Grade Expectations for Vermont's Framework of Standards and Learning Opportunities

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c.

Summer 2004

(Science)

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STATE OF VERMONT
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Dear Vermont Educational Leader:

In the fall of 1996, the State Board of Education adopted *Vermont's Framework of Standards and Learning Opportunities*. Over the years thousands of Vermont teachers, parents and students have participated in group meetings and reviews aimed at improving the standards with the goal of making them more useful as guides to curriculum development. In 2000, the standards were formally revised and again adopted by the State Board.

Now, in the summer of 2004, another chapter in the standards, *Grade Expectations for Vermont's Framework of Standards and Learning Opportunities*, has been written. Each of the existing standards for Science has been carefully studied and applied to a process of development that has produced Grade Cluster Expectations (GCEs).

Like the Grade Level Expectations in Mathematics, Reading, and Writing, these GCEs are more specific statements of the Vermont standards in *Vermont's Framework*. Unlike the Grade Level Expectations (GLEs), which delineate specific grade levels, these Grade Expectations are organized by Grade Clusters (pre-K and K; 1 and 2; 3 and 4; 5 and 6; 7 and 8; and high school). The purpose of using grade clusters is to provide additional flexibility for alignment of local curriculum and local comprehensive assessment systems.

As in the development of the GLEs, the development and review of these Grade Expectations involved Department of Education and Vermont Institutes staff, teachers, administrators, content experts and professional associations. Nationally recognized standards, research and curriculum, standards from other states, and Vermont local curriculum were reviewed and considered as part of the development process.

I want to thank everyone who participated in this process.

Sincerely,

Richard H. Cate
Commissioner

Introduction

As Vermont educators work toward meeting the challenges of the School Quality Standards in Act 68 (formerly Act 60), open communication is critical. The School Quality Standards state:

> Vermont schools will have fully implemented a local comprehensive assessment system by which students are assessed in those *Framework* or comparable standards associated with the Fields of Knowledge and Vital Results and those standards associated with the arts, health and safety education, physical education, foreign languages and applied learning.

In response to this challenge, Grade Cluster Expectations (GCEs) have been developed. Assessment items are currently available on The Vermont Institutes website, and more will be added as they are developed for Science. Grade Expectations (GEs), encompass both Grade Level Expectations in Reading, Writing and Math, and Grade Cluster Expectations. These GEs will serve multiple purposes in terms of teaching, student learning, and local assessment.

What are GEs?

Vermont's Framework of Standards and Learning Opportunities provides the foundation for Local Comprehensive Assessment Systems. The creation of GEs will provide more explicit guidance. GEs will:

- provide a valuable resource for teachers and schools as they implement the Vermont Framework
- relate directly to the Vermont Standards and associated evidences
- differentiate performance on content knowledge or skills between adjacent grade clusters
- lead to focused, coherent and developmentally appropriate instruction without narrowing the curriculum

The purposes of the Vermont Framework will not change with the development of GEs.

Why two-grade clusters?

The GCEs specify two-grade cluster skills and content (PreK-K, 1-2, 3-4, 5-6, 7-8, and proficient at high school, and advanced at high school). Two-grade clusters will:

- provide more flexibility in creating local curriculum
- allow for a broader time span in which developmental changes can be addressed
- take into account local opportunities to learn

How were the GEs developed?

Grade Expectation development in Vermont involved many educators in order to get the best thinking for this important effort. This required work of teachers, content experts, curriculum coordinators, and administrators. Using background research in national, state, and local documents, committees of teachers came together to discuss and debate what was essential for Vermont's students to know and be able to do. These essential skills and concepts became the GEs, which were then reviewed by hundreds of teachers around the state during the field review process.

What are assessment items?

An assessment item could include performance, a product, a response to a prompt, a reflection, or a portfolio of work over time – a way of documenting what a student knows and is able to do.

Ideally, taken as a group, assessment items should:

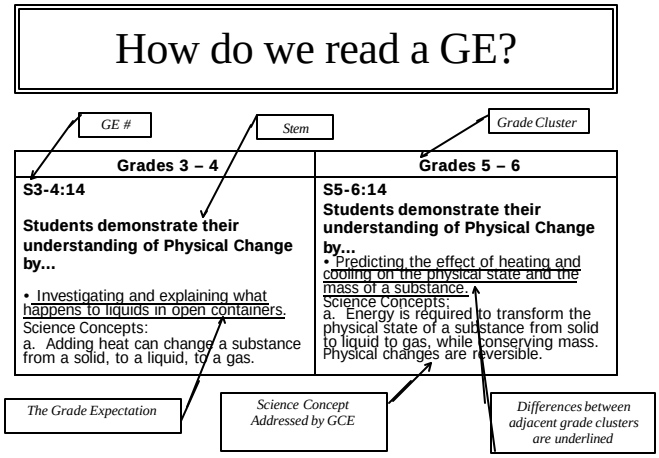
- focus on depth of understanding by identifying key knowledge and skills that progress developmentally
- provide clear guidance to classroom teachers on content and skills that can be adequately assessed
- assess what is essential for our learners right now and what will be essential for our students 5, 10, or 20 years from now
- be designed to help the learner revise his or her performance independently

Assessments will be available at: http://www.vermontinstitutes.org/assessment/index.htm.

How do you read the GEs?

As you read the GEs, remember that each has four parts:

- A bolded statement called the "stem" is at the beginning of each GCE. Each "stem" remains the same across the grades, and is meant to communicate the focus of the GCE across the grades.
- Bullets in a GCE indicate how the GCE is specified at that grade cluster.
- Differences between adjacent grades are underlined.
- "E.g.s" are **examples** (not requirements or limited sets) of student demonstration or further clarification of a GCE.



How do GEs fit into the curriculum?

The GEs are designed to work in conjunction with local decisions to help develop assessments and curricula, as represented by the following formula:

Content + Assessment (GEs) + Learning Opportunity + Teaching Opportunity = Curriculum

Science Overview

Educators from around the state, with the help of The Vermont Institutes, developed Science Grade Expectations as a means to identify the content knowledge and skills expected of all students for local assessment required under Act 68. This work was accomplished using the *Vermont's Framework of Standards and Learning Opportunities*, Vermont curricula, national standard documents, state standard documents, and current research as resources. The GEs were reviewed by science educators from around the state. The data from field review was collected, reviewed, and used to revise the GEs. They were then sent out for Expert Review and revised one final time.

Science GEs are not intended to represent the full curriculum for instruction at each grade cluster. GEs are meant to capture the essential learning elements that can be assessed locally. In other words, the GEs are a guide to assessment and should not "narrow" the curriculum for instructional purposes*.

GEs include concepts and skills not easily assessed in an on-demand setting. Many processes are ongoing throughout the school year and are best assessed within the classroom.

The *Grade Cluster Expectations* were developed from National Science Resources to help teachers and schools identify "core" learning goals (scientific concept benchmarks) and performance goals (evidence of achievement), as students progress through a continuum of scientific learning from grades Pre-K to Twelve. These Expectations can be used to guide both assessment and instruction. The GEs describe the specific developmental level of a learning goal within a two year grade span. At any one cluster, students would be expected to know or be able to do everything that came before as well as the new skills or concepts in the targeted cluster. The Science GEs align with Vermont Framework Standards: 7.1 Scientific Method, and 7.2 Investigation (Inquiry); 7.12 Space, Time, and Matter; 7.13 The Living World; 7.14 The Human Body; and 7.15, The Universe, Earth and Environment.

***The Science GEs represent learning elements that will be both addressed AND assessed at the designated grade cluster.**

Enduring Knowledge: These are unifying themes that address the fundamental knowledge of the domains of science. They are called "Enduring" because they contain essential ideas that students need to internalize and retain in order to achieve science literacy.

Grade Expectation (GE): This is an example of the evidence a teacher would look for in determining whether students understand a concept at an appropriate developmental level. The GE includes the content of the science concept, scientific inquiry as a way of knowing, and a cognitive demand that is appropriate for the concept and age group. In some cases, a grade cluster might not have a GE either because there is no concept benchmark at that level or because the concept is not developmentally appropriate.

Science Concept: This is an age appropriate description of the scientific concept addressed by the GE. Although the science concept statements are written for adults, they clearly outline the boundaries of understanding for particular age groups and outline a preK-12 continuum of conceptual growth. Most GEs have more than one associated science concept. The science concepts are lettered consecutively for each GE.

(Note: Inquiry GEs are skill-based and apply to all concept areas.)

Vermont Science Grade Cluster Expectations Overview Chart

GE Number(s)	Science Content	Vermont Standards and Evidences	Stem
Scientific Inquiry: ***Scientific Inquiry is a critical habit of mind for scientific literacy, and it is expected that Inquiry GEs (S:1-8) be addressed with students of each grade cluster with EACH of the**			
Enduring Knowledge (Scientific Questioning): Students raise scientifically oriented questions that can be answered through observations, experimentation and/or research. At early stages, students learn how to develop investigable questions that guide their work. At later stages, students connect their questions to scientific ideas, concepts, and quantitative relationships that inform investigations.			
S:1	**Scientific Questioning**	7.1a; 2.1 a, b, c, d, e	**S:1** Students demonstrate their understanding of scientific questioning.
Enduring Knowledge (Predicting and Hypothesizing): Scientists' explanations about what happens in the world come partly from what they observe and partly from what they think. Preliminary explanations are constructed with conceptual knowledge and propose a new level of understanding. At early stages, students think about what may happen during an investigation and justify their thinking. At later stages, students identify cause and effect relationships within an hypothesis and base			
S:2	**Predicting & Hypothesizing**	7.1 b	**S:2** Students demonstrate their understanding of predicting and hypothesizing.
Enduring Knowledge (Designing Experiments): Students design investigations that control variables, generate adequate data/observations to provide reasonable explanations and can be reproduced by other scientists. At early stages, experimental design reflects what the experimenter will do to answer a question and ensure that a test is fair. At later stages, students design investigations that will produce the appropriate kinds of evidence to support or refute an hypothesis. Multiple trials or the collection of multiple data points are incorporated into the design and variables are controlled to ensure that the investigation is valid and reproducible.			
S:3	**Designing Experiments**	7.1 c; 7.2 a; b; 2.2 a, b	**S:3** Students demonstrate their understanding of experimental design.
Enduring Knowledge (Conducting Experiments): Students follow an experimental design and use scientific tools (including measurement tools) appropriately and accurately. At early stages, students are encouraged to pay close attention to their experimental plan and record data throughout an investigation. At later stages, students engage in extended investigations and use more sophisticated science tools including computers .			
S:4	**Conducting Experiments**	7.1 c; 7.2 c, d; 2.2 e, f, g	**S:4** Students demonstrate their ability to conduct experiments
Enduring Knowledge (Representing Data and Analysis): Students represent data using text, charts, tables, graphs.			
S:5 **S:6** **S:7**	**Representing Data and Analysis**	7.1 c, d, e, f, g; 1.17 a, b, c, d; 1.20; 2.2 c, d	**S:5** Students demonstrate their ability to represent data. **S:6** Students demonstrate their ability to analyze data. **S:7** Students demonstrate their ability to explain data.
Enduring Knowledge (Applying Results): Students synthesize the results of an investigation by generating new questions related to the results of the investigation stating a general rule regarding the understandings learned from the investigation, or applying the understandings learned to similar situations. At early stages, students make connections between classroom investigations and similar situations or experiences. At later stages, students recognize that different explanations can sometimes arise from the same evidence. Students demonstrate an ability to resist overgeneralizations based on insufficient evidence and suggest the types of evidence that need to be gathered in order to better understand the focus of the investigation.			
S:8	**Applying Results**	7.1 g, h; 7.2 e, h	**S:8** Students demonstrate their ability to apply results.

Vermont Science Grade Cluster Expectations Overview Chart

GE Num-bers	Science Content	Vermont Standards and Evidences	Stem
Space, Time and Matter (Physical Science)			
Enduring Knowledge: All living and non-living things are composed of matter having characteristic properties that distinguish one substance from another.			
S:9 S:10 S:11 S:12 S:13	**Properties of Matter**	7.12—Applies to all, a, aa, aaa, b, bb, bbb, c, cc, ccc	**S:9, S:10, S:11** Students demonstrate their understanding of the properties of matter. **S:12** Students demonstrate their understanding of states of matter. **S:13** Students demonstrate their understanding of properties of a gas.
Enduring Knowledge: A transfer of energy can result in the physical change of state of a substance .			
S:14	**Physical Change**	7.12 e, ee, eee	**S:14** Students demonstrate their understanding of physical change.
Enduring Knowledge: When matter undergoes a chemical change it turns into a new and different sub stance whose properties are different that the original. No matter how substances interact with one another, the total mass of the system remains the same.			
S:15 S:16	**Chemical Change**	7.12b, bb, bbb; e, ee, eee	**S:15, S:16** Students demonstrate their understanding of chemical change.
Enduring Knowledge: The nucleus of some atoms is unstable and may spontaneously decay.			
S:17 S:18	**Nuclear Change**	7.12b, bb, bbb; e, ee, eee	**S:17, S:18** Students demonstrate their understanding of nuclear change.
Enduring Knowledge: Everything is constantly moving; motion is relative, but the motion of an object can be described and predicted by tracing and measuring its position over time.			
S:19 S:20	**Motion**	7.12 d, dd, ddd	**S:19, S:20** Students demonstrate their understanding of motion.
Enduring Knowledge: Force is an influence that can to change the motion of an object.			
S:21 S:22	**Force**	7.12 d, dd, ddd	**S: 21** Students demonstrate their understanding of force. **S:22** Students demonstrate their understanding of gravitational force.
Enduring Knowledge: Energy is necessary for change to occur. It is the ability of matter to bring about change. *** There are many forms of energy.** *** The total energy in the universe is constant.** ***Energy can be transformed and transferred, but not destroyed. (Conservation of Energy).** ***Energy transfers and transformations exhibit the characteristics of systems with inputs, processes and outputs as well as connections to other systems.**			
S:23 S:24 S:25 S:26 S:27 S:28, S:29	**Energy**	7.12 e, ee, eee; f, ff, fff	**S:23** Students demonstrate their understanding of heat energy. **S:24** Students demonstrate their understanding of electrical energy. **S:25** Students demonstrate their understanding of magnetism. **S:26 & S:27** Students demonstrate their understanding of electromagnetic forces. **S:28** Students demonstrate their understanding of light energy. **S:29** Students demonstrate their understanding of sound energy.

Vermont Science Grade Cluster Expectations Overview Chart

The Living World—Life Science			
GE Number(s)	**Science Content**	**Vermont Standards and Evidences**	**Stem**
Enduring Knowledge: All living organisms and their component cells have identifiable characteristics that allow for survival.			
S:30	**Survival of Organisms**	7.13 a, aa, aaa	**S:30** Students demonstrate their understanding of structure and function.
S:31	**Life Cycles and Reproduction**	7.13 c, cc, ccc	**S:31** Students demonstrate their understanding of reproduction.
S:32	**Cell and Tissue Differentiation**	7.13 b, bb, bbb	**S:32** Students demonstrate their understanding of differentiation.
S:33	**Chemical Reactions within Cells**	7.13 c, cc, ccc	**S:33** Students demonstrate their understanding of how energy flow within cells supports an organism's survival.
Enduring Knowledge: Energy enters an ecosystem in the form of sunlight and flows through the system to each cell. Matter interacts, changes and recycles in an ecosystem. Populations of organisms survive by maintaining interdependent relationships with one another and by utilizing biotic and abiotic resources from the environment.)			
S:34 **S:35** **S:36** **S:37**	**Interdependence within Ecosystems**	7.13 c, cc, ccc	**S:34** Students demonstrate their understanding of energy flow in an ecosystem. **S:35** Students demonstrate their understanding of food webs in an ecosystem. **S:36** Students demonstrate their understanding of equilibrium in an ecosystem. **S:37** Students demonstrate their understanding of recycling in an ecosystem.
Enduring Knowledge: All Living Things exhibit patterns of similarity in their structures, behaviors and biochemistry.			
S:38	**Classification of Living Things**	7.13 b, bb, bbb	**S:38** Students demonstrate their understanding of classification of organisms.
Enduring Knowledge: All Living Things exhibit patterns of similarity in their structures, behaviors and biochemistry.			
S:39	**Natural Selection/ Evolution**	7.13 d, dd, ddd	**S:39** Students demonstrate their understanding of evolution/ natural selection.

Vermont Science Grade Cluster Expectations Overview Chart

GE Number(s)	Science Content	Vermont Standards and Evidences	Stem
The Human Body			
Enduring Knowledge: **The human body is unique in its heredity, body systems and development and can be affected by the environment.**			
S:40	**Heredity**	7.14 a, aa, aaa	**S:40** Students demonstrate their understanding of human heredity.
S:41	**Body Systems**	7.14b, bb, bbb	**S:41** Students demonstrate their understanding of human body (biochemical)systems.
S:42	**Human Disease**	7.14 c, cc, ccc	**S:42** Students demonstrate their understanding of patterns of human health/disease.
S:43	**Patterns of Human Development**	7.14 c, cc, ccc	**S:43** Students demonstrate their understanding of the patterns of human development.
Universe, Earth and Environment—Earth Science			
Enduring Knowledge: **The universe, earth and all earth systems have undergone change in the past, continue to change in the present and predicted to continue changing in the future.**			
S:44	**Solar System**	7.15 d, dd, ddd	**S:44** Students demonstrate their understanding of the characteristics of the solar system.
S:45	**Scale, Distances, Star Formation, Theories, Instrumentation**	7.15 a, aa, aaa; d, dd, ddd; f, ff	**S:45** Students demonstrate their understanding of processes and change over time within systems of the universe.
S:46	**Earth Materials and the Rock Cycle**	7.15 b, bb, bbb	**S:46** Students demonstrate their understanding of processes and change over time.
S:47	**Forces and Changes on the Earth's Surface**	7.15 b, bb, bbb; c, cc, ccc	**S:47** Students demonstrate their understanding of processes and change over time within earth systems.
S:48	**Atmosphere, Water Cycle, Weather, Seasons**	7.15 c, cc, ccc	**S:48** Students demonstrate their understanding of processes and change over time within earth systems.
S:49	**Natural Resources**	7.15 e, ee, eee	**S:49** Students demonstrate their understanding of processes and change within natural resources.

