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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

The goal in the development of the standard was to assure that the six strands and five unifying concepts are interwoven into a fabric of science that represents the true nature of science. Students have the opportunity to develop both the skills and content knowledge necessary to be scientifically literate members of the community.

Strands 1, 2, and 3 are designed to be explicitly taught *and* embedded *within* each of the content strands 4, 5, and 6, and are not intended to be taught in isolation. The processes, skills, and content of the first three strands are designed to “umbrella” and complement the content of Life Science, Physical Science, and Earth and Space Science.

### Strand 1: Inquiry Process

Inquiry Process establishes the basis for students’ learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.

#### **Concept 1: Observations, Questions, and Hypotheses**

Formulate predictions, questions, or hypotheses based on observations. Locate appropriate resources.

**PO 1.** Differentiate among a question, hypothesis, and prediction.

**PO 2.** Formulate questions based on observations that lead to the development of a hypothesis.  
(See M06-S2C1-01)

**PO 3.** Locate research information, not limited to a single source, for use in the design of a controlled investigation.  
(See W-E8-01)

#### **Concept 2: Scientific Testing (Investigating and Modeling)**

Design and conduct controlled investigations.

*PO 1. Demonstrate safe behavior and appropriate procedures (e.g., use and care of technology, materials, organisms) in all science inquiry.*

**PO 2.** Design an investigation to test individual variables using scientific processes.

**PO 3.** Conduct a controlled investigation using scientific processes.

**PO 4.** Perform measurements using appropriate scientific tools (e.g., balances, microscopes, probes, micrometers).  
(See M06-S4C4-02)

**PO 5.** Keep a record of observations, notes, sketches, questions, and ideas using tools such as written and/or computer logs.

*Italics denote a repetition of a performance objective (learned in an earlier grade) that is to be applied to grade level content or at a higher level of complexity.*

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

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### Concept 3: Analysis and Conclusions

Analyze and interpret data to explain correlations and results; formulate new questions.

PO 1. Analyze data obtained in a scientific investigation to identify trends.  
(See M06-S2C1-03)

**PO 2.** Form a logical argument about a correlation between variables or sequence of events (e.g., construct a cause-and-effect chain that explains a sequence of events).

**PO 3.** Evaluate the observations and data reported by others.

PO 4. Interpret simple tables and graphs produced by others.

**PO 5.** Analyze the results from previous and/or similar investigations to verify the results of the current investigation.

PO 6. Formulate new questions based on the results of a completed investigation.



### Concept 4: Communication

Communicate results of investigations.

PO 1. Choose an appropriate graphic representation for collected data:

- line graph
- double bar graph
- stem and leaf plot
- histogram

(See M06-S2C2-02)

PO 2. Display data collected from a controlled investigation.  
(See M06-S2C1-02)

**PO 3.** Communicate the results of an investigation with appropriate use of qualitative and quantitative information.  
(See W-E6-PO1)

**PO 4.** Create a list of instructions that others can follow in carrying out a procedure (without the use of personal pronouns).

**PO 5.** Communicate the results and conclusion of the investigation.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

### Strand 2: History and Nature of Science

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.



#### Concept 1: History of Science as a Human Endeavor

Identify individual, cultural, and technological contributions to scientific knowledge.

**PO 1.** *Identify how diverse people and/or cultures, past and present, have made important contributions to scientific innovations (e.g., Jacques Cousteau [inventor, marine explorer], supports Strand 4; William Beebe [scientist], supports Strand 4; Thor Heyerdahl [anthropologist], supports Strand 6).*

**PO 2.** Describe how a major milestone in science or technology has revolutionized the thinking