration in eukaryotes is limited to the mitochondria (transforms energy to a usable form for the cell)
- The cell part related to photosynthesis is limited to the chloroplast (converts light energy to chemical energy)
- Cell parts related to protein synthesis in eukaryotes are limited to nucleus (site of transcription) and ribosomes (site of translation)
- Structures related to protein synthesis in prokaryotes are limited to genetic material (site of transcription) and ribosomes (site of translation)
- Cell parts related to cell reproduction in eukaryotes are limited to the nucleus (site of replication), genetic material (DNA), nuclear membrane (nuclear barrier), cell membrane (cytoplasmic barrier) and cell wall (cytoplasmic division)
- Cell parts related to cell reproduction in prokaryotes are limited to genetic material (DNA) and cell membrane (cytoplasmic barrier)
- Items will NOT address prokaryotic respiration or photosynthesis
- Cell division in prokaryotes is limited to binary fission
- Items may use other cell parts not listed here as distractors

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9.4.1.2.5
Compare and contrast passive transport (including osmosis and facilitated transport) with active transport, such as endocytosis and exocytosis.
Item Specifications
- Active transport is limited to endocytosis and exocytosis
- Passive transport is limited to diffusion, osmosis and facilitated transport
- Additional vocabulary may include terms such as concentration gradient and selective barrier

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9.4.1.2.6
Explain the process of mitosis in the formation of identical new cells and maintaining chromosome number during asexual reproduction.
Item Specifications
- Items may require students to know that mitosis is part of the process that produces cells that are genetically identical with the same number of chromosomes
- Items addressing the process of mitosis may include knowing the sequence of events
- Items will NOT assess the terms haploid, diploid, interphase, prophase, metaphase, anaphase or telophase
- Items assessing this benchmark may also assess benchmark 9.4.4.2.5

Substrand: Interdependence Among Living Systems
(8–10 points)

Standard: The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems. (9.4.2.1)
(4–6 points)

Benchmarks

9.4.2.1.1

Describe factors that affect the carrying capacity of an ecosystem and relate these to population growth.

Item Specifications

- Examples of factors include resources such as food or nutrient availability, shelter, water and light
- Items may address how competition for the same resources decreases carrying capacity such as predators competing for the same resource
- Contexts will use examples of Minnesota ecosystems when appropriate

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9.4.2.1.2

Explain how ecosystems can change as a result of the introduction of one or more new species. For example: The effect of migration, localized evolution or disease organisms.

Item Specifications

- Contexts for items will use examples of Minnesota ecosystems when appropriate
- Items may require students to predict, analyze and reflect on global issues
- Items may include invasive species

Standard: Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways. (9.4.2.2)
(3–5 points)

Benchmarks

9.4.2.2.1

Use words and equations to differentiate between the processes of photosynthesis and respiration in terms of energy flow, beginning reactants and end products.

Item Specifications

- Items will refer to reactants and products of cellular respiration as oxygen, glucose, carbon dioxide, water, ATP
- Items will refer to reactants and products of photosynthesis as carbon dioxide, water, oxygen, glucose
- Molecular formulas will include labels, for example water (H_2O)
- Items will NOT require students to understand absorption spectra
- Items will NOT require students to recognize light reactions or the Calvin cycle
- Items will NOT include glycolysis, Krebs cycle, electron transport system or fermentation

9.4.2.2.2
Explain how matter and energy is transformed and transferred among organisms in an ecosystem, and how energy is dissipated as heat into the environment.
Item Specifications
- Items may address the processes of photosynthesis, respiration and decomposition in recycling matter
- Items may include energy and matter cycling in food chains and food webs
- Items may address the conceptual cycling of matter in the carbon, nitrogen and oxygen cycles but will NOT require a detailed understanding of the mechanisms of these cycles
- Items will NOT include glycolysis, Krebs cycle, electron transport system, fermentation or entropy
- Contexts for items will use examples of Minnesota ecosystems when appropriate
- Additional vocabulary may include terms such as producer, primary consumer, secondary consumer, tertiary consumer, decomposer, autotroph, heterotroph, energy pyramid, trophic level

Substrand: Evolution in Living Systems
(11–13 points)

Standard: Genetic information found in the cell provides information for assembling proteins, which dictate expression of traits in an individual. (9.4.3.1)
(2–4 points)