Many thanks to all the educators and business persons around Vermont who gave of their time and expertise to develop these Science Grade Expectations.

Grades PreK-K

Scientific Questioning

SPK-K:1

Students demonstrate their understanding of SCIENTIFIC QUESTIONING by…

- Developing a question by completing the prompt, "I wonder. . .?"

AND

- Demonstrating a "questioning mind" through extended, intentional (purposeful) interactions with materials or people; Experiments with possibilities.

Predicting and Hypothesizing

SPK-K:2

Students demonstrate their understanding of PREDICTING AND HYPOTHESIZING by…

- Stating ideas about what may happen or be observed in the future (e.g., Student thinks ahead).

Designing Experiments

SPK-K:3

Students demonstrate their understanding of EXPERIMENTAL DESIGN by…

- Explaining the process of an investigation before and during the process (e.g., "on the job" planning, investigating, and explaining can happen simultaneously).

AND

- Using procedures that are safe and humane.

Grades 1-2

Scientific Questioning

S1-2:1

Students demonstrate their understanding of SCIENTIFIC QUESTIONING by…

- Posing observational questions that compare things in terms of number, shape, texture, size, weight, color, motion, etc. (e.g., How fast does a Lady Beetle move compared to a Bess Beetle?).

AND

- Investigating and completing questions to identify a variable that can be changed (e.g., What will happen if…? or I wonder if I change…?).

AND

- Generating new questions that could be explored at the end of an investigation.

Predicting and Hypothesizing

S1-2:2

Students demonstrate their understanding of PREDICTING AND HYPOTHESIZING by…

- Predicting a logical outcome to a situation, using prior knowledge, experience and/or evidence.

AND

- Explaining reasons for that prediction.

Designing Experiments

S1-2:3

Students demonstrate their understanding of EXPERIMENTAL DESIGN by…

- Writing a plan related to a question that includes:

  a. What the experimenter will do.

  b. What will be observed, measured, and/or compared.

AND

- Recording major steps sequentially.

Grades 3-4

Scientific Questioning

S3-4:1

Students demonstrate their understanding of SCIENTIFIC QUESTIONING by…

- Identifying at least one variable that affects a system and using that variable to generate an experimental question that includes a cause and effect relationship.

Predicting and Hypothesizing

S3-4:2

Students demonstrate their understanding of PREDICTING AND HYPOTHESIZING by…

- Identifying simple patterns of evidence used to develop a prediction and propose an explanation.

Designing Experiments

S3-4:3

Students demonstrate their understanding of EXPERIMENTAL DESIGN by…

- Writing a plan related to the question that includes:

  a. A list of materials needed.

  b. A diagram, with important elements labeled, that supports procedures and illustrates the setup.

  c. A procedure that lists steps sequentially (beginning, middle, and end) and describes how the experimenter will manipulate or change only one variable at a time. ("Fair Test").

  d. Appropriate timing between observations (intervals) and/or number of trials needed.

Grades 5-6

Scientific Questioning

S5-6:1

Students demonstrate their understanding of SCIENTIFIC QUESTIONING by …

- Distinguishing between observational, experimental, and research questions **(**e.g., Observational—How does a cricket chirp? Experimental—-Does the amount of light affect how a cricket chirps? Research—Do all crickets chirp? Why do crickets chirp?).

AND

- Identifying multiple variables that affect a system and using the variables to generate experimental questions that include cause and effect relationships.

Predicting and Hypothesizing

S 5-6: 2

Students demonstrate their understanding of PREDICTING AND HYPOTHESIZING by…

- Using logical inferences derived from evidence to predict what may happen or be observed in the future.

AND

- Providing an explanation (hypothesis) that is reasonable in terms of available evidence.

Designing Experiments

S5-6:3

Students demonstrate their understanding of EXPERIMENTAL DESIGN by…

- Writing a plan related to the question and prediction that includes:

  a. A list of materials needed that specifies quantities (e.g., 250 ml water).

  b. A procedure that lists significant steps sequentially and describes which variable will be manipulated or changed and which variables will remain the same **("Fair Test")**.

  c. An appropriate format for recording data,

  d. A strategy for conducting multiple trials **("Fair Test")**.

Grades 5-6

Scientific Questioning

S5-6:1

Students demonstrate their understanding of SCIENTIFIC QUESTIONING by …

- Identifying multiple variables that affect a system and using the variables to generate experimental questions that include cause and effect relationships.

AND

- Distinguishing between observational, experimental, and research questions **(**e.g., Observational—How does a cricket chirp? Experimental—-Does the amount of light affect how a cricket chirps? Research—Do all crickets chirp? Why do crickets chirp?).

Predicting and Hypothesizing

S5-6:2

Students demonstrate their understanding of PREDICTING AND HYPOTHESIZING by…

- Using logical inferences derived from evidence to predict what may happen or be observed in the future.

AND

- Providing an explanation (hypothesis) that is reasonable in terms of available evidence.

Designing Experiments

S5-6:3

Students demonstrate their understanding of EXPERIMENTAL DESIGN by…

- Writing a plan related to the question and prediction that includes:

  a. A list of materials needed that specifies quantities (e.g., 250 ml water).

  b. A procedure that lists significant steps sequentially and describes which variable will be manipulated or changed and which variables will remain the same **("Fair Test"**).

  c. An appropriate format for recording data.

  d. A strategy for conducting multiple trials **("Fair Test")**.

Grades 7-8

Scientific Questioning

S7-8:1

Students demonstrate their understanding of SCIENTIFIC QUESTIONING by…

- Developing questions that reflect prior knowledge.

AND

- Refining and focusing broad ill-defined questions.

Predicting and Hypothesizing

S7-8:2

Students demonstrate their understanding of PREDICTING AND HYPOTHESIZING by…

- Predicting results (evidence) that support the hypothesis.

AND

- Proposing a hypothesis based upon a scientific concept or principle, observation, or experience that identifies the relationship between variables.

Designing Experiments

S7-8:3

Students demonstrate their understanding of EXPERIMENTAL DESIGN by…

- Writing a plan related to the question, hypothesis, and prediction that includes:

  a. A diagram labeled using scientific terminology that supports procedures and illustrates the setup .

  b. A procedure that lists significant steps that identify manipulated (independent) and responding (dependent) variables.

  c. A control for comparing data when appropriate.

  d. Identification of tools and procedures for collecting data and reducing error.

Grades 9-12

Scientific Questioning

S9-12:1

Students demonstrate their understanding of SCIENTIFIC QUESTIONING by…

- Framing testable questions showing evidence of observations and prior knowledge to illustrate cause and effect.

AND

- Developing a testable question appropriate to the scientific domain being investigated.

Predicting and Hypothesizing

S 9-12:2

Students demonstrate their understanding of PREDICTING AND HYPOTHESIZING by…

- Developing a testable/guiding hypothesis and predictions based upon evidence of scientific principles.

AND

- Predicting results (evidence) that supports the hypothesis.

AND

- Clearly distinguishing cause and effect within a testable/guiding hypothesis.

Designing Experiments

S9-12:3

Students demonstrate their understanding of EXPERIMENTAL DESIGN by…

- Writing a plan that includes:

  a. Procedures that incorporate appropriate protection (e.g., no food in lab area).

  b. Appropriate tools, units of measurement and degree of accuracy.

  c. Components that reflect current scientific knowledge and available technology.

  d. Use of scientific terminology that supports the identified procedures.

Grades PreK-K

Conducting Experiments

SPK-K:4

Students demonstrate their ability to CONDUCT EXPERIMENTS by…

- Using more than one of the senses to make observations.

AND

- Describing obvious features of an object or event.

AND

- Representing data in a variety of ways including words, numbers, symbols, and pictures

AND

- Drawing scientifically:

  a. Recording shapes, prominent features with supporting details (e.g., eyelashes on eyes), and color.

  b. Spatially organizing and differentiating significant parts observed.

  c. Adding essential information to a diagram provided by the teacher.

  d. Using simple equipment and nonstandard measurement tools to gather data and extend the senses (e.g., balances, scales, counters, magnifiers).

  e. Following teacher guidance to complete steps while investigating a question.

Representing Data and Analysis

SPK-K:5

Students demonstrate their ability to REPRESENT DATA by…

- Organizing a piece of data (measurement or observation) or a group representation (e.g., pictograph, bar graph, or chart).

Grades 1-2

Conducting Experiments

S1-2:4

Students demonstrate their ability to CONDUCT EXPERIMENTS by…

- Referring to and following a simple plan for an investigation.

AND

- Describing observations using senses rather than feelings (e.g., The snail has a hard shell with wavy, brown lines, rather than the snail is awesome).

AND

- Recording observations of similarities and differences.

AND

- Drawing scientifically:

  a. Recording relative proportion (e.g., Eyes are approximately the right size when compared to the head) including focus on finer details, and differentiating all parts observed.

  b. Labeling significant aspects of a scientific drawing or diagram with words provided,

  c. Creating a title for a scientific drawing or diagram.

- Recording data (in a table provided by the teacher) generated from the use of simple science equipment , as well as nonstandard and standard measurement tools.

Representing Data and Analysis

S1-2:5

Students demonstrate their ability to REPRESENT DATA by…

- Organizing a collection of data into a table or a graph template.

AND

- Creating a title for a table or graph.

Grades 3-4	Grades 5-6
Conducting Experiments	**Conducting Experiments**
S3-4:4	**S5-6:4**
Students demonstrate their ability to CONDUCT EXPERIMENTS by…	**Students demonstrate their ability to CONDUCT EXPERIMENTS by…**
• Referring to and following a detailed plan for an investigation. **AND** • Clearly describing evidence and quantifying observations with appropriate units. **AND** • Recording data at various points during an investigation by reporting what actually happens, even when data conflicts with expectations. **AND** • Recording the sequence in which events take place. **AND** • Recording relevant details of an object and its surroundings when applicable. **AND** • Drawing scientifically: a. Recording varying degrees of color, shading or texture and consistent proportion throughout. b. Labeling significant parts of a scientific drawing or diagram and includes a key if necessary.	• Choosing appropriate measurements for the task and measuring accurately. **AND** • Collecting data and recording accurate and complete data from multiple trials. **AND** • Drawing scientifically: a. Selecting an appropriate perspective (e.g., cross section, top view, side view) and recording precise proportions.
Representing Data and Analysis	**Representing Data and Analysis**
S3-4:5	**S5-6:5**
Students demonstrate their ability to REPRESENT DATA by…	**Students demonstrate their ability to REPRESENT DATA by…**
• Classifying objects and phenomena into sets and subsets and justifying groupings. **AND** • Displaying and labeling data for separate trials/observations. **AND** • Determining an appropriate representation (graph or table or chart or diagram) to represent their findings most accurately. **AND** • Including in tables a title, labeled rows and columns and any necessary keys. **AND** • Including in graphs a title, labels, scale, and recording data correctly.	• Determining an appropriate representation (line graph in addition to prior examples) to represent their findings accurately. **AND** • Selecting a scale that is appropriate for range of data to be plotted, labels units, and presents data in an objective way. **AND** • Including clearly labeled keys and symbols, when necessary. **AND** • Using correct scientific terminology to label representations.

Grades 5-6	Grades 7-8
Conducting Experiments **S5-6:4** **Students demonstrate their ability to CONDUCT EXPERIMENTS by…** • Choosing appropriate measurements for the task and measuring accurately. **AND** • Collecting data and recording accurate and complete data from multiple trials. **AND** • Drawing scientifically: a. Selecting an appropriate perspective (e.g., cross section, top view, side view) and recording precise proportions.	**Conducting Experiments** **S7-8:4** **Students demonstrate their ability to CONDUCT EXPERIMENTS by…** • Accurately quantifying observations using appropriate measurement tools. **AND** • Using technology to collect, quantify, organize, and store observations (e.g., use of probe). **AND** • Drawing scientifically: a. Recording multiple perspectives to scale (e.g., magnification, cross section, top view, side view, etc.).
Representing Data and Analysis **S5-6:5** **Students demonstrate their ability to REPRESENT DATA by…** • Determining an appropriate representation (line graph in addition to prior examples) to represent their findings accurately. **AND** • Selecting a scale that is appropriate for range of data to be plotted, labels units, and presents data in an objective way. **AND** • Including clearly labeled keys and symbols, when necessary. **AND** • Using correct scientific terminology to label representations.	**Representing Data and Analysis** **S7-8:5** **Students demonstrate their ability to REPRESENT DATA by…** • Representing independent variable on the "X" axis and dependent variable on the "Y" axis. **AND** • Determining a scale for a diagram that is appropriate to the task. **AND** • Using technology to enhance a representation. **AND** • Using color, texture, symbols and other graphic strategies to clarify trends/patterns within a representation.

Grades 9-12

Conducting Experiments

S9-12:4:

Students demonstrate their ability to CONDUCT EXPERIMENTS by…

- Collecting significant data through completing multiple trials.

AND

- Evaluating and revising procedures as investigation progresses.

Representing Data and Analysis

S9-12:5

Students demonstrate their ability to REPRESENT DATA by…

- Representing data quantitatively to the appropriate level of precision through the use of mathematical calculations.

AND

- Developing the skill of drawing a "best fit" curve from data.

AND

- Recording accurate data, free of bias

AND

- Avoiding plagiarism/fabrication of other recorded research data.

Grades PreK-K	Grades 1-2
Representing Data and Analysis	**Representing Data and Analysis**
SPK-K:6 **Students demonstrate their ability to ANALYZE DATA by…** • Sorting objects based upon current observations and justifying groupings.	**S1-2:6** **Students demonstrate their ability to ANALYZE DATA by…** • Sorting and classifying objects based upon observations, prior knowledge, or experience and justifying groupings. **AND** • Identifying and describing the pattern in diagrams and charts (e.g., model, bar graph, pictograph, diagram or chart).
SPK-K:7 **Students demonstrate their ability to EXPLAIN DATA by…** • Explaining observations with the support of material props, photographs, drawings, or diagrams.	**S1-2:7** **Students demonstrate their ability to EXPLAIN DATA by…** • Developing a reasonable explanation based upon observations (e.g., I found out. . .).
Applying Results	**Applying Results**
SPK-K:8 **Students demonstrate their ability to APPLY RESULTS by…** • Identifying similarities between past experiences and current investigations.	**S1-2:8** **Students demonstrate their ability to APPLY RESULTS by…** • Generating new questions related to discoveries during an investigation. **AND** • Relating current investigation to a similar investigation.

Grades 3-4

Representing Data and Analysis

S3-4:6

Students demonstrate their ability to ANALYZE DATA by…

- Interpreting patterns or trends in data.

AND

- Relating data to the original question and prediction.

S3-4:7

Students demonstrate their ability to EXPLAIN DATA by…

- Providing a reasonable explanation that accurately reflects data.

AND

- Identifying differences between proposed predictions and experimental data.

Applying Results

S3-4:8

Students demonstrate their ability to APPLY RESULTS by…

- Generating a new question to obtain additional information.

AND

- Creating a plan to investigate a scientific concept further or connecting a classroom model to a real-world example.

AND

- Connecting the investigation or model to a real world example.

Grades 5-6

Representing Data and Analysis

S 5-6: 6

Students demonstrate their ability to ANALYZE DATA by…

- Identifying relationships of variables based upon evidence.

AND

- Questioning data that might not seem accurate or does not fit into the pattern of other findings.

S5-6:7

Students demonstrate their ability to EXPLAIN DATA by…

- Explaining data using correct scientific terminology.

AND

- Using experimental results to support or refute original hypothesis.

AND

- Considering all data when developing an explanation/conclusion.

AND

- Using additional resources (e.g., books, journals, databases, interview, etc.) to strengthen an explanation.

AND

- Identifying problems/flaws with the experimental design.

AND

- Preparing a conclusion statement/summary.

Applying Results

S5-6:8

Students demonstrate their ability to APPLY RESULTS by…

- Explaining how experimental findings can be generalized to other situations.

Grades 5-6

Representing Data and Analysis

S 5-6: 6

Students demonstrate their ability to ANALYZE DATA by…

- Identifying relationships of variables based upon evidence.

AND

- Questioning data that might not seem accurate or does not fit into the pattern of other findings.

S5-6:7

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- Explaining data using correct scientific terminology.

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- Considering all data when developing an explanation/conclusion.

AND

- Using additional resources (e.g., books, journals, databases, interview, etc.) to strengthen an explanation.

AND

- Identifying problems/flaws with the experimental design.

AND

- Preparing a conclusion statement/summary.

Applying Results

S5-6:8

Students demonstrate their ability to APPLY RESULTS by…

- Explaining how experimental findings can be generalized to other situations.

Grades 7-8

Representing Data and Analysis

S7-8:6

Students demonstrate their ability to ANALYZE DATA by…

- Identifying, considering and addressing experimental errors (e.g., errors in experimental design, errors in data collection procedures).

AND

- Identifying limitations and/or sources of error within the experimental design.

S7-8:7

Students demonstrate their ability to EXPLAIN DATA by…

- Using scientific concepts, models, and terminology to report results, discuss relationships, and propose new explanations.

AND

- Generating alternative explanations.

AND

- Documenting and explaining changes in experimental design.

AND

- Sharing conclusion/summary with appropriate audience beyond the research group.

AND

- Using mathematical analysis as an integral component of the conclusion.

Applying Results

S7-8:8

Students demonstrate their ability to APPLY RESULTS by…

- Identifying additional data that would strengthen an investigation.

AND

- Explaining limitations for generalizing findings.

AND

- Explaining relevance of findings (e.g., So what?) to local environment (community, school, classroom)

AND

- Devising recommendations for further investigation and making decisions based on evidence.

Grades 9-12

Representing Data and Analysis

S9-12:6

Students demonstrate their ability to ANALYZE DATA by…

- Accounting for identified experimental errors.

AND

- Analyzing significance of experimental data.

AND

- Critically comparing evidence collected with that of others (e.g., classmates or scientists in the field).

S9-12:7

Students demonstrate their ability to EXPLAIN DATA by…

- Proposing, synthesizing, and evaluating alternative explanations for experimental results.

AND

- Citing experimental evidence within explanation.

AND

- Including logically consistent position to explain observed phenomena.

AND

- Comparing experimental conclusion to other proposed explanations by peer review (e.g., students, scientists or local interest groups).

AND

- Conducting objective scientific analysis, free of bias.

AND

- Identifying and evaluating uncontrolled variables inherent in experimental model.

EXTENSION:

- Considering multiple variables when interpreting mathematical analysis.

Applying Results

S9-12:8

Students demonstrate their ability to APPLY RESULTS by…

- Using technology to communicate results effectively and appropriately to others (e.g., power point, web site, posters, etc.).

AND

- Predicting/recommending how scientific conclusions can be applied to civic, economic or social issues.

AND

- Proposing and evaluating new questions, predictions, procedures and technology for further investigations.

Physical Science: Vermont Standards and Evidences—Properties of Matter 7.12 a, aa, aaa, b, bb, bbb, c, cc, ccc, 3.10, 3.11, 3.13 [See also connection with S: 14 Physical Science—Physical Change]

Grades PreK-K

Properties of Matter

SPK-K:9

Students demonstrate their understanding of the Properties of Matter by…

- Observing and sorting substances that are solids and liquids and identifying their differences.

Science Concepts:

a. The physical properties of objects can be sorted by how they are alike or different.

b. Objects can be sorted according to their properties.

SPK-K:10

Not assessed at this grade level

SPK-K:11

Not assessed at this grade level

Grades 1-2

Properties of Matter

S1-2:9

Students demonstrate their understanding of Properties of Matter by…

- Identifying, recording and comparing characteristics of objects made of similar and different properties.

Science Concepts:

a. Objects are made of one or more materials such as paper, wood, metal, or cloth.

b. Similarities and differences in physical properties can be identified.

S1-2:10

Not assessed at this grade level

S1-2:11

Not assessed at this grade level

Grades 3-4

Properties of Matter

S3-4:9

Students demonstrate their understanding of the Properties of Matter by…

- Investigating and measuring how the total weight of the parts of a substance, no matter how they are combined, remains the same (e.g., water and gravel mixture, or a Legoâ car system, or the weight of sugar plus the weight of water equals the total weight of the sugar solution).

Science Concepts:

a. All matter has weight that can be measured.

b. The weight of the whole is the same as the sum of the parts.

c. Most objects/substances are made of smaller parts.

S3-4:10

Not assessed at this grade level

S3-4:11

Not assessed at this grade level

Grades 5-6

Properties of Matter

S5-6:9

Students demonstrate their understanding of the Properties of Matter by…

- Investigating and explaining how the relative volume or mass of an object affects the density of the object.

Science Concepts:

a. All substances have a unique density that depends on the volume (amount of space) that the substance is packed into.

b. The relative densities of substances can be observed and described.

S5-6:10

Not assessed at this grade level

S5-6:11

Not assessed at this grade level

Physical Science: Vermont Standards and Evidences—Properties of Matter 7.12 a, aa, aaa, b, bb, bbb, c, cc, ccc, 3.10, 3.11, 3.13 [See also connection with S: 14 Physical Science—Physical Change]

Grades 5-6

Properties of Matter

S5-6:9

Students demonstrate their understanding of the Properties of Matter by…

- Investigating and explaining how the relative volume or mass of an object affects the density of the object.

Science Concepts:

a. All substances have a unique density that depends on the volume (amount of space) that the substance is packed into.

b. The relative densities of substances can be observed and described.

S5-6:10

Not assessed at this grade level

S5-6:11

Not assessed at this grade level

Grades 7-8

Properties of Matter

S7-8:9

Students demonstrate their understanding of the Properties of Matter by…

- Calculating the density of regularly and irregularly shaped objects.

AND

- Explaining why all three states of matter can be observed in a room that has a uniform temperature.

Science Concepts:

a. The density of a substance can be measured and quantified as the mass (amount of a substance) that is contained per unit volume of that substance.

b. Changing the temperature of materials will change the density of the material.

S7-8:10

Students demonstrate their understanding of the Properties of Matter by…

- Illustrating through words or representations, the differences between atoms and molecules.

AND

- Recognizing that all living and non-living things are formed from combinations of about 100 elements.

Science Concepts:

a. All matter is made up of atoms that are too small to see.

b. Atoms bond together to form molecules.

c. An element is a substance in which the atoms are all the same.

d. All living and non-living things are formed from combinations of about 100 elements.

S7-8:11

Not assessed at this level

Grades 9-12

Properties of Matter

S9-12:9

Students demonstrate their understanding of Properties of Matter by…

- Distinguishing one substance from another through examination of physical properties (such as density, melting point, conductivity), chemical properties (such as reactivity with O_2 or acid or water), and nuclear properties (such as changes in atomic mass, isotopes and half-life).

Science Concepts:

a. Substances (elements, compounds) differ from one another based on their physical, chemical and nuclear properties.

S9-12:10

Students demonstrate their understanding of Properties of Matter by…

- Comparing the characteristics of three major components of all atoms (protons, electrons, neutrons) their location within an atom, their relative size and their charge.

AND

- Writing formulae for compounds and developing models using electron structure (e.g., Lewis dot).

Science Concepts:

a. Atoms have a dense nucleus containing positively charged protons and neutral neutrons. The number of protons in the nucleus determines the identity of an element.

b. The nucleus of an atom is surrounded by much lighter negatively-charged electrons in .mostly empty space.

c. In neutral atoms the number of protons and electrons is equal.

d. The arrangement of electrons of an atom determines what kinds of bonds are formed to produce molecules (compounds).

S9-12:11

Students demonstrate their understanding of the Properties of Matter by…

- Identifying and explaining the basis for the arrangement of elements within the Periodic Table (e.g., trends, valence, reactivity, electro negativity, ionization).

AND

- Determining valence electrons of selected elements.

AND

- Predicting the relative physical and chemical properties of an element based on its location within the Periodic Table.

Science Concepts:

a. Elements (substances composed of a single type of atom) are arranged in repeating.

b. The arrangement of electrons of an atom determines placement in the Periodic Table.

Extension

Properties of Matter

S9-12:9

Students demonstrate their understanding of Properties of Matter by…

- Explaining the states of a substance in terms of the particulate nature of matter and the forces of interaction between particles.

Science Concepts:

a. Substances (elements, compounds) differ from one another based on their physical, chemical and nuclear properties.

Physical Science: Vermont Standards and Evidences—Properties of Matter 7.12 a, aa, aaa, b, bb, bbb, c, cc, ccc, 3.10, 3.11, 3.13 [See also connection with S: 14 Physical Science—Physical Change]

Grades PreK-K	Grades 1-2
Properties of Matter	**Properties of Matter**
SPK-K:12	**S1-2:12**
Not assessed at this level	**Students demonstrate their understanding of the States of Matter by…** • Identifying, describing and comparing the state of matter of solids and liquids. Science Concepts: a. Solids and liquids are states of matter and have properties that can be described. b. Solids have the properties of hardness, color, and ability to maintain shape. c. Liquids have properties of color, tendency to flow, ability to mix with other liquids, taking up the shape of the container.
SPK-K:13	**S1-2:13**
Not assessed at this level	**Not assessed at this level**

Grades 3-4	Grades 5-6
Properties of Matter **S3-4:12** **Students demonstrate their understanding of the States of Matter by…** • Identifying , describing and comparing the properties of selected solids, liquids and gases. Science Concepts: a. Solids, liquids and gases are states of matter that can be observed, described, and measured. b. Gases take up as much space as you give them.	**Properties of Matter** **S5-6:12** **Not assessed at this grade level** **Teachers may review Grades 3-4 States of Matter Concepts**
S3-4:13 **Students demonstrate their understanding of the Properties of a Gas by…** • Experimenting with gas in a closed container (such as a balloon or a bag) and describing how pressure on the container changes when the volume of the gas changes. Science Concepts: a. Gas is a state of matter that takes up space**.**	**S5-6:13** **Students demonstrate their understanding of the Properties of a Gas by** • Measuring the mass of a gas (e.g., air in a basketball). Science Concept: a. Gas is a state of matter that has mass.

Physical Science: Vermont Standards and Evidences—Properties of Matter 7.12 a, aa, aaa, b, bb, bbb, c, cc, ccc, 3.10, 3.11, 3.13 [See also connection with S: 14 Physical Science—Physical Change]

Grades 5-6	Grades 7-8
Properties of Matter	**Properties of Matter**
S5-6:12	**S7-8:12**
Not assessed at this grade level	**Students demonstrate their understanding of the States of Matter by…**
Teachers may review Grades 3-4 States of Matter Concepts	• Modeling (plays, models, diagrams) molecular motion of the three states of matter and explaining how that motion defines each state.
	Science Concepts:
	a. Atoms and molecules are in perpetual motion.
	b. The atoms in solids only vibrate closely together.
	c. The atoms in liquids loosely slide past one another.
	d. The atoms in gases move freely apart from one another, and collide with one another.
S5-6:13	**S7-8:13**
Students demonstrate their understanding of the Properties of a Gas by	**Students demonstrate their understanding of the Properties of a Gas by…**
• Measuring the mass of a gas (e.g., air in a basketball).	• Using real world examples (tires, balloons, soda) predict and explain the effect that a change in one variable (pressure, temperature or volume) will have on the other (s).
Science Concept:	Science Concepts:
a. Gas is a state of matter that has mass.	a. There exists a predictable relationship among the volume, temperature, and amount of a gas and the pressure the gas exerts
	b. For any specified amount of a gas, the pressure that the gas exerts will increase as the temperature increases or the volume of the gas decreases. The pressure that the gas exerts will decrease as the temperature decreases or the volume of the gas increases.
	c. Gases exert pressure in all directions.

Grades 9-12	Extensions
Properties of Matter	**Properties of Matter**
S9-12:12	**S9-12:12**
Not assessed at this grade level	**Students demonstrate their understanding of the States of Matter by…**
Teachers may review Grades 7-8 States of Matter Concepts	• Investigating the interactions between atoms or molecules within a system (e.g., hydrogen bonding, van der Waals forces, fluorescent light, stars). Science Concepts: a. Solids, liquids and gases differ in distance and angles between atoms or molecules and the energy that binds them. b. Plasma is another state of matter composed of electrons and positive ions that have been separated by collisions at very high temperatures.
S9-12:13	**S9-12:13**
Students demonstrate their understanding of the Properties of a Gas by...	**Students demonstrate their understanding of the Properties of a Gas by…**
• Determining the pressure of a given volume of gas when the temperature changes incrementally (doubles, triples, etc.).	• Quantitatively determining how volume, pressure, temperature and amount of gas affect each other (PV=nRT) in a system**.**
Science Concepts: a. There are specific proportional relationships that exist among volume, pressure, temperature and amount of gas (mass) in a system.	Science Concepts: a. There are specific relationships that exist between volume, pressure, temperature and amount of gas (moles).

Physical Science: Vermont Standards and Evidences—Energy and Energy Transformation 7.12 b, bb, bbb; Chemical Change 7.12 b, bb, bbb, e, ee, eee, 2.2, 3.10, 3.11 [See also connection with S: 48 Universe, Earth, Environment—Weather]

Grades PreK-K	Grades 1-2
Properties of Matter	**Properties of Matter**
No SPK-K:14 at this grade level	**S1-2:14** **Students demonstrate their understanding of Physical Change by…** • Describing and reporting the change in properties when heat is applied to a solid or when heat leaves a liquid (e.g., water and ice). Science Concepts: a. Heating and cooling (changes in temperature) can change states of matter. Water can be a liquid or a solid through the processes of melting and freezing.
Chemical Change	**Chemical Change**
No SPK-K:15 at this grade level	**No S1-2:15 at this grade level**
No SPK-K:16 at this grade level	**No S1-2:16 at this grade level**

Grades 3-4

Properties of Matter

S3-4:14

Students demonstrate their understanding of Physical Change by…

- Investigating and explaining what happens to liquids in open containers.

Science Concepts:

a. Adding heat can change a substance from a solid, to a liquid, to a gas.

Chemical Change

No S3-4:15 at this grade level

No S3-4:16 at this grade level

Grades 5-6

Properties of Matter

S5-6:14

Students demonstrate their understanding of Physical Change by…

- Predicting the effect of heating and cooling on the physical state and the mass of a substance.

Science Concepts:

a. Energy is required to transform the physical state of a substance from solid to liquid to gas, while conserving mass. Physical changes are reversible.

Chemical Change

S5-6:15

Students demonstrate their understanding of Chemical Change by…

- Observing evidence of simple chemical change to identify that new substances are formed when a chemical reaction has occurred (e.g., rusted nail, vinegar combined with baking soda).

Science Concepts:

a. Simple chemical reactions will produce new substances that might be indicated by a different state of matter, a color change, or a temperature change of the substances.

No S5-6:16 at this level

Grades 5-6

Properties of Matter

S5-6:14

Students demonstrate their understanding of Physical Change by…

- Predicting the effect of heating and cooling on the physical state and the mass of a substance.

Science Concepts:

a. Energy is required to transform the physical state of a substance from solid to liquid to gas, while conserving mass. Physical changes are reversible.

Chemical Change

S5-6:15

Students demonstrate their understanding of Chemical Change by…

- Observing evidence of simple chemical change to identify that new substances are formed when a chemical reaction has occurred (e.g., rusted nail, vinegar combined with baking soda).

Science Concepts:

a. Simple chemical reactions will produce new substances that might be indicated by a different state of matter, a color change, or a temperature change of the substances.

No S5-6:16 at this level

Grades 7-8

Properties of Matter

S7-8:14

Students demonstrate their understanding of Physical Change by…

- Constructing their own models representing the states of matter at the molecular level and explaining the effect of increased and decreased heat energy on the motion and arrangement of molecules.

AND

- Observing the physical processes of evaporation and condensation, and accounting for the disappearance and appearance of liquid water in terms of molecular motion and conservation of mass.

Science Concepts:

a. Increased temperature of substances causes increased motion of the atoms and molecules in the substance.

b. As the temperature and motion of molecules in a substance increase, the space between molecules in the substance increases possibly causing a change in state.

Chemical Change

S7-8:15

Students demonstrate their understanding of Chemical Change by…

- Observing evidence of chemical change, and offering qualitative explanations for the observed changes in substances in terms of interaction and rearrangement of the atoms, and the production of new substances with different characteristics but the same mass as the original substance.

Science Concepts:

a. Chemical change is a transformation of matter that results from the interaction of the molecules in a substance and a new substance results (e.g., electrophoresis of water). Chemical change is not reversible.

b. During chemical change, the atoms in the substances are rearranged and because the mass of the product of a chemical reaction is the same as the mass of the reactants in that reaction, we know the total number of atoms in the substances stays the same.

No S7-8:16 at this level

Grades 9-12

Properties of Matter

S9-12:14

Students demonstrate their understanding of Physical Change by…

- Investigating and graphing the effect of heat energy on the phase changes of water from a solid state to a liquid state to a gaseous state and comparing that data to other substances.

Science Concepts:

a. Different compounds require different amounts of energy for phase change due to their unique molecular structure.

Chemical Change

S9-12:15

Students demonstrate their understanding of Chemical Change by…

- Writing simple balanced chemical equations to represent chemical reactions and illustrate the conservation of atoms.

AND

- Qualitatively predicting reactants and products in a prescribed investigation (e.g. oxidation, reduction, acid/base reactions).

Science Concepts:

a. The mass of reactants of any chemical reaction is the same as the mass of the products of that chemical reaction (The total mass of reactants is also the same as the total mass of products in a chemical reaction.).

S9-12:16

Students demonstrate their understanding of Chemical Change by…

- Investigating, and explaining the increase or decrease in temperature of the substances in a chemical reaction caused by a transfer of heat energy from that reaction. (e.g., exothermic and endothermic reactions).

Science Concepts:

a. During a chemical change, energy is absorbed or released (e.g., AMP, ADP, ATP or burning wood).

Extensions

Properties of Matter

S 9-12: 15

Students demonstrate their understanding of Chemical Change by…

- Using chemical equations and information about molar masses to predict quantitatively the masses of reactants and products in chemical reactions.

Science Concepts:

a. The numbers of atoms of the reactants of any chemical reaction are the same as the numbers of atoms of the products of that chemical reaction.

Grades PreK-K	Grades 1-2
Properties of Matter	**Properties of Matter**
No SPK-K:17 at this level	**No S1-2:17 at this level**
No SPK-K:18 at this level	**No S1-2:18 at this level**

Grades 3-4

Properties of Matter

No S3-4:17 at this level

No S3-4:18 at this level

Grades 5-6

Properties of Matter

No S5-6:17 at this level

No S5-6:18 at this level

Grades 5-6	Grades 7-8
Properties of Matter	**Properties of Matter**
No S5-6:17 at this level	**No S7-8:17 at this grade level**
No S5-6:18 at this level	**No S7-8:18 at this grade level**

Grades 9-12

Properties of Matter

S9-12:17

Students demonstrate their understanding of Nuclear Change by…

- Explaining how alpha and beta emissions create changes in the nucleus of an atom, resulting in a completely different element.

AND

- Distinguishing between the reactants and products of a chemical reaction and those of a nuclear decay reaction.

AND

- Comparing the relative energies produced by each.

AND

- Explaining the organization of an atomic nucleus and identifying the universal forces from strongest to weakest.

Science Concepts:

a. The number of neutrons in the nucleus can vary and gives rise to different isotopes of an element.

b. Certain nuclear configurations lead to radioactive decay, producing alpha and beta particles, and ultimately a different element.

c Nuclear forces, which exist only within the nucleus of an atom, are the forces that hold the nucleus of an atom together and are much stronger than either gravitational or electrical forces.