Benchmarks

9.4.3.1.1
Explain the relationships among DNA, genes and chromosomes.
Item Specifications
- Items will NOT include the terms histone, chromatin or chromatid

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9.4.3.1.2
In the context of a monohybrid cross, apply the terms phenotype, genotype, allele, homozygous and heterozygous.
Item Specifications
- Items may require students to understand a Punnett square
- Items may require students to understand dominant and recessive inheritance
- Items will NOT reference specific human genetic disorders
- Items will NOT use the terms or assess concepts of sex-linked, polygenic, incomplete dominance, codominance or multiple allele inheritance patterns

9.4.3.1.3
Describe the process of DNA replication and the role of DNA and RNA in assembling protein molecules.
Item Specifications
- Items may include the terms mRNA, tRNA, amino acids, Uracil in RNA and ribosomes
- Items may require students to know the location of replication, transcription and translation in addition to the role of DNA, mRNA and proteins (amino acids) in these processes
- Items may require students to understand DNA base pairing rules A=T and G=C
- Items may require students to understand RNA base pairing rules A=U and G=C
- Items will NOT reference specific human genetic disorders
- Items assessing this benchmark may also assess benchmark 9.4.1.2.2

Standard: Variation within a species is the natural result of new inheritable characteristics occurring from new combinations of existing genes or from mutations of genes in reproductive cells. (9.4.3.2)
(4–6 points)

Benchmarks

9.4.3.2.1
Use concepts from Mendel's laws of segregation and independent assortment to explain how sorting and recombination (crossing over) of genes during sexual reproduction (meiosis) increases the occurrence of variation in a species.
Item Specifications
- Items will NOT reference specific human genetic disorders
- The term recombination may be used to describe any event that results in new combinations of genetic material (e.g., crossing over, mutation, random fertilization)
- Items may require students to know that the products of meiosis are cells that are genetically unique with half the number of chromosomes
- Items will NOT use the terms haploid or diploid
- Additional vocabulary may include terms such as gamete, egg and sperm
- Items assessing this benchmark may also assess 9.4.3.3.4

9.4.3.2.2
Use the processes of mitosis and meiosis to explain the advantages and disadvantages of asexual and sexual reproduction.
Item Specifications
- Examples of advantages to sexual (meiosis) reproduction include genetic diversity
- Examples of disadvantages to sexual (meiosis) reproduction include expending increased energy and time
- Examples of advantages to asexual reproduction (mitosis) include no requirement of a mate and the organism may reproduce more rapidly
- Examples of disadvantages to asexual reproduction (mitosis) include decreased genetic variation
- Items will NOT use the terms haploid or diploid
- Additional vocabulary may include terms such as gamete, egg and sperm

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9.4.3.2.3
Explain how mutations like deletions, insertions, rearrangements or substitutions of DNA segments in gametes may have no effect, may harm, or rarely may be beneficial, and can result in genetic variation within a species.
Item Specifications
- Items will NOT require students to define or identify specific types of mutations (e.g., deletion, insertion, rearrangement, substitution)
- Items may use terms that describe specific mutations
- Items will NOT reference specific human genetic disorders
- Items assessing this benchmark may also assess benchmarks 9.4.4.2.4 and 9.4.4.2.5

Standard: Evolution by natural selection is a scientific explanation for the history and diversity of life on Earth. (9.4.3.3)
(3–5 points)

Benchmarks

9.4.3.3.1
Describe how evidence led Darwin to develop the theory of natural selection and common descent to explain evolution.
Item Specifications
- Items may require students to identify relevant evidence or connect evidence to the development of Darwin’s ideas

9.4.3.3.2
Use scientific evidence, including the fossil record, homologous structures, and genetic and/or biochemical similarities, to show evolutionary relationships among species.
Item Specifications
- Items may illustrate the concept of analogous structures but will NOT use the term
- Items may require understanding a graphical illustration of the relationships between organisms such as a cladogram or a phylogenetic tree but will NOT use these terms
- Items will NOT use specific terms involved in geological time scales
- Additional vocabulary may include terms such as common ancestor, relatedness and anatomical evidence

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9.4.3.3.3
Recognize that artificial selection has led to offspring through successive generations that can be very different in appearance and behavior from their distant ancestors.