S9-12:18

Students demonstrate their understanding of Nuclear Change by…

- Explaining the concept of half-life and using the half-life principle to predict the approximate age of a material (See Half-Life Investigation on VI website).

Science Concepts:

a. Radioactive decay occurs at a predictable rate (half-life) which allows radioactivity to be used for estimating the age of materials that contain radioactive substances.

Extensions

Properties of Matter

S9-12:17

Students demonstrate their understanding of Nuclear Change by…

- Comparing the transmission and penetration effects of alpha, beta and gamma radiation.

Science Concepts:

a. Gamma radiation may also be produced.

Grades PreK-K

Motion

SPK-K:19

Students demonstrate their understanding of Motion by…

- Manipulating objects and observing and describing the motion.

Science Concepts:

a. The position of an object can be described. (e.g., in front of or behind)

b. The motion of an object can be described as a direction. (e.g., straight, zig zag, round and round back and forth, up, down).

No SPK-K:20 at this level

Grades 1-2

Motion

S1-2:19

Students demonstrate their understanding of Motion by

- Investigating and describing how objects move in different ways.

Science Concepts:

a. The position and movement of an object can be described such as fast, slow, speeding up and slowing down and movement in different directions.

No S1-2:20 at this level

Grades 3-4

Motion

No S3-4:19 at this grade level

Teachers may review Grades 1-2 Motion Concepts.

No S3-4:20 at this grade level

Grades 5-6

Motion

S5-6:19

Students demonstrate their understanding of Motion by…

- Measuring and calculating speed (the distance an object moves over a measured amount of time).

Science Concepts:

a. Speed indicates the rate at which an object is traveling.

b. Speed is a relationship between the distance an object travels and time elapsed.

S5-6:20

Students demonstrate their understanding of Motion by…

- Investigating and identifying evidence of an object's inertia and explaining their observation in terms of the object's tendency to resist a change in motion.

Science Concepts:

a. Inertia is the tendency of an object that depends on the object's mass. The inertia (mass) of an object resists change in the object's motion (Stationary objects remain stationary; moving objects continue moving: Newton's First Law).

Grades 5-6

Motion

S5-6:19

Students demonstrate their understanding of Motion by…

- Measuring and calculating speed (the distance an object moves over a measured amount of time).

Science Concepts:

a. Speed indicates the rate at which an object is traveling.

b. Speed is a relationship between the distance an object travels and time elapsed.

S5-6:20

Students demonstrate their understanding of Motion by…

- Investigating and identifying evidence of an object's inertia and explaining their observation in terms of the object's tendency to resist a change in motion.

Science Concepts:

a. Inertia is the tendency of an object that depends on the object's mass. The inertia (mass) of an object resists change in the object's motion (Stationary objects remain stationary; moving objects continue moving: Newton's First Law).

Grades 7-8

Motion

S7-8:19

Students demonstrate their understanding of Motion by...

- Designing investigations that illustrate the effect of a change in mass or velocity on an object's momentum.

AND

- Describing that the acceleration of an object is proportional to the force on the object and inversely proportional to the mass of the object.

Science Concepts:

a. Velocity indicates the speed and the direction of a moving object.

b. Momentum is the characteristic of an object in motion that depends on the object's mass and velocity. Momentum provides the ability for a moving object to stay in motion without an additional force.

c. Acceleration is a relationship between the force applied to a moving object and the mass of the object (Newton's Second Law).

No S7-8:20 at this level

Teachers may review Grade 5-6 Motion Concepts

Grades 9-12

Motion

S9-12:19

Students demonstrate their understanding of Motion by...

- Predicting the path of an object in different reference planes and explaining how and why this occurs.

AND

- Using modeling, illustrating and explaining of how distance and velocity change over time for a free falling object.

AND

- Modeling, illustrating and explaining the path of an object which has horizontal and free fall motion (i.e., football, bullet).

Science Concept:

a. Motion is relative. The motion of an object is observed and measured relative to a given frame of reference (point of view) (e.g. trees flashing by when sitting in a moving vehicle).

b. Acceleration occurs when an object undergoes a change in velocity over time (speed up, slow down, change direction).

c. .Motion is predictable; a falling object increases speed in a predictable pattern as it falls.

d. Motion is predictable; projectile motion combines a uniform horizontal motion and free-fall motion simultaneously.

S9-12:20

Students demonstrate their understanding of Motion by…

- Qualitatively analyzing how inertia affects the outcome in each of a series of situations (i.e., kicking a sand-filled football, moving a bowl of soup quickly across the table).

Science Concept:

a. An object at rest or moving uniformly (in a straight line) will remain so unless acted upon by an external unbalanced (net) force. (Newton's Third Law The Law of Inertia) (e.g., We wear seatbelts, because our body has a tendency to keep moving when the vehicle stops.).

Extensions

Motion

S9-12:19

Students demonstrate their understanding of the predictability of Motion by...

- Using a quantitative representation of how distance and velocity change over time for a free falling object.

AND

- Using a quantitative representation of the path of an object which has horizontal and free fall motion (i.e., football, bullet).

Science Concept:

a. Motion is predictable; a falling object increases speed in a predictable pattern as it falls.

b. Motion is predictable; projectile motion combines a uniform horizontal motion and free-fall motion simultaneously.

Grades PreK-K

Force

No SPK-K:21 at this grade level

No SPK-K:22 at this grade level

Grades 1-2

Force

S1-2:21

Students demonstrate their understanding of Force by…

- Investigating and identifying how pushing or pulling moves or does not move an object.

Science Concepts:

a. A force is a push or a pull. Force can change the motion of an object.

S1-2:22

Students demonstrate their understanding of Gravitational Force by…

- Observing and describing that different objects fall to the earth unless something is holding them up.

Science Concepts:

a. Objects fall to the ground unless something holds them.

Grades 3-4

Force

S3-4:21

Students demonstrate their understanding of Force by…

- Investigating and describing how different amounts of force can change the direction and speed of an object in motion.

Science Concepts:

a. Changes in speed or direction of motion are caused by forces.

b. The greater the force, the greater the change of motion.

No S3-4:22 at this grade level

Teachers may review Grade 1-2 Force Concepts

Grades 5-6

Force

S5-6:21

Students demonstrate their understanding of Force by…

- Investigating variables that change an object's speed, direction, or both, and identifying and describing the forces that cause the change in motion.

Science Concepts:

a. A force applied to a moving object will change the object's speed, direction or both.

b. Friction is a force that often opposes motion.

c. Gravity and magnetism are examples of long-range forces that do not require direct contact of the interacting objects.

S5-6:22

Students demonstrate their understanding of Gravitational force by…

- Predicting the effect of gravitational forces between pairs of objects (i.e., earth and object's on the surface, earth and moon, earth and sun).

Science Concepts:

a. Gravity is the force that holds objects to the earth's surface, keeps planets, in orbit around the sun and governs the rest of the motion in the solar system.

b. The force of gravity pulls toward the center of mass of an object.

Grades 5-6

Force

S5-6:21

Students demonstrate their understanding of Force by…

- Investigating variables that change an object's speed, direction, or both, and identifying and describing the forces that cause the change in motion.

Science Concepts:

a. A force applied to a moving object will change the object's speed, direction or both.

b. Friction is a force that often opposes motion.

c. Gravity and magnetism are examples of long-range forces that do not require direct contact of the interacting objects.

S5-6:22

Students demonstrate their understanding of Gravitational force by…

- Predicting the effect of gravitational forces between pairs of objects (i.e., earth and object's on the surface, earth and moon, earth and sun).

Science Concepts:

a. Gravity is the force that holds objects to the earth's surface, keeps planets, in orbit around the sun and governs the rest of the motion in the solar system.

b. The force of gravity pulls toward the center of mass of an object.

Grades 7-8

Force

S7-8:21

Students demonstrate their understanding of Force by…

- Diagramming or describing, after observing a scenario with a moving object, the forces acting on the object before and after it is put in motion (Students include in their diagram or description, the effect of these forces on the motion of the object.)

Science Concepts:

a. If there is no change in the speed or direction of a moving object or stationary object, the forces acting on the object are balanced

b. If there is a change in the speed or direction of an object, an outside force needs to be applied and the forces acting on the object are unbalanced (Newton's First Law).

S7-8:22

Students demonstrate their understanding of Gravitational Force by…

- Describing the effects of gravitational force on objects in the Solar System, and identifying evidence that the force of gravity is relative to the mass of objects and their distance apart.

Science Concepts:

a. The force of gravity depends on the amount of mass objects have and how far apart they may be.

b. The force of gravity is hard to detect unless at least one of the objects has considerable mass.

.

Grades 9-12

Force

S9-12:21

Students demonstrate their understanding of Force by…

- Investigating (model, illustrate, explain) whether the acceleration is greater or less as either the mass of the system or the force accelerating the mass is changed (e.g., cart with variable weights on horizontal table attached to a string with weights).

AND

- Investigating whether acceleration is greater or less as either the mass of the system or the force accelerating the mass is changed (e.g., cart with variable weights on horizontal table attached to a string with weights).

AND

- Demonstrating action force/reaction force in one of three different ways; describing in words, demonstrating physically, and modeling the occurrence of opposing actions.

Science Concept:

a. If an unbalanced force acts on an object it will accelerate; the acceleration is proportional to the net force and inversely proportional to the mass of the object. (Newton's Law F=ma) (e.g. A vehicle accelerates more slowly when it's full of passengers.)

b. Whenever one object exerts a force on a second object, a force equal in magnitude but opposite in direction is exerted on the first object. (Forces always arise in pairs) (e.g., When you lean against a wall, the wall pushes back at you.) (Newton's Law of Action/ Reaction).

S9-12:22

Students demonstrate their understanding of Gravitational Force by…

- Predicting in a variety of situations how gravitational force changes when mass changes; or when distance changes.

Science Concept:

a. The force of gravity is a universal force of attraction between ANY two objects and is proportional to the masses of those two objects and weakens rapidly with the distance between the objects (e.g., More mass produces more force; less distance produces more force) (e.g., small objects on earth, bodies in the solar system).

Force

S9-12:21

Students demonstrate their understanding of Force by…

- Investigating quantitatively the acceleration as either the mass of the system or the force accelerating the mass is changed (e.g., cart with variable weights on horizontal table attached to a string with weights).

Science Concept:

a. If an unbalanced force acts on an object it will accelerate; the acceleration is proportional to the net force and inversely proportional to the mass of the object. (Newton's Law F=ma) (e.g., A vehicle accelerates more slowly when it's full of passengers.)

S9-12:22

Students demonstrate their understanding of Gravitational Force by…

- Determining quantitatively how gravitational force changes when mass changes; or when distance changes.

Science Concept:

a. The force of gravity is a universal force of attraction between two objects and is proportional to the product of the masses of those two objects and inversely proportional to the square of the distance between objects. (i.e. $F = G m_1 m_2 / d^2$).

Grades PreK-K

Energy and Energy Transformation

SPK-K :23

Students demonstrate their understanding of Heat Energy by.. .

- Identifying the sun as a source of heat energy.

Science Concepts:

a. The sun warms the land, air and water.

No SPK-K:24 at this grade level

SPK-K:25

Students demonstrate their understanding of Magnetism by…

- Investigating, observing and describing how magnets can make some things move without touching (e.g., determining the distance needed for a magnet to attract an object).
- Science Concepts:

  a. Magnets can move some objects without touching them.

Grades 1-2

Energy and Energy Transformation

S 1-2:23

Students demonstrate their understanding of Heat Energy by…

Experimenting, observing, and describing how heat moving from one object to another can cause temperature changes.

Science Concepts:

a. Heat can move from one object to another.

b. The temperature of substances can change.

No S1-2:24 at this grade level

S1-2:25

Students demonstrate their understanding of Magnetism by…

- Investigating, observing and describing how magnets can make some things move without touching (e.g., determining the distance needed for a magnet to attract an object).
- Science Concepts:

  a. Magnets can move some objects without touching them.

Grades 3-4

Energy and Energy Transformation

No S3-4:23 at this grade level

Teachers may review Grades 1-2 Heat Energy Concepts.

S3-4:24

Students demonstrate their understanding of Electrical Energy by…

- Building complete. circuits , drawing diagrams of these electric circuits and explaining why electricity flows or does not flow through the circuit.

AND

- Using experimental data to classify different materials as conductors and insulators.
- Science Concepts:

  a. A complete loop is needed through which an electric charge can flow.

  b. Batteries are a source of electrical energy.

  c. Electric circuits can produce light, run motors and create sounds.

  d. Certain materials are conductors of electricity. Non conductors of electricity are called insulators.

S3-4:25

Students demonstrate their understanding of Magnetism by…

- Describing what happens when like and opposite poles of the magnet are placed near each other.
- Science Concepts:

  a. Magnets have opposite charged poles.

  b. When the same poles of a magnet are placed near each

Grades 5-6

Energy and Energy Transformation

S5-6:23

Students demonstrate their understanding of Heat Energy by…

- Identifying real world applications where heat energy is transferred and by showing the direction that the heat energy flows.

Science Concepts:

a. Heat energy only flows from high temperature to lower temperature. in order to reach equilibrium (same temperature).

b. Heat can move from one object to another by conduction.

S5-6:24

Students demonstrate their understanding of Electrical Energy by…

- Investigating charged objects (static electricity) and describing their observations in terms of behavior of charges and equilibrium.
- Science Concepts:

  a. Unbalanced charges produce a potential for a flow of electricity. (Static)

  b. Unbalanced charges will move toward equilibrium because like charges repel and opposite charges attract.

S5-6:25

Students demonstrate their understanding of Magnetism by…

- Identifying real world objects that demonstrate and utilize a magnetic force field acting over a distance.

AND

- Distinguishing between objects affected by magnetic force and objects affected by other non-contact forces.
- Science Concepts:

  a. Magnetism is a force field that acts over a distance.

Grades 5-6

Energy and Energy Transformation

S5-6:23

Students demonstrate their understanding of Heat Energy by…

- Identifying real world applications where heat energy is transferred and by showing the direction that the heat energy flows.

Science Concepts:

a. Heat energy only flows from high temperature to lower temperature. in order to reach equilibrium (same temperature).

b. Heat can move from one object to another by conduction.

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Students demonstrate their understanding of Electrical Energy by…

- Investigating charged objects (static electricity) and describing their observations in terms of behavior of charges and equilibrium.

Science Concepts:

a. Unbalanced charges produce a potential for a flow of electricity. (Static)

b. Unbalanced charges will move toward equilibrium because like charges repel and opposite charges attract.

S5-6:25

Students demonstrate their understanding of Magnetism by…

- Identifying real world objects that demonstrate and utilize a magnetic force field acting over a distance.

AND

- Distinguishing between objects affected by magnetic force and objects affected by other non-contact forces.

Science Concepts:

a. Magnetism is a force field that acts over a distance.

Grades 7-8

Energy and Energy Transformation

S7-8:23

Students demonstrate their understanding of Heat Energy by…

- Creating a diagram, model, or analogy for a material in a warmer and cooler state showing or describing the motion of the molecules.

AND

- Creating a diagram, model, or analogy to explain the difference between conduction, convection, and radiation, and using their visual to explain how heat energy travels in different directions and through different materials by each method of energy transfer.

Science Concepts:

a. Heat energy is the motion of molecules.

b. Increased motion of the molecules in a system increases the heat energy of the system.

c. Heat energy is transferred by:

Conduction—Collision of molecules in solids.

Convection—Organized flow of heat currents through a fluid.

Radiation—Transfer by waves that can travel through a vacuum.

S7-8:24

Students demonstrate their understanding of Electrical Energy by…

- Building an electric circuit and explaining the transfer of electrical energy into heat, light, and sound, leaving the system but not destroyed.

AND

- Describing the effect of a change in voltage in the circuit system.

Science Concepts:

a. Electric circuits provide a means of transferring electrical energy when heat, light, and sound are produced. The electrical energy is spread out yet still conserved.

b. Electric charges can have “Potential” energy (voltage). The higher the potential energy of the charges, the higher the voltage.

No S7-8:25 at this grade level

Teachers may review Grade 5-6 Magnetism Concepts.

Grades 9-12

Energy and Energy Transformation

S9-12:23

Students demonstrate their understanding of Heat Energy by…

- Comparing and contrasting characteristics of the different forms of energy, particularly within chemical reactions.

AND

- Describing or diagramming the changes in energy (transformation) that occur in different situations (e.g., chemical, biological, physical) through analysis of the input and output energies in a system (e.g., calorimetry, specific heat of water, heat of fusion of water).

AND

- Investigating examples of entropy in discrete systems (e.g., electrical systems, the effectiveness of insulating materials, the human thermostat—hypothermia/homeostasis).

Science Concepts:

a. Different energy levels are associated with different configurations within atoms and molecules (firework explosions).

b. The total energy in an isolated system remains constant regardless of transformation. (Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by an equivalent amount.).

c. Whenever energy is transformed from one form to another, some energy becomes less available (heat) energy (ENTROPY = heat/temperature e.g., such as from engines, electrical wires, how-water tanks, our bodies, stereo systems).

S9-12:24

Students demonstrate their understanding of Electrical Energy by…

- Explaining through words, diagrams, models or electrostatic demonstrations the principle that like charges repel and unlike charges attract.

AND

- Explaining (through words, charts, diagrams, models or mathematical examples) the effects of distance and the amount of charge on the strength of the electrical force present.

AND

- Describing how friction and other mechanical forces are the result of electromagnetic forces.

Science Concept:

a. Electrical force is a universal force that arises from charge and can be attractive (between different charges) or repulsive (between similar charges).

b. The strength of the electrical force is proportional to the amount of charge and weakens rapidly with distance between the charges.

c. Mechanical forces such as tension, compression and friction are manifestations of electrostatic forces between atoms and molecules.

No S9-12:25 at this level

Grades PreK-K	Grades 1-2
Energy and Energy Transformation	**Energy and Energy Transformation**
No SPK-K:26 at this level	**No S1-2:26 at this level**
No SPK-K:27 at this level	**No S1-2:27 at this level**

Grades 3-4	Grades 5-6
Energy and Energy Transformation	**Energy and Energy Transformation**
No S3-4:26 at this level	**S5-6:26** **Students demonstrate their understanding of Electromagnetic Forces by…** • Investigating devices that demonstrate the magnetic effects of electricity and the electric effects of moving magnets. **AND** • Identifying the relationship between the device and the magnetic or electric effect it produces. Science Concepts: a. Moving electrical charges [electricity] produce magnetic force [magnetism] (i.e., electromagnet, motor). b. Moving magnets produce electricity (e.g., generator).
No S3-4:27 at this level	**No S5-6:27 at this grade level**

Grades 5-6	Grades 7-8
Energy and Energy Transformation	**Energy and Energy Transformation**
S5-6:26 **Students demonstrate their understanding of Electromagnetic Forces by…** • Investigating devices that demonstrate the magnetic effects of electricity and the electric effects of moving magnets. **AND** • Identifying the relationship between the device and the magnetic or electric effect it produces. Science Concepts: a. Moving electrical charges [electricity] produce magnetic force [magnetism] (i.e., electromagnet, motor). b. Moving magnets produce electricity (e.g., generator).	**No S7-8:26 at this grade level.** **Teachers may review Grade 5-6 Electromagnetic Forces Concepts.**
No S5-6:27 at this grade level	**No S7-8:27 at this grade level** **Teachers may review Grade 5-6 Electromagnetic Forces Concepts.**

Grades 9-12

Energy and Energy Transformation

S9-12:26

Students demonstrate their understanding of Electromagnetic Forces by…

- Comparing and contrasting the wave nature of electromagnetic energy to other forms of waves (water, sound, etc).

AND

- Relating the particle nature of electromagnetic waves to their frequencies and to discrete changes in energy levels within atoms.

Science Concepts:

a. Electromagnetic energy has both wave and particle properties.

S9-12:27

Students demonstrate their understanding of Electromagnetic Forces by…

- Describing through words, models, or diagrams the presence of electromagnetic forces in an atom.

AND

- Comparing and contrasting the electromagnetic and gravitational forces between the particles that make up an atom.

AND

- Explaining in words, models or diagrams how electric currents produce magnetic fields and how moving fields and how moving magnets produce electric currents.

Science Concept:

a. An electromagnetic force is a universal force that acts within and between atoms and is vastly stronger than the gravitational forces between atoms (Strength depends upon how much charge is present.).

b. Electricity and magnetism are two aspects of an electromagnetic force. Moving electrical charges produce magnetic forces and moving magnets produce electrical forces.

Grades 9-12

Energy and Energy Transformation

S9-12:26

Students demonstrate their understanding of Electromagnetic Forces by…

- Giving examples and explaining the wave nature of electromagnetic energy (refraction, diffraction, etc.) and describing and explaining the particle nature of electromagnetic energy (photoelectric effect, Compton effect).

Science Concepts:

a. Electromagnetic energy has both wave and particle properties.

Grades PreK-K	Grades 1-2
Energy and Energy Transformation	**Energy and Energy Transformation**
No SPK-K:28 at this grade level	**No S1-2:28 at this grade level**
No SPK-K:29 at this grade level	**S1-2:29** **Students demonstrate their understanding of Sound Energy by…** • Investigating different objects, observing and describing the vibrations of those objects and the sounds that are made. Science Concepts: a. Sound is caused by vibrating objects.

Grades 3-4

Energy and Energy Transformation

S3-4:28

Students demonstrate their understanding of Light Energy by…

- Investigating with flash lights and other light sources and describing how light rays reflect off of objects.

AND

- Explaining what occurs when light rays are blocked (e.g., shadows).

Science Concepts:

a. Light maintains direction of motion until it interacts with another object.

b. Light can be reflected or absorbed.

No S3-4:29 at this grade level

Teachers May Review Grade 1-2 Sound Energy Concepts.

Grades 5-6

Energy and Energy Transformation

S5-6:28

Students demonstrate their understanding of Light Energy by…

- Designing demonstrations that represent the characteristics of light energy transfer.

Science Concepts:

a. Light travels from an energy source (such as the sun) in straight lines.

b. When light hits an object, it is absorbed, reflected, transmitted or some combination.

c. Objects can be seen only when light waves are emitted from or reflected off the object and enter into the eye.

S5-6:29

Students demonstrate their understanding of Sound Energy by…

- Generating a sound and identifying the path of vibration from the source to the ear.

Science Concepts:

a. Sound is produced by vibrations in materials that set up wavelike disturbances that spread away from the source.

Grades 5-6

Energy and Energy Transformation

S5-6:28

Students demonstrate their understanding of Light Energy by…

- Designing demonstrations that represent the characteristics of light energy transfer.

Science Concepts:

a. Light travels from an energy source (such as the sun) in straight lines.

b. When light hits an object, it is absorbed, reflected, transmitted or some combination.

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S5-6:29

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- Generating a sound and identifying the path of vibration from the source to the ear.

Science Concepts:

a. Sound is produced by vibrations in materials that set up wavelike disturbances

Grades 7-8

Energy and Energy Transformation

S7-8:28

Students demonstrate their understanding of Light Energy by…

- Designing demonstrations that represent the characteristics of light energy transfer.

AND

- Explaining that visible light is made up of the colored light waves.

Science Concepts:

a. Light is a form of radiant energy.

b. Transmitted light can be refracted (change in direction of the light) when it passes from one media into another.

c. Visible light is part of the electromagnetic spectrum. Visible (white) light is made up of the colored light waves of the visible spectrum.

No S7-8:29 at this grade level

Teacher may review Grade 5-6 Sound Energy Concepts.

Grades 9-12

Energy and Energy Transformation

S9-12:28

Students demonstrate their understanding of Light Energy by…

- Investigating examples of wave phenomena (e.g., ripples in water, sound waves, seismic waves).

AND

- Comparing and contrasting electromagnetic waves to mechanical waves.

Science Concepts:

a. Mechanical waves are periodic disturbances of matter.

b. Accelerating electrical charges produce electromagnetic waves around them. Some of these appear as radiation (e.g. radio waves, microwaves radiant heat, visible light, ultra-violet rays, and x-rays).

No S7-8:29 at this grade level

Teacher may review Grade 5-6 Sound Energy Concepts.

Life Science: Vermont Standards and Evidences—Survival of Organisms and Cells 7.13 a, aa, aaa, 1.18, 2.2, 3.10, 3.11 [See also connection with Inquiry S: 4—Conducting Experiments.]

Grades PreK-K	Grades 1-2
Survival of Organisms and Cells **SPK-K:30** **Students demonstrate their understanding of Structure and Function–Survival Requirements by…** • Observing and recording what happens when food and water are given to living and non-living things. Science Concept: a. There are differences between living and non-living things.	**Survival of Organisms and Cells** **No S1-2:30 at this grade level** **Teachers may review Grades PreK-K Structure and Function Concepts.** • Observing and recording the parts that make up living things (i.e., roots, stems, leaves, flowers, legs, antennae, tail, shell). Science Concept: a. Living things (plant and animals) are made of parts that enable survival.

Grades 3-4

Survival of Organisms and Cells

S3-4:30

Students demonstrate their understanding of Structure and Function–Survival Requirements by…

- Identifying how the physical structure/characteristic of an organism allows it to survive and defend itself (e.g., The coloring of a fiddler crab allows it to camouflage itself in the sand and grasses of its environment so that it will be protected from predators. A rose is protected by its thorns.).

Science Concept:

a. Organisms have characteristics that help them find what they need to survive in their environment and provide for their survival:

- Defense
- Obtaining food
- Reproduction
- Eliminate waste

Grades 5-6

Survival of Organisms and Cells

S5-6:30

Students demonstrate their understanding of Structure and Function-Survival Requirements by…

- Explaining that the cell, as the basic unit of life, has the same survival needs as the organism.

AND

- Identifying and drawing individual cells seen through a microscope and recognizing that most cells are microscopic.

AND

- Diagramming the exchange of materials through a cell membrane.

Science Concepts:

a. All organisms are made of one or more cells. Cells are the basic unit of structure and function in an organism.

- All cells carry out the same basic functions to survive:
- Obtain food (energy) and materials for growth and repair
- Eliminate (recycle) waste
- Reproduce
- Provide for defense

b. All cells are enclosed in a membrane that allows materials to pass into and out of the cell.

c. Most cells are microscopic.

Grades 5-6

Survival of Organisms and Cells

S5-6:30

Students demonstrate their understanding of Structure and Function-Survival Requirements by…

- Explaining that the cell, as the basic unit of life, has the same survival needs as the organism.

AND

- Identifying and drawing individual cells seen through a microscope and recognizing that most cells are microscopic.

AND

- Diagramming the exchange of materials through a cell membrane.

Science Concepts:

a. All organisms are made of one or more cells. Cells are the basic unit of structure and function in an organism.

- All cells carry out the same basic functions to survive:
- Obtain food (energy) and materials for growth and repair
- Eliminate (recycle) waste
- Reproduce
- Provide for defense

b. All cells are enclosed in a membrane that allows materials to pass into and out of the cell.

c. Most cells are microscopic. .

Grades 7-8

Survival of Organisms and Cells

S7-8:30

Students demonstrate their understanding of Structure and Function–Survival Requirements by…

- Conducting experiments that investigate how different concentrations of materials (inside vs. outside a cell) will cause water to flow into or out of cells.

- Examining cells under a microscope and identifying cell wall, and chloroplasts and by comparing the function of a common cell structure such as membrane in all cells with the function of a unique structure such as chloroplasts in plant cells.

AND

- Examining cells under a microscope, identifying the nucleus and explaining the relationship between genes (located in the nucleus) and traits.

Science Concepts:

a. Cells contain structures that carry out survival functions.

b. The nucleus of a cell contains the genes. Every cell contains a complete set of genes for that organism.

c. Genes provide the instructions that direct the functions of the cell.

d. Plant cells have a cell wall in addition to a cell membrane. The cell wall has openings that allow materials to pass through to the cell and the cell wall provides structural support for the cell.

e. Most plant cells contain chloroplasts where green pigment traps the energy from sunlight and transforms it from light energy into chemical energy.

f. Some materials can pass into and out of cells as concentrations move toward equilibrium (diffusion).

Grades 9-12

Survival of Organisms and Cells

S9-12:30:

Students demonstrate their understanding of Cell Structure and Function—Survival Requirements by…

- Predicting the direction of movement of substances across a membrane.

AND

- Developing a model that illustrates the interdependence of cellular organelles (mitochondria, ribosomes, lysosomes, endoplasmic reticulum, cytoplasm) in biochemical pathways within the cell (e.g. mitochondria and chloroplasts : cellular respiration and photosynthesis; nucleus and ribosomes : DNA transcription and protein synthesis).

AND

- Identifying how the basic (general) shape and structure of each of the four types of organic molecules determine its role in maintaining cell survival (i.e., simple carbohydrates [monosaccharides] can be an energy source as a single molecule and a storage/structural molecule when multiple units are chemically combined—[starch, cellulose, chitin].).

AND

- Explaining that a specific sequence of amino acids determines the shape of a protein (i.e., sickle cell hemoglobin).

Science Concepts:

a. There are four basic types of organic compounds found in a cell (proteins, carbohydrates, lipids and nucleic acids).

b. Enzymes, proteins that regulate biochemical reactions, are critical to the survival of cells.

c. The molecular structure of a cell membrane allows for elective transfer of substances into and out of the cell. (i.e., diffusion, osmosis, facilitated diffusion, active transport).

d. The shape of proteins in a cell determines the structure and function of that cells, hence survival of the organism (i.e., cytoskeleton, biochemical functions).

Grades PreK-K

Life Cycles and Reproduction

No SPK-K:31 at this grade level

Grades 1-2

Life Cycles and Reproduction

S1-2:31

Students demonstrate their understanding of Reproduction by…

- Drawing and labeling the stages of development in the life of a familiar plant or animal.

Science Concept:

a. All organisms undergo stages of development that include being born, developing into adulthood, reproducing and dying.

b. Most organisms come from male and female parents.

Grades 3-4

Life Cycles and Reproduction

S3-4:31

Students demonstrate their understanding of Reproduction by…

- Investigating and describing a variety of plant and animal life cycles.

Science Concept:

a. Although all organisms have common stages of development, details of a life cycle are different for different organisms.

Grades 5-6

Life Cycles and Reproduction

No S5-6:31 at this grade level

Teachers may review Grades 3-4 Reproduction Concepts.

[See S 5-6: 40 Human Body-Human Heredity.]

Grades 5-6

Life Cycles and Reproduction

No S5-6:31 at this grade level

Teachers may review Grades 3-4 Reproduction Concepts.

[See S 5-6: 40 Human Body-Human Heredity.]

Grades 7-8

Life Cycles and Reproduction

S7-8:31

Students demonstrate their understanding of Reproduction by …

- Explaining that cells come only from other living cells and that genes duplicate in the process of cell division producing an identical copy of the original cell.

AND

- Describing the relationship between human growth and cell division.

Science Concepts:

a. Cells only come from other cells.

b. Cells repeatedly divide to make more cells for growth and repair.

c. During cell reproduction, genes duplicate so that each new cell will have an identical set of genes.

d. When cells divide, they are reproducing asexually.

e. In asexual reproduction, the new cell (organism) is identical to the parent.

f. Some complete organisms can reproduce asexually (e.g., budding).

g. In asexual reproduction, the new cell (organism) is identical to the parent.

h. Half of an individual's traits come from one parent—half from the other.

[See S 7-8: 40 Human Body-Human Heredity.]

Grades 9-12

Life Cycles and Reproduction

S9-12:31

Students demonstrate their understanding of Reproduction by…

- Developing a model which illustrates how the DNA of all cells/tissues in an organism is produced from a single fertilized egg cell (mitosis).

AND

- Explaining how the nucleotide sequence in DNA (gene) directs the synthesis of specific proteins needed by a cell (e.g., protein synthesis).

Science Concepts:

a. Every body cell in an organism contains the identical genome (DNA) which is maintained from one cell generation to the next by mitosis and DNA replication.

b. The genetic information in a cell's DNA is used to direct the synthesis of the thousands of proteins that each cell requires, however only portions of the genome are active in any one cell.

c. Genetic variation in cells arises from gamete formation and sexual reproduction.

Life Science: Vermont Standards and Evidences—Cell and tissue Differentiation 7.13 b, bb, bbb; and Chemical Reactions within Cells 7.13 c, cc, ccc, 1.19, 2.1, 3.10, 3.13 [See also connection with S:33 Life Science—Energy Flow AND connections with S:15 Physical Science—Chemical Change and S:23 Physical Science Heat Energy.]

Grades PreK-K	Grades 1-2
Cell and Tissue Differentiation **No SPK-K:32 at this grade level**	**Cell and Tissue Differentiation** **No S1-2:32 at this grade level**
Chemical Reactions within Cells **No SPK-K:33 at this grade level**	**Chemical Reactions within Cells** **No S1-2:33 at this grade level**

Grades 3-4	Grades 5-6
Cell and Tissue Differentiation **No S3-4:32 at this grade level**	**Cell and Tissue Differentiation** **S5-6:32** **Students demonstrate their understanding of how Differentiation by…** • Explaining the relationship between cell, tissue, organ and system. **AND** • Observing plant or animal tissue and explaining how "specialized" cells help to support the specialized function of tissue (e.g., muscle cells form muscle tissue, skin cells form skin tissue, nerve cells form brain tissue). Science Concepts: a. In addition to basic functions, cells can carry out "specialized" functions that support the survival of groups of cells and the organism. b. Groups of similar cells connect and work together to form tissue, groups of tissue form organs, and groups of organs form systems.
Chemical Reactions within Cells **No S3-4:33 at this grade level**	**Chemical Reactions within Cells** **S5-6:33** **Students demonstrate their understanding of how Energy Flow Within Cells Supports an Organism's Survival by…** • Demonstrating through drawings, stories or models that cells take in food and oxygen to produce energy and send out waste materials. Science Concepts: a. In order to obtain energy for all the functions of survival, individual cells take in food and oxygen to produce energy and send out waste materials.

Life Science: Vermont Standards and Evidences—Cell and tissue Differentiation 7.13 b, bb, bbb; and Chemical Reactions within Cells 7.13 c, cc, ccc, 1.19, 2.1, 3.10, 3.13 [See also connection with S:33 Life Science—Energy Flow AND connections with S:15 Physical Science—Chemical Change and S:23 Physical Science Heat Energy.]

Grades 5-6

Cell and Tissue Differentiation

S5-6:32

Students demonstrate their understanding of how Differentiation by…

- Explaining the relationship between cell, tissue, organ and system.

AND

- Observing plant or animal tissue and explaining how "specialized" cells help to support the specialized function of tissue (e.g., muscle cells form muscle tissue, skin cells form skin tissue, nerve cells form brain tissue).

Science Concepts:

a. In addition to basic functions, cells can carry out "specialized" functions that support the survival of groups of cells and the organism.

b. Groups of similar cells connect and work together to form tissue, groups of tissue form organs, and groups of organs form systems.

Chemical Reactions within Cells

S5-6:33

Students demonstrate their understanding of how Energy Flow Within Cells Supports an Organism's Survival by…

- Demonstrating through drawings, stories or models that cells take in food and oxygen to produce energy and send out waste materials.

Science Concepts:

a. In order to obtain energy for all the functions of survival, individual cells take in food and oxygen to produce energy and send out waste materials.

Grades 7-8

Cell and Tissue Differentiation

No S7-8:32 at this grade level

Teachers may review Grades 5-6 Differentiation Concepts.

Chemical Reactions within Cells

S7-8:33

Students demonstrate their understanding of how Energy Flow Within Cells Supports an Organism's Survival by…

- Recognizing that energy from the sun is transferred and utilized in plant and animal cells through chemical changes and then transferred into other forms such as heat (e.g., using word equation).

Science Concepts:

a. Plant cells take in carbon dioxide and water and use the energy from sunlight to chemically change them to food (sugar) and oxygen.

b. All cells chemically change sugar (food) and oxygen into energy required to survive.

c. Energy is used by all cells to carry out functions for survival and some energy is transferred to the environment as heat.

Grades 9-12

Cell and Tissue Differentiation

S9-12:32

Students demonstrate their understanding of Differentiation by…

- Predicting the change in an embryo, caused by disruption of the ectoderm or mesoderm or endoderm during embryonic development (e.g., Fetal Alcohol Syndrome, drugs, injury)**.**

AND

- Comparing the role of various sub-cellular units in unicellular organisms to comparable structures in multicellular organisms (i.e., oral groove, gullet, food vacuole in *Paramecium* compared to digestive systems in multicellular organisms).

- Science Concepts:

  a. Cell differentiation is regulated through the expression of different genes within the embryo cells. During embryonic development of complex multicellular organisms, chemicals within the cells deactivate portions of the genetic code as influenced by the cell's environment and past history.

  b. Unicellular organisms lack differentiation, but sub-cellular units carry out all life functions.

Chemical Reactions within Cells

S9-12:33

Students demonstrate their understanding of how Energy Flow Within Cells Supports an Organism's Survival by…

- Comparing and contrasting the structure of mitochondria and chloroplasts as cell organelles, the interrelatedness of their functions, and their importance to the survival of all cells.

AND

- Describing a possible flow of energy from the environment through an organism to the cellular level, and through the cell from assimilation through storage in ATP.

AND

- Investigating and describing enzyme action under a variety of chemical and physical conditions.

Science Concepts:

a. In living systems energy flows through matter and is stored and released through chemical reactions. Basic survival energy transformations between cells and their environment include aerobic and anaerobic respiration and photosynthesis reactions.
Energy is necessary for work to be accomplished and life to be sustained (e.g., At the cellular level this work can be growth, repair, reproduction, and synthesis.) .

b. Energy is stored in living systems in ATP molecules. Energy is transformed through living systems from the environment through specific cell organelles and specific chemical processes.

c. Energy transformations in living systems are enzyme-dependent.

Life Science: Vermont Standards and Evidences—Interdependence within Ecosystems 7.13 c, cc, ccc, 1.19, 2.2, 7.9, 7.11 [See also connection with S: 49 Universe, Earth, Environment—Natural Resources.]

Grades PreK-K

Interdependence within Ecosystems

SPK-K:34

Students demonstrate their understanding of Energy Flow in an Ecosystem by…

- Caring for plants and animals by identifying and providing for their needs.

Science Concept:

a. Plants and animals both need water, food and air.

No SPK-K:35 at this level

Grades 1-2

Interdependence within Ecosystems

S1-2:34

Students demonstrate their understanding of Energy Flow in an Ecosystem by…

- Experimenting with plant growth under different conditions, including light and no light.

Science Concept:

a. Plants need light (energy) to survive.

S1-2:35

Students demonstrate their understanding of Food Webs in an Ecosystem by…

- Acting out or constructing simple diagrams, pictures or words that show what eats what.

Science Concept:

a. All animals depend on plants. Some animals eat plants for food; other animals eat animals that eat plants.

Grades 3-4

Interdependence within Ecosystems

S3-4:34

Students demonstrate their understanding of Energy Flow in an Ecosystem by…

- Identifying the source of energy for the survival of organisms.

Science Concept:

a. Energy derived from food is needed for all organisms (plants and animals) to stay alive and grow.

S3-4:35

Students demonstrate their understanding of Food Webs in an Ecosystem by…

- Recognizing that, in a simple food chain, all animals' food begins with plants.

AND

- Researching and designing a habitat and explaining how it meets the needs of the organisms that live there.

Science Concept:

a. Food for animals can be traced back to plants.

b. Organisms can survive best only in habitats in which their needs are met.

Grades 5-6

Interdependence within Ecosystems

S5-6:34

Students demonstrate their understanding of Energy Flow in an Ecosystem by…

- Developing a model that shows how the flow of energy from the sun is transferred to organisms as food in order to sustain life.

Science Concept:

a. Energy within an ecosystem originates from the sun. Plants use energy from the sun, carbon dioxide, and water, to make energy rich food and oxygen.

Plants are producers.

b. Animals eat food that plants make combined with oxygen to produce energy, carbon dioxide, and water. .

Animals are consumers.

S5-6:35

Students demonstrate their understanding of Food Webs in an Ecosystem by..

- Developing a model for a food web of a local aquatic and local terrestrial environment.

Science Concept:

a. Food webs model the interdependent relationships that organisms engage in as they acquire their food and energy needs. Aquatic food webs (fresh water and marine) are supported by microscopic ocean plants. Land food webs are supported by land plants.

.

Grades 5-6

Interdependence within Ecosystems

S5-6:34

Students demonstrate their understanding of Energy Flow in an Ecosystem by…

- Developing a model that shows how the flow of energy from the sun is transferred to organisms as food in order to sustain life.

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.

Grades 7-8

Interdependence within Ecosystems

S7-8:34

Students demonstrate their understanding of Energy Flow in an Ecosystem by…

- Describing how light is transformed into chemical energy by producers and how this chemical energy is used by all organisms to sustain life (e.g., using a word equation).

Science Concept:

a. Plants transform energy from the sun into stored chemical energy by changing carbon dioxide and water into sugar (food). Plants use or store the sugar they produce to satisfy their energy needs.

b. All organisms release the energy stored in sugar (food) through a chemical change that requires oxygen and produces carbon dioxide and water in addition to energy. Some consumers eat plants directly (herbivores). Some consumers eat other animals (carnivores) and use the energy from the plant's sugar food that was stored in the animal's cells. Some consumers eat both plant and animal material (omnivore).

No S7-8:35 at this grade level

Teachers may review Grades 5-6 Food Web Concepts.

Grades 9-12

Interdependence within Ecosystems

S9-12:34

Students demonstrate their understanding of Energy Flow in an Ecosystem by…

- Developing a model that compares the energy at different trophic levels in a given ecosystem.

Science Concept:

a. Energy from the sun enters all ecosystems through photosynthesis, is passed through trophic levels (producers, consumers, decomposers) with energy released as heat at every level until all the original energy is eventually released as heat (Energy Pyramid and 10% Rule).

S9-12:35

Students demonstrate their understanding of Food Webs in an Ecosystem by…

- Designing (and implementing) an investigation that demonstrates the chemical relationship between carbon compounds of the organisms in a food web (e.g., dyed yeast—*Paramecium*—roundworm).

Science Concept:

a. Within ecosystems, the processes of photosynthesis and cell respiration recycle matter (i.e., carbon compounds) found within organisms and the abiotic environment.

Life Science: Vermont Standards and Evidences—Interdependence within Ecosystems 7.13 c, cc, ccc, 7.11 [See also connection with S: 15 Physical Science—Chemical Change AND S: 49 Universe, Earth, Environment—Natural Resources.]

Grades PreK-K	Grades 1-2
Interdependence within Ecosystems	**Interdependence within Ecosystems**
No SPK-K:36 at this grade level	**No S1-2:36 at this level**
No SPK-K:37 at this grade level	**No S1-2:37 at this level**

Grades 3-4

Interdependence within Ecosystems

S3-4:36

Students demonstrate their understanding of Equilibrium in an ecosystem by…

- Explaining how one organism depends upon another organism to survive.

Science Concept:

a. Organisms interact with one another in various ways besides providing food (e.g., Many plants depend on animals for carrying their pollen to other plants for fertilizing their flowers).

No S3-4:37 at this grade level

Grades 5-6

Interdependence within Ecosystems

S5-6:36

Students demonstrate their understanding of Equilibrium in an Ecosystem by…

- Experimenting with a closed system, describing how an environmental change effects the system (e.g., bottle biology).

Science Concept:

a. The number of organisms an ecosystem can support depends on the kinds of organisms present and the availability of biotic and abiotic resources (i.e., quantity of light and water, range of temperatures, and soil composition).

S5-6:37

Students demonstrate their understanding of Recycling in an ecosystem by…

- Identifying the recycling role of decomposers in a variety of situations.

Science Concept:

a. Decomposers, primarily bacteria and fungi, are consumers that use waste material and dead organisms for food.

Grades 5-6

Interdependence within Ecosystems

S5-6:36

Students demonstrate their understanding of Equilibrium in an Ecosystem by…

- Experimenting with a closed system, describing how an environmental change effects the system (e.g., bottle biology).

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S5-6:37

Students demonstrate their understanding of Recycling in an ecosystem by…

- Identifying the recycling role of decomposers in a variety of situations.

Science Concept:

a. Decomposers, primarily bacteria and fungi, are consumers that use waste material and dead organisms for food.

Grades 7-8

Interdependence within Ecosystems

S 7-8: 36

Students demonstrate their understanding of Equilibrium in an Ecosystem by…

- Identifying an abiotic or biotic change in a local ecosystem and predicting the short and long-term effects of t his change (e.g., local river study).

Science Concept:

a. Given adequate biotic and abiotic resources, an ecosystem will maintain equilibrium and continue indefinitely.

b. Factors that affect biotic or abiotic resources such as disease, predation, climate, and pollution can change the dynamics of an ecosystem and the interdependent relationships among populations of organisms. until a new equilibrium is reached (e.g., Members of a species that occur together at a given time are referred to as a population).

S7-8:37

Students demonstrate their understanding of Recycling in an ecosystem by…

- Explaining how products of decomposition are utilized by the ecosystem to sustain life while conserving mass (e.g., worm farm, compost).

Science Concept:

a. When decomposers break down the matter contained in plants and animals, the molecules of matter can be recycled through the ecosystem and used by plants to produce food or as building material for all organisms.

b. As matter is transferred from one organism to another in an ecosystem, the total amount (mass) remains the same. [See S :15— Physical Science Chemical Change.]

Grades 9-12

Interdependence within Ecosystems

S9-12:36

Students demonstrate their understanding of Equilibrium in an Ecosystem by…

- Designing an investigation to compare a natural system with one altered by human activities (e.g., acid rain, eutrophication through agricultural runoff, fertilizer, pollution, solid waste, clear cutting, toxic emissions or conservation and habitat reclamation).

Science Concept:

a. Human beings are part of the earth's ecosystems; human activities can deliberately or inadvertently, alter the equilibrium in an ecosystem.

S9-12:37

Students demonstrate their understanding of Recycling in an Ecosystem by…

- Developing and explaining a model that shows the recycling of inorganic compounds within a natural ecosystem (e.g., Compare worm compost with commercial fertilizer.).

Science Concept:

a. Matter (inorganic compounds) used by living things on the molecular level is cycled from old life to new life through major chemical cycles of the earth (e.g., N, H_2O, C-O, P).

Life Science: Vermont Standards and Evidences—Classification of Living Things 7.13 b, bb, bbb , and Natural Selection 7.13 d, dd, ddd, 3.12[See also connection with S:40 Human Body—Human Heredity AND connection with S:30 Life Science—Survival Requirements.]

Grades PreK-K

Classification of Living Things

SPK-K:38

Students demonstrate their understanding of Classification of Organisms by…

- Sorting and identifying examples of plants and animals.

Science Concept:

a. Some living things (organisms) are identified as plants or animals.

Natural Selection/Evolution

No SPK-K:39 at this level

Grades 1-2

Classification of Living Things

No S1-2:38 at this level

Teachers may review Grades PK-K Classification Concepts.

Natural Selection/Evolution

S1-2:39

Students demonstrate their understanding of Evolution/Natural Selection by…

- Identifying physical similarities and differences between living extinct things. (e.g., wooly mammoth/elephant; reptiles/dinosaurs).

Science Concept:

a. Some kinds of organisms that once lived on earth have completely disappeared, although they were similar to others that are alive today.

.

Grades 3-4

Classification of Living Things

S3-4:38

Students demonstrate their understanding of Classification of Organisms by…

- Describing and sorting plants and animals into groups based on structural similarities and differences (e.g., All pine, spruce and evergreen trees have similar leaf structures; Spiders have eight legs, and insects have six).

Science Concept:

a. The great variety of living things can be sorted into groups in many ways using various characteristics to decide which things belong to which group.

Natural Selection/Evolution

S3-4:39

Students demonstrate their understanding of Evolution/Natural Selection by…

- Identifying differences in characteristics of a certain type of organism (e.g., dogs with long hair or short hair; humans with blue or brown eyes).

Science Concept:

a. Organisms of the same kind differ in their individual characteristics (traits) (e.g., Even though all dogs are of the same species, they can have very different traits.).

Grades 5-6

Classification of Living Things

No S5-6:38 at this grade level

Teachers may review Grades 3-4 Classification Concepts.

Natural Selection/Evolution

S5-6:39

Students demonstrate their understanding of Evolution/Natural Selection by…

- Explaining, through engaging in simulations, how a variation in a characteristic (trait) enables an organism to survive in a changing environment.

Science Concepts:

a. When the environment changes some plants and animals with advantageous traits are able to survive; others, with less-advantageous traits, either move to new locations or die.

Life Science: Vermont Standards and Evidences—Classification of Living Things 7.13 b, bb, bbb , and Natural Selection 7.13 d, dd, ddd, 3.12[See also connection with S:40 Human Body—Human Heredity AND connection with S:30 Life Science—Survival Requirements.]

Grades 5-6	Grades 7-8
Classification of Living Things **No S5-6:38 at this grade level** **Teachers may review Grades 3-4 Classification Concepts.**	**Classification of Living Things** **S7-8:38** **Students demonstrate their understanding of Classification of Organisms by…** • Comparing and sorting organisms with similar characteristics into groups based on internal and external structures recognized by scientists. **AND** • Recognizing that individuals that can reproduce with one another and produce fertile offspring are classified as a species. Science Concepts: a. Scientists organize the vast diversity of organisms by describing similarities and differences among living things. Details of internal and external structures of organisms are more important for scientific classification than behavior and general appearance. b. Individuals that can reproduce with one another and produce fertile offspring are classified as a species.
Natural Selection/Evolution **S5-6:39** **Students demonstrate their understanding of Evolution/Natural Selection by…** • Explaining, through engaging in simulations, how a variation in a characteristic (trait) enables an organism to survive in a changing environment. Science Concepts: a. When the environment changes some plants and animals with advantageous traits are able to survive; others, with less-advantageous traits, either move to new locations or die.	**Natural Selection/Evolution** **S7-8:39** **Students demonstrate their understanding of Evolution/Natural Selection by…** • Explaining that advantageous traits of organisms are passed on through reproduction. **AND** • Identifying that traits occur randomly. Science Concepts: a. Differences in physical characteristics (traits) occur randomly (by chance) in a population or species. b. As environments change, organisms that possess advantageous traits (those that enable them to survive) pass those traits to offspring through reproduction.

Grades 9-12

Classification of Living Things

S9-12:38

Students demonstrate their understanding of Classification of Organisms by …

- Developing a graphic representation that illustrates and compares the degree of molecular similarity among several species (e.g., DNA or amino acid sequences).

Science Concepts:

a. Formal classification systems of organisms (Domain, Kingdom, Phylum…) are based upon molecular similarities and differences among organisms.

b. A species is the most fundamental unit of classification. Similarity of species (degree of kinship) can be substantiated by the molecular composition (e.g., DNA /amino acid sequences).

Natural Selection/Evolution

S9-12:39

Students demonstrate their understanding of Evolution/Natural Selection by…

- Applying the theory of Natural Selection to a scenario depicting change within a given population over time (through many generations) (e.g., bacterial resistance to antibiotics, neck of the giraffe, animal camouflage).

Science Concepts:

a. The diversity of present-day organisms resulted from changes over time in many ancestral organisms.

b. Evolution (change over time) is based on variety within species. A greater variation within a species increases the possibility of species survival under changing conditions. Life on earth is thought to have begun four billion years ago, as simple, one-celled organisms about some of which still exist today.

c. Natural Selection provides a mechanism for evolution and leads to organisms well-suited for survival in a particular, existing environment.

d. Species result from evolution due to:

- overpopulation
- genetic variability of offspring
- a finite supply of resources, producing stress and competition
- the selection (survival and subsequent reproduction) of offspring best suited to a particular environment

e. Molecular evidence supports other types of evidence for evolution.

Human Body: Vermont Standards and Evidences—Heredity 7.14 a, aa, aaa, 2.1, 3.11, 3.12 [See also connection with S: 31 Life Science—Reproduction and S: 32 Life Science—Differentiation.]

Grades PreK-K

Heredity

No PK-K:40 at this level

Grades 1-2

Heredity

S 1-2:40

Students demonstrate their understanding of Human Heredity by…

- Observing and comparing their physical features with those of classmates and other organisms.

Science Concepts:

a. People have different external features, such as size, color of hair, skin, and eyes. However, humans are more like one another than like other animals.

Human Body: Vermont Standards and Evidences—Heredity 7.14 a, aa, aaa, 2.1, 3.11, 3.12 [See also connection with S: 31 Life Science—Reproduction and S: 32 Life Science—Differentiation.]

Grades 3-4

Heredity

S3-4:40

Students demonstrate their understanding of Human Heredity by…

- Identifying similarities that are inherited from a biological parent.

Science Concepts:

a. Some similarities between children and parents such as eye color, are inherited.

Grades 5-6

Heredity

S5-6:40

Students demonstrate their understanding of Human Heredity by…

- Identifying that an offspring's traits are determined by combining the sex cells (female egg and male sperm) of the parents.

Science Concepts:

a. Organisms can reproduce sexually when a female egg cell is fertilized by a male sperm cell to produce an offspring that has the traits of both parents.

Human Body: Vermont Standards and Evidences—Heredity 7.14 a, aa, aaa, 2.1, 3.11, 3.12 [See also connection with S: 31 Life Science—Reproduction and S: 32 Life Science—Differentiation.]

Grades 5-6

Heredity

S5-6:40

Students demonstrate their understanding of Human Heredity by…

- Identifying that an offspring's traits are determined by combining the sex cells (female egg and male sperm) of the parents.

Science Concepts:

a. Organisms can reproduce sexually when a female egg cell is fertilized by a male sperm cell to produce an offspring that has the traits of both parents.

Grades 7-8

Heredity

S7-8:40

Students demonstrate their understanding of Human Heredity by…

- Identifying that traits are produced from the instructions of one or more genes that are inherited from the parents.

Science Concepts:

a. Every organism requires a set of instructions (genes) for specifying its traits. Heredity is the passage of these instructions from one generation to another.

b. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait.

Grades 9-12

Heredity

S9-12:40

Students demonstrate their understanding of Human Heredity by…

- Modeling and explaining how the structure of DNA is maintained and relates to genes and chromosomes, which code for specific protein molecules within a cell.

AND

- Modeling or diagramming new gene combinations that result from sexual reproduction (e.g., dominant/recessive traits).

AND

- Explaining how alteration of a DNA sequence may affect physical/chemical characteristics of the human body (e.g., sickle-cell anemia, cancer).

AND

- Comparing and contrasting the chromosome content of somatic cells and that of sex cells (gametes).

Science Concept: (Human Heredity)

a. Instructions for specified characteristics of an organism are carried in DNA. (NSES) The information passed from parents to offspring is coded in DNA molecules. DNA molecules are long chains linking just four kinds of smaller molecules, whose sequence encodes genetic information.

b. The human body is formed from cells that contain homologous parrs two copies of each chromosome.

c. New heritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells.

d. All body cells have identical genetic information, but its expression may be very different from one cell to another due to the instructions given to different types of cells.

- The sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations (Include value of meiosis, but not phases).
- Some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities and some can be deleterious.
- Gene mutations can be caused by radiation and chemicals (legal and illegal) and are passed on to offspring when they occur in sex cells.
- Inserting, deleting or substituting DNA segments can alter genes.
- Changes in DNA (mutations) occur spontaneously at low rates, but can affect the organism in many ways or may go unnoticed.

e. Gene mutations in a cell can result in uncontrolled division called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus chances of cancer.

Human Body: Vermont Standards and Evidences—Body Systems 7.14 b, bb, bbb, 3.5, 3.11, 7.11[See also connection with S: 30 Life Science—Survival Requirements and S: 34 Life Science---Energy Flow within Ecosystems; AND S: 15 Physical Science—Chemical Change.]

Grades PreK-K

Body Systems

SPK-K:41

Students demonstrate their understanding of Human Body Systems by…

- Identifying the five senses and using the senses to identify objects in their environment.

Science Concepts:

a. People use their senses to find out about their surroundings and themselves. Different senses give different information.

Grades 1-2

Body Systems

S1-2:41

Students demonstrate their understanding of Human Body Systems by…

- Identifying the senses needed to meet survival needs for a given scenario.

Science Concepts:

a. People use their senses to find out about their surroundings and meet their needs.

b. Body parts help people satisfy their need for food.

- eyes/nose: find food

- legs/hands: get food

- mouth: eat food

c. Senses help people satisfy their need to avoid danger.

- nose: smell fire

- ears: hear danger

Human Body: Vermont Standards and Evidences—Body Systems 7.14 b, bb, bbb, 3.5, 3.11, 7.11[See also connection with S: 30 Life Science—Survival Requirements and S: 34 Life Science---Energy Flow within Ecosystems; AND S: 15 Physical Science—Chemical Change.]

Grades 3-4

Body Systems

S3-4:41

Students demonstrate their understanding of Human Body Systems by…

- Showing connections between external and internal body structures and how they help humans survive,

Science Concepts:

a. There are external and internal structures that provide for the survival needs of human organisms.

- Skin protects the body from harmful substances and other organisms and from drying out.

- The skeletal system provides shape and protection for the body's organs.

- The brain gets/gives signals from/to all parts of the body "telling" the body what to do.

- From food, people obtain nutrients and other materials for body repair and growth. The un-digestible parts of food are eliminated. Key structures are mouth, esophagus, stomach, intestine and anus.

- By breathing, people take in the oxygen that they need to live. Key structure is the lung.

Grades 5-6

Body Systems

S5-6:41

Students demonstrate their understanding of Human Body Systems by…

- Investigating circumstances that affect more than one body system and explaining the interconnected relationship between the body systems (e.g., the effects of exercise on several interdependent body systems, such as respiratory, circulatory, digestive, nervous, skeletal systems).

Science Concepts:

a. The digestive, respiratory and circulatory systems are connected.

- The digestive system processes the food that cells need. The excretory system disposes of cellular waste and the intestinal tract removes solid waste.

- The respiratory system exchanges oxygen and carbon dioxide.

- The circulatory system moves all these substances to and from the cells.

b. A change in one system can have an effect on other systems. (e.g., exercise changing heart rate and breathing rate).

Human Body: Vermont Standards and Evidences—Body Systems 7.14 b, bb, bbb, 3.5, 3.11, 7.11[See also connection with S: 30 Life Science—Survival Requirements and S: 34 Life Science---Energy Flow within Ecosystems; AND S: 15 Physical Science—Chemical Change.]

Grades 5-6	Grades 7-8
Body Systems **S5-6:41** **Students demonstrate their understanding of Human Body Systems by…** • Investigating circumstances that affect more than one body system and explaining the interconnected relationship between the body systems (e.g., the effects of exercise on several interdependent body systems, such as respiratory, circulatory, digestive, nervous, skeletal systems).	**Body Systems** **S7-8:41** **Students demonstrate their understanding of Human Body Systems by…** • Identifying ways that the human body responds to changes to maintain equilibrium. **AND** • Explaining the function of the lungs in respiration. **AND** • Developing models that illustrate the human reproductive system.
Science Concepts: a. The digestive, respiratory and circulatory systems are connected. - The digestive system processes the food that cells need. The excretory system disposes of cellular waste and the intestinal tract removes solid waste. - The respiratory system exchanges oxygen and carbon dioxide. - The circulatory system moves all these substances to and from the cells. b. A change in one system can have an effect on other systems. (e.g., exercise changing heart rate and breathing rate).	Science Concepts: a. The lungs take in the oxygen that the body cell's need for the chemical change that releases energy from food and the lungs eliminate carbon dioxide that produced during the chemical change. b. The reproductive system enables the whole organism (human) to reproduce. c . In order to maintain equilibrium, internal body systems react to environmental changes through the nervous system. (e.g., sweating, increased respiration during exercise, response to environmental stimuli, etc.).

Grades 9-12

Body Systems

S9-12:41

Students demonstrate their understanding of Human Body (biochemical) Systems by…

- Diagramming a feedback loop that illustrates how several human body systems work together to restore homeostasis in response to an external stimulus (environmental/.behavioral) (e.g., exercise, fight/flight, stress, drugs, normal cellular metabolism, any nervous system response).

AND

- Explaining examples of how the human body may be affected by the state of the internal environment and by heredity and by life experience (e.g., effects of malnutrition).

AND

- Predicting and explaining how the effect of various physiological factors influences the continuation of the human species (reproductive success) (e.g., anorexia and/or steroid use, radiation/toxic wastes/drug use, mutagenic agents and/or improper diet/obesity).

Science Concepts:

a. All systems of the body are continually working together (communicating) to maintain balance (homeostasis) by responding to internal and external stimuli, (e.g., cell-cell (B and T lymphocyte interaction, neurotransmitter secretion by nerve cells); organ-organ (hormones trigger target cells; motor impulses trigger muscles); system (respiratory/circulatory/excretory system interactions, endocrine/digestive/motor and biochemical responses to stress); external stimuli-organism (hypo/hyperthermia, chemical stimuli affect organs/systems/whole organism; sense reception, nerve response)

b. Human behavior is determined by the state of our internal biochemical environment, our heredity and our life experiences (e.g., innate/learned behaviors).

c. Reproduction is necessary for survival of a species. (e.g., *in vitro* fertilization, fetal alcohol syndrome, hormone imbalances, stress).

Human Body: Vermont Standards and Evidences—Human Disease 7.14 c, cc, ccc, 2.2, 3.5, 3.10, 3.11 [See also connection with S: 32 Life Science—Differentiation.]

Grades PreK-K

Human Disease

No SPK-K:42 at this grade level

Grades 1-2

Human Disease

S 1-2:42

Students demonstrate their understanding of the Patterns of Human Health/Disease by…

- Identifying things in the environment that could be harmful if swallowed (e.g., soaps, cleaning solutions, unknown pills).

Science Concepts:

a. Some things people take into their bodies from the environment are toxic and can hurt them.

Grades 3-4

Human Disease

S3-4:42

Students demonstrate their understanding of the Patterns of Human Health/Disease by…

- Explaining that tears, saliva, and skin, can protect the body from harmful germs.

Science Concepts:

a. If germs are able to get inside a person's body, they may keep it from working properly. Tears, saliva, and skin protect our bodies from germs.

Grades 5-6

Human Disease

S5-6:42

Students demonstrate their understanding of the Patterns of Human Health/Disease by…

- Connecting the specialized function of white blood cells to their location in the circulatory system.

Science Concepts:

a. White blood cells engulf invading microbes or produce antibodies that attack them.

Human Body: Vermont Standards and Evidences—Human Disease 7.14 c, cc, ccc, 2.2, 3.5, 3.10, 3.11 [See also connection with S: 32 Life Science—Differentiation.]

Grades 5-6	Grades 7-8
Human Disease **S5-6:42** **Students demonstrate their understanding of the Patterns of Human Health/Disease by…** • Connecting the specialized function of white blood cells to their location in the circulatory system. Science Concepts: a. White blood cells engulf invading microbes or produce antibodies that attack them.	**Human Disease** **S7-8:42** **Students demonstrate their understanding of the Patterns of Human Health/Disease by…** • Identifying a variety of microbes (e.g., virus, bacteria, fungi) and toxic materials that can interfere with body systems and cause harm. Science Concepts: a. Viruses, bacteria. Fungi, and parasites may infect then human body and interfere with normal body functions. b. The environment may contain dangerous levels of substances that are harmful to human beings.

Grades 9-12

Human Disease

S9-12:42

Students demonstrate their understanding of the Patterns of Human Health/Disease by...

- Identifying a variety of nonspecific means of protection for the human body and explaining how these maintain human health (i.e., prevent disease).

AND

- Describing the general process of the human immune response to foreign substances and organisms (e.g., phagocyte action and antibody production and maintenance).

AND

- Showing through models/diagrams/graphic organizers how specific biological abnormalities alter the normal functioning of human systems (e.g., feedback diagram).

AND (EXTENSION)

- Explaining the effect of unique viral diseases on the cells of the human immune system (e.g., retroviruses).

Science Concepts:

a. The Human Body protects itself against infectious diseases (caused by microorganisms, viruses, animal parasites) through physical protection and physiological (immune) responses.

b. The Immune System is designed to protect against microscopic organisms (bacteria, fungi) and foreign substances that enter from outside the body and against some cancer cells that arise within.

c. Some allergic responses are caused by the body's immune responses to usually harmless environmental substances.

d. Humans have a variety of mechanisms—sensory, motor, emotional, social and technological—that can reduce and modify health hazards (e.g. blinking, fight or flight, coping mechanisms, medicine).

e. The severity of human disease depends upon many factors, such as resistance to disease the virulence of the infecting organism.

f. Biological abnormalities, such as injuries or chemical imbalance, cause or increase susceptibility to disease (e.g. hormonal imbalance, epilepsy, depression). (Atlas 91)

g. (EXTENSION) Some viral diseases, such as AIDS, destroy critical cells of the immune system.

Grades PreK-K

Patterns of Human Development

No SPK-K:43 at this level

Grades 1-2

Patterns of Human Development

S 1-2:43

Students demonstrate their understanding of the Patterns of Human Development by…

- Identifying activities that you can do now that you could-n't do as a baby (e.g., dress yourself, get food form refrig-erator, bathe yourself).

AND

- Explaining where babies grow and develop.

Science Concepts:

a. A human baby grows inside its mother until its birth. Even after birth, a human baby is unable to care for itself, and its survival depends on the care it receives from adults.

Grades 3-4

Patterns of Human Development

No S3-4:43 at this level

Teacher may review Grade 1-2 Patterns of Human Development Concepts.

Grades 5-6

Patterns of Human Development

S5-6:43

Students demonstrate their understanding of the Patterns of Human Development by…

- Drawing/diagramming/modeling the life span of humans in a timeline highlighting major points in the cycle (e.g., one cell grows into a many-celled embryo, composed of different types of cells--grows into a fetus--baby is born—grows into a toddler—grows into a child—grows into a teenager—grows into an adult).

AND

- Explaining what occurs in the processes of fertilization and early embryo development (e.g., sperm + egg combine to produce a new individual).

Science Concepts:

a. Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and function to form the basic tissues and organs of an embryo, which eventually grows into an adult organism.

Grades 5-6

Patterns of Human Development

S5-6:43

Students demonstrate their understanding of the Patterns of Human Development by…

- Drawing/diagramming/modeling the life span of humans in a timeline highlighting major points in the cycle (e.g., one cell grows into a many-celled embryo, composed of different types of cells--grows into a fetus--baby is born—grows into a toddler—grows into a child—grows into a teenager—grows into an adult).

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Grades 7-8

Patterns of Human Development

No S7-8:43 at this grade level

Teacher may review Grade 5-6 Patterns of Human Development Concepts.

Grades 9-12

Patterns of Human Development

S9-12:43

Students demonstrate their understanding of the Patterns of Human Development by…

- Tracing the development of the human embryo from fertilization to gastrula stage, comparing its progress to that of other vertebrate organisms (e.g., amphibians and reptiles and birds and mammals).

AND

- Comparing the gestation of humans and the period of dependency after birth to that of other vertebrates.

AND

- Identifying the important events that occur in each stage (trimester) of human development (e.g., First trimester—embryonic organ systems established, Second trimester—fetal development/organ maturation, Third trimester—overall growth).

AND

- Justifying a position on the use of technology to influence human embryonic or fetal life.

Science Concepts:

a. Human development begins with a single cell formed by fusion of egg cell and sperm cell and continues through nine months of further development and growth, similar to the development of other animals with backbones; and differences in an embryo's environment can influence the path of development.

b. During human gestation and development a balance is necessary between brain size and birth size, therefore humans need more time after birth for full development of the brain and nervous system than other vertebrates.

c. The long period of human development is associated with the prominent role of the brain.

d. The use of technologies to maintain, prolong sustain or terminate life raise social, moral, ethical and legal issues.

Grades PreK-K

Solar System

SPK-K:44

Students demonstrate their understanding of Characteristics of the Solar System by…

- Observing and recording the day and night sky.

Science Concepts:

a. The sun can be seen only at day time

b. The sun and moon are in the sky.

Grades 1-2

Solar System

S1-2:44

Students demonstrate their understanding of Characteristics of the Solar System by…

- Observing and describing qualitatively how the sky looks at different times.

AND

- Keeping a journal record of the shape of the moon each night for a month.

Science Concepts:

a. The moon looks slightly different every day, but looks the same again about every four weeks.

b. The moon can be seen sometimes at night and sometimes during the day.

Grades 3-4

Solar System

S3-4:44

Students demonstrate their understanding Characteristics of the Solar System by…

- Creating a model of the planets and their correct order from the sun.

AND

- Drawing or building and then explaining a model of the earth rotating on its axis in relation to the sun and moon (i.e., day and night).

Science Concepts:

a. The earth is one of several planets that orbit the sun, and the moon orbits the earth.

b. Like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the night and day cycle.

Grades 5-6

Solar System

S5-6:44

Students demonstrate their understanding of Characteristics of the Solar System by…

- Creating a diagram or model of the orbit of the earth around the sun and the moon around the earth.

Science Concepts:

a. The earth orbits the sun in a near circular path that takes a year to complete.

b. The moon's orbit around the earth once in about 28 days changes the portion of the moon visible to us, as a result of the sun's reflected light. (phases of the moon).

Grades 5-6

Solar System

S5-6:44

Students demonstrate their understanding of Characteristics of the Solar System by…

- Creating a diagram or model of the orbit of the earth around the sun and the moon around the earth.

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Grades 7-8

Solar System

No S7-8:44 at this grade level

Teachers may review Grade 5-6 Solar System Concepts.

Grades 9-12

Solar System

S9-12:44

Students demonstrate their understanding of Characteristics of the Solar System by…

- Comparing the nature and composition of the atmosphere of inner and outer planets.

AND

- Explaining the effect of distance from the sun on the nature of the planets (e.g., inner vs. outer planets).

Science Concepts:

a. Our solar system developed from a giant cloud of gas and debris of exploding stars 4.6 billion years ago, and everything on earth, including organisms, is made of this material.

b. As the earth and other planets formed, the heavier elements fell to their centers. On planets close to the sun (Mercury, Venus, Earth and Mars) the lightest elements were mostly blown or boiled away by radiation from the newly formed sun; on the outer planets (Jupiter, Saturn, Uranus, Neptune, and Pluto) the lighter elements still surround them as deep atmospheres f gas or as frozen solid layers.

Grades PreK-K

Scale, distances, star formation, theories, instrumentation

No SPK-K:45 at this grade level

Grades 1-2

Scale, distances, star formation, theories, instrumentation

S1-2:45

Students demonstrate their understanding of Processes and Change over Time within Systems of the Universe by…

- Drawing a picture of stars in the night sky.

Science concept:

a. There are more stars in the sky than anyone can easily count, but they are not scattered evenly; and they are not all the same in brightness or color.

Grades 3-4

Scale, distances, star formation, theories, instrumentation

S3-4:45

Students demonstrate their understanding of Processes and Change over Time within Systems of the Universe by…

- Identifying similar star patterns/or groups from night photographs of the same location at different times of the years.

AND

- Comparing (similarities) between the sun and stars.

Science Concepts:

a. Stars are like the sun, but so far away that they look like points of light. Some are smaller; some are larger than the sun.

b. The patterns of the stars stay the same, although they appear to move across the sky.

Grades 5-6

Scale, distances, star formation, theories, instrumentation

S5-6:45

Students demonstrate their understanding of Processes and Change over Time within Systems of the Universe by…

- Explaining (after viewing a picture or illustration with sun/moon showing true relative size) why the sun and moon appear to be the same size when seen from the earth.

AND

- Relating this phenomenon to a lunar and solar eclipses.

Science Concepts:

a. From earth the moon and the sun appear to be the same size, because the moon is so much closer to the earth than the sun.

b. Telescopes magnify the appearance of some very distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.

Grades 5-6

Scale, distances, star formation, theories, instrumentation

S5-6:45

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b. Telescopes magnify the appearance of some very distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye.

Grades 7-8

Scale, distances, star formation, theories, instrumentation

S7-8:45

Students demonstrate their understanding of Processes and Change over Time within Systems of the Universe by…

- Identifying and labeling the location of the sun in our solar system and its relationship to the galaxy.

Science Concepts:

a. The sun is many thousands of times closer to the earth than any other star. The sun is located near the edge of a disc-shaped galaxy of stars.

Grades 9-12

Scale, distances, star formation, theories, instrumentation

S9-12:45

Students demonstrate their understanding of Processes and Change over Time within Systems of the Universe by…

- Describing the process of star formation (i.e. our sun) in relation to its size, including the interaction of the force of gravity, fusion and energy release.

AND

- Explaining the process of the Big Bang Theory and its effect on the Universe today, citing evidence to support its occurrence (Doppler effect/red shift).

AND

- Explaining how technology through time has influenced our understanding of the vastness (i.e., light years) and the nature of the universe (e.g., Ptolemy, Copernicus, Kepler, Einstein).

Science Concepts:

a. Stars formed by gravitational clumping of hydrogen and helium out of clouds of molecules of these lightest elements until nuclear fusion of these light elements into heavier ones began to occur, releasing great amounts of energy over millions of years. The process of star formation continues today, as some stars explode, creating new clouds from which other stars from and eventually dissipate with changes in matter and energy Stars differ in size, temperature and age, but appear to be made of the same elements found on earth and behave according to the same physical principles.

b.. The Universe expanded explosively into being perhaps between 10 and 20 billion years ago from a hot, dense, chaotic mass.

c. The nature of electromagnetic waves (radio waves-- the longest, to gamma rays, the shortest) has provided a useful tool to determine the movement of objects in the Universe. Because light from almost all distant galaxies has longer wavelengths that comparable light here on earth, astronomers believe the whole Universe is continuing to expand. Mathematical models and computer simulations are used to study evidence from many sources to explain events in the Universe. A variety of increasingly sophisticated technology is used to learn about the Universe (e.g., visual telescopes, radio telescopes, X-ray telescopes, computers, space probes, atomic accelerators.

d. Scientific theories on the nature of the Universe have evolved significantly through the past 2000+ years (Ptolemy, Copernicus, Kepler, Galileo), and new views are emerging.

Grades PreK-K

Earth Materials and the Rock Cycle

SPK-K:46

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Sorting and recognizing similarities and differences in a variety of rocks (from boulders to grains of sand).

Science Concepts:

a. Chunks of rocks come in many sizes and shapes, from boulders to grains of sand and even smaller.

Grades 1-2

Earth Materials and the Rock Cycle

S1-2:46

Students demonstrate their understanding of Processes and Change over Time within Systems of the Universe by…

- Observing, describing and comparing color and texture of different types of rocks and soils.

AND

- Conducting tests on how different types of soils retain water.

Science Concepts:

a. Earth materials are solid rocks and soils.

b. Soils and rocks have properties of color and texture; in addition, some soils retain different amounts of water.

Grades 3-4

Earth Materials and the Rock Cycle

S3-4:46

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Observing and identifying components of soils and rocks.

AND

- Recognizing and identifying the four basic materials of the earth (i.e., rocks, soil water and gases).

AND

- Observing and describing the properties of rocks.

Science Concepts:

a. Soil is made partly from rock, partly from plant remains and also contains many living organisms.

b. Earth materials are solid rocks, soils, water and the gases of the atmosphere.

c. Rock is composed of different combinations of minerals. Large rocks can be broken down into small rocks.

d. Rocks have properties of color, texture and hardness. Rocks can be classified by their physical properties.

Grades 5-6

Earth Materials and the Rock Cycle

S5-6:46

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Explaining the process of how rocks are formed (the Rock Cycle).

AND

- Creating a model of the earth's structure explaining the nature of the layers.

Science Concepts:

a. Rocks come from magma or lava, as well as from sediments that build up in layers. As all rocks from earth's surface weather, form sediments and become buried and heated (through pressure or direct heat), they may crystallize into new rock. Eventually those new rocks may be brought to the surface by forces that drive plate motions (The Rock Cycle).

b. The earth is layered with a rigid shell, a hot mantle and a dense metallic core.

Grades 5-6

Earth Materials and the Rock Cycle

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b. The earth is layered with a rigid shell, a hot mantle and a dense metallic core.

Grades 7-8

Earth Materials and the Rock Cycle

No S7-8:46 at this grade level

Teachers may review Grade 5-6 Change Over Time within Earth Systems Concepts.

Grades 9-12

Earth Materials and the Rock Cycle

S9-12:46

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Investigating and explaining evidence illustrating that despite changes in form, conservation in the amount of earth materials occurs during the Rock Cycle.

AND

- Explaining how the heat (energy) produced by radioactive decay and pressure affects the Rock Cycle.

AND

- Explaining the processes by which elements (e.g., carbon, nitrogen, oxygen atoms) move through the earth's reservoirs (soil, atmosphere, bodies of water, organisms).

Science Concepts:

a. The formation, weathering, sedimentation and reformation of rock constitutes a continuing "rock cycle" in which the total amount of material remains the same, while its form changes.

b. The earth's systems have internal sources of energy (heat), such as radioactive decay and pressure which create heat.

c. The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Movement of this matter between reservoirs, driven by the earth's internal and external sources of energy, is often accomplished by a change in the physical and chemical properties of the matter in the solid earth atmosphere and organisms.

Grades PreK-K

Forces and Changes on the Earth's Surface

No SPK-K:47 at this grade level

Grades 1-2

Forces and Changes on the Earth's Surface

S 1-2:47

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Creating categories of "things that change" and keeping a record of them over the school year.

Science Concept:

a. Change is something that happens to many things.

Grades 3-4

Forces and Changes on the Earth's Surface

S3-4:47

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Building models that simulate deposits of sediments (e.g., a stream table.

AND

- Investigating local land forms and comparing them with models created in the classroom.

Science Concept:

a. Waves, wind, water and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas.

Grades 5-6

Forces and Changes on the Earth's Surface

S5-6:47

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Identifying examples of geologic changes on the earth's surface, where possible in the local environment (include slow and fast changes).

AND

- Plotting locations of volcanoes and earthquakes and explaining the relationship between location and plate movement.

AND

- Explaining the processes that occur when rocks are changed from one form to another.

AND

- Determining the relative age of fossils within sedimentary rocks from their location in the strata (i.e. which fossils within a sequence are older).

Science Concepts:

a. Some changes on the earth can be very slow, such as weathering and mountain-building, and some can be very fast—such as volcanoes and earthquakes.

b. Earth's rigid shell is composed of large plates that move at rates of centimeters a year Major geologic events, such as earthquakes, volcanic eruptions and mountain building, result from these plate motions.

c. Thousands of layers of sedimentary rock confirm the long history of the changing surface of the earth and the changing life forms whose remains are found in successive layers (land forms—coastlines, mountains, rivers, canyons, deltas).

Grades 5-6

Forces and Changes on the Earth's Surface

S5-6:47

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Grades 7-8

Forces and Changes on the Earth's Surface

No S7-8:47 at this grade level

Teachers may review Grade 5-6 Processes and Changes Over Time within Earth Systems Concepts.

Grades 9-12

Forces and Changes on the Earth's Surface

S9-12:47

Students demonstrate their understanding of Processe1s and Change over Time within Earth Systems by…

- Creating a model, diagram or computer simulation to demonstrate how convection circulation of the mantle initiates the movement of crustal plates which then causes earthquake and volcanic activity (e.g. Mid-Atlantic Ridge, North American and European plate collisions producing the Green Mountains).

AND

- Analyzing samples of rock sequences to determine the relative age of the rock structure.

AND

- Comparing the usefulness of various methods of determining the age of different rock structures (e.g. relative dating vs. C-dating vs. K-Ar dating. If rock structure is less than 500,000 years old, K-Ar dating cannot be used and C-dating can only be used for tens of thousands of years).

Science Concepts:

a. The convection circulation of the earth's mantle slowly moves the solid crustal sections of the earth's continents and ocean basins over the denser, hot layers beneath—separating in some areas and pressing against one another in other areas resulting in plate collisions—mountain building—volcanic activity—islands.

b. Interactions among solid earth, atmosphere, oceans and organisms have resulted in ongoing change of earth's systems (e.g., effects of earthquakes, volcanic eruptions, and glacial activity).

c. The age and changes of the earth and its inhabitants can be extrapolated from rock sequences and fossils in the earth's sediments and land forms and also through the decay rates of radioactive isotopes, indicating a long history (Lyell's Principles of Geology, fossil records, Charles Darwin**).**

Grades PreK-K

Atmosphere, Water Cycle, Weather, Seasons

SPK-K:48

Students demonstrate their understanding of **Processes and Change over Time within Earth Systems by…**

- Observing and describing weather daily throughout a school year.

Science Concepts:

a. Weather changes from day to day.

Grades 1-2

Atmosphere, Water Cycle, Weather, Seasons

S1-2:48

Students demonstrate their understanding of **Processes and Change over Time within Earth Systems by…**

- Observing and recording weather data through the seasons and identifying and drawing conclusions based on the patterns in the data collected.

Science Concepts:

a. The sun provides the light and heat necessary to maintain the temperature of the earth.

b. There are cyclical changes that we see throughout the seasons that can be observed and recorded.

Grades 3-4

Atmosphere, Water Cycle, Weather, Seasons

S3-4:48

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Observing, recording and analyzing local weather data and making predictions based on that data.

AND

- Describing water as it changes into vapor in the air and reappears as a liquid when it is cooled.

AND

- Explaining how this cycle of water relates to weather and the formation of clouds.

Science Concepts:

a. Weather changes from day to day and over the seasons. Weather can be described by measurable quantities (such as temperature, wind direction and speed, precipitation and air pressure.

b. Air is a substance that surrounds us, takes up space and whose movement we feel as wind.

c. Liquid water is changed by heat from the sun to gas (vapor) and returns to a liquid or solid state when cooled to the freezing point.

d. Clouds and fog are made of small drops of water.

Grades 5-6

Atmosphere, Water Cycle, Weather, Seasons

S5-6:48

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Diagramming, labeling and explaining the process of the water cycle (e.g., evaporation, precipitation, run-off).

Science Concepts:

a. The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, and falls again to the surface as rain. The water falling on land collects in rivers and lakes, soil and porous layers of rock and much of it flows back into the ocean.

Grades 5-6

Atmosphere, Water Cycle, Weather, Seasons

S5-6:48

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Diagramming, labeling and explaining the process of the water cycle (e.g., evaporation, precipitation, run-off).

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a. The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, and falls again to the surface as rain. The water falling on land collects in rivers and lakes, soil and porous layers of rock and much of it flows back into the ocean.

Grades 7-8

Atmosphere, Water Cycle, Weather, Seasons

S7-8:48

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Diagramming, labeling and explaining the process of the water cycle (precipitation, evaporation, condensation, run-off, ground water, transpiration).

AND

- Identifying the major gases of earth's atmosphere.

AND

- Explaining how differential heating can affect the earth's weather patterns.

AND

- Creating a model showing the tilt of the earth on its axis and explaining how the sun's energy hitting the earth surface creates the seasons.

Science Concepts:

a. The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, condenses into rain or snow, and falls again to the surface. Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat.

b. The entire planet is surrounded by a relatively thin blanket of air composed of nitrogen, oxygen, and small amounts of other gases, including water vapor.

c. Heat from the sun is the primary source of energy for changes on the earth's surface. The differences in heating of the earth's surface produce the planet's weather patterns.

d. Seasons result from variations in the amount of sun's energy hitting the earth's surface. This happens because of the tilt of the earth's axis and the orbit of the earth around the sun.

Grades 9-12

Atmosphere, Water Cycle, Weather, Seasons

S9-12:48

Students demonstrate their understanding of Processes and Change over Time within Earth Systems by…

- Explaining the uniqueness of the earth's characteristics (e.g., solar intensity, gravity related to size of earth, makeup of atmosphere).

AND

- Explaining how water as a molecule is also unique in its ability to retain heat, compared to land and air on earth.

AND

- Diagramming and explaining local and large scale wind systems (e.g., land and sea breezes and global wind patterns, Coriolis effect).

AND

- Predicting weather for a particular location, using weather map data (barometric pressure, frontal systems, isobars, isotherms, mountain effects, lake/ocean effects, ocean currents, temperature/humidity) and examining world weather maps and identifying the most likely locations where extreme weather might occur (e.g., blizzards thunderstorms, hurricanes, tornadoes).

Science Concepts:

a. Of all the diverse planets and moons in the solar system, earth's unique physical/chemical characteristics, its position, its atmosphere and its intensity of solar radiation that allows for the existence of liquid water. Water is a unique molecule generating unique properties that influence the earth's weather (ability to retain heat, melting, boiling, and freezing points). The intensity of radiation from the sun allows water to cycle between liquid and vapor, which supports life as we know it on earth.

b. The earth's climatic patterns and weather are governed by the transfer of heat energy between atmosphere and land and oceans. Heat transfer at boundaries of atmosphere and oceans causes the circulation of wind and ocean currents, which influence the composition (temperature and moisture content) and the movement of large air masses).

c. The meeting of air masses with different characteristics causes our most.

Grades PreK-K

Natural Resources

SPK-K:49

Students demonstrate their understanding of Processes and Change within Natural Resources by…

- Identifying items that students consume on a daily basis (e.g., food, fiber, paper, wool or wood).

Science Concepts:

a. Natural Resources are materials that we obtain from the living and non-living environment.

Grades 1-2

Natural Resources

S1-2:49

Students demonstrate their understanding of Processes and Change within Natural Resources by…

- Identifying the natural sources of the food that is consumed on a daily basis (e.g., Bread-- wheat—flour; Sap—maple syrup; Pasture—meat and dairy).

Science Concept:

a. Most food comes from farms either directly as crops or through the animals that eat the crops.

Grades 3-4

Natural Resources

S3-4:49

Students demonstrate their understanding of Processes and Change within Natural Resources by…

- Observing and describing properties of living and non-living resources.

AND

- Explaining how the properties of living and n on-living resources make them suitable for use by humans.

Science Concepts:

a. The varied earth materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, for growing the plants we use as food, or supporting animal life. Earth materials provide many of the resources that humans use.

b. Earth materials have chemical and physical properties that make them useful as building materials, or for growing plants or for fuel.

Grades 5-6

Natural Resources

S5-6:49

Students demonstrate their understanding of Processes and Change within Natural Resources by…

- Identifying examples of good and poor management of natural resources.

AND

- Explaining how overpopulation of living things can degrade an environment due to increased use of resources.

Science Concepts:

a. Responsible management of the earth's resources (air, soil, water, trees) is beneficial for the environment and for human use.

Grades 5-6

Natural Resources

S5-6:49

Students demonstrate their understanding of Processes and Change within Natural Resources by…

- Identifying examples of good and poor management of natural resources.

AND

- Explaining how overpopulation of living things can degrade an environment due to increased use of resources.

Science Concepts:

a. Responsible management of the earth's resources (air, soil, water, trees) is beneficial for the environment and for human use.

Grades 7-8

Natural Resources

S7-8:49

Students demonstrate their understanding of Processes and Change within Natural Resources by…

- Investigating natural resources in the community and monitoring/managing them for responsible use.

AND

- Identifying a human activity—in a local environment—and determining the impact of that activity on a specific (local) natural resource.

AND

- Researching the impact of different human activities on the earth's land, waterways and atmosphere and describing possible effects on the living organisms in those environments.

Science Concepts:

a. Human activities have impacts on natural resources, such as increasing wildlife habitats, reducing/managing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere and intensive farming. Some of these changes have decreased the capacity of the environment to support life forms. Others have enhanced the environment to support greater availability of resources.

b. Fresh water, limited in supply, is essential for life and also for most industrial processes. Rivers, lakes, and groundwater can be depleted or polluted, becoming unavailable or unsuitable for life.

Grades 9-12

Natural Resources

S9-12:49

Students demonstrate their understanding of Processes and Change within Natural Resources by …

- Comparing the availability of natural resources and the impact of different management plans (e.g., management of forests depends upon use, lumber production, sugar-bush, deer habitat, mining, recreation) within the management area (forest, farmland, rivers, streams).

AND

- Choosing a Vermont ecosystem and tracing its succession before and after a damaging event, showing how the ecosystem has been restored through the maintenance of atmosphere quality, generation of soils, control of the water cycle, disposal of wastes and recycling of nutrients (e.g., flooding, former mining sites, glacial impact, deforestation, recovery of rivers from sewage/chemical dumping, burning of fossil fuels).

AND

- Explaining a natural chemical cycle that has been disrupted by human activity and predict what the long term effect will be on organisms (e.g., acid precipitation, global warming. ozone depletion, pollution of water by phosphates, mercury, PCBs, etc.).

AND

- Tracing the processes that are necessary to produce a common, everyday object from the original raw materials to its final destination after human use, considering alternate routes—including extraction of raw material, production and transportation, energy use and waste disposal throughout, packaging and recycling and/or disposal (e.g., aluminum can, steel).

Science Concepts:

a. Human activities can enhance potential for accelerating rates of natural change.

b. Natural ecosystems provide many basic processes that affect humans—maintenance of atmospheric quality, generation of soils, control of the water cycle, disposal of wastes and recycling of nutrients, etc.

c. Materials and habits from human societies affect both physical and chemical cycles on earth, and human alteration of these cycles can be detrimental to all organisms.

d. Natural ecosystems provide the raw materials for the development of many products for human use (e.g. steel, glass, fertilizers).