9.4.3.3.4
Explain why genetic variation within a population is essential for evolution to occur.
Item Specifications
- Items assessing this benchmark may also assess benchmark 9.4.3.2.1

9.4.3.3.5
Explain how competition for finite resources and the changing environment promotes natural selection on offspring survival, depending on whether the offspring have characteristics that are advantageous or disadvantageous in the new environment.
Item Specifications
- Contexts for items will use examples of Minnesota ecosystems when appropriate

9.4.3.3.6
Explain how genetic variation between two populations of a given species is due, in part, to different selective pressures acting independently on each population and how, over time, these differences can lead to the development of new species.
Item Specifications
- Items may refer to the concept of directional, disruptive or stabilizing selection but will NOT use these terms
- Items may address the following processes and terms: divergence, convergence and adaptive radiation
- Items will NOT address the concept of bottlenecks, founder effects or genetic drift
- Contexts for items will use examples of Minnesota ecosystems when appropriate

Substrand: Human Interactions with Living Systems
(7–10 points)

Standard: Human activity has consequences on living organisms and ecosystems. (9.4.4.1)
(3–5 points)

Benchmarks

9.4.4.1.1
Describe the social, economic and ecological risks and benefits of biotechnology in agriculture and medicine. For example: Selective breeding, genetic engineering, and antibiotic development and use.
Item Specifications
- Items will NOT assess details of specific technological processes
- Items will NOT reference specific human diseases, human genetic disorders or human cloning
- Items assessing this benchmark may also assess benchmarks in standards 9.1.2.1 and 9.1.3.1 and benchmarks 9.1.3.4.1 and 9.4.3.3.3

9.4.4.1.2
Describe the social, economic and ecological risks and benefits of changing a natural ecosystem as a result of human activity. For example: Changing the temperature or composition of water, air or soil; altering the populations and communities, developing artificial ecosystems; or changing the use of land or water.
Item Specifications
- Contexts for items will use examples of Minnesota ecosystems when appropriate
- Items assessing this benchmark may also assess benchmarks in standards 9.1.2.1 and 9.1.3.1

9.4.4.1.3
Describe contributions from diverse cultures, including Minnesota American Indian tribes and communities, to the understanding of interactions among humans and living systems. For example: American Indian understanding of sustainable land use practices.
Item Specifications
- Items will be placed in contexts that give sufficient background information
- Items will NOT require students to match an individual to a specific contribution
- Items may require students to analyze the impact or results of a contribution when provided with a specific contribution
- Items assessing this benchmark may also assess benchmarks 9.1.3.2.1 and 9.1.1.1.6

Standard: Personal and community health can be affected by the environment, body functions, and human behavior. (9.4.4.2)
(4–6 points)

Benchmarks

9.4.4.2.1
Describe how some diseases can sometimes be predicted by genetic testing and how this affects parental and community decisions.
Item Specifications
- Items will NOT reference specific human diseases or genetic disorders
- Items will NOT require students to make ethical decisions

9.4.4.2.2
Explain how the body produces antibodies to fight disease and how vaccines assist this process.
Item Specifications
- Items will NOT reference specific human diseases or genetic disorders
- Items will NOT require students to identify specific vaccines
- Items may require students to understand the relationship between antigens and antibodies
- Items will NOT assess the specific processes by which antibodies are formed
- Additional vocabulary may include such terms as antihistamine

9.4.4.2.3
Describe how the immune system sometimes attacks some of the body's own cells and how some allergic reactions are caused by the body's immune responses to usually harmless environmental substances.
Item Specifications
- Items will NOT reference specific human diseases or genetic disorders
- Items may require students to understand the relationship between antigens and antibodies
- Items will NOT assess the specific processes by which antibodies are formed
- Additional vocabulary may include such terms as antihistamine

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9.4.4.2.4
Explain how environmental factors and personal decisions, such as water quality, air quality and smoking affect personal and community health.
Item Specifications
- Items will NOT require students to make ethical decisions
- Items may include point and nonpoint sources of pollution
- Items assessing this benchmark may also assess benchmarks in standards 9.1.2.1, 9.1.2.2 and 9.1.3.3 and benchmark 9.4.3.2.3

9.4.4.2.5
Recognize that a gene mutation in a cell can result in uncontrolled cell division called cancer, and how exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.
Item Specifications
- Items will NOT require students to make ethical decisions
- Items will NOT assess specific forms of cancer
- Items assessing this benchmark may also assess benchmarks 9.4.1.2.6 and 9.4.3.2.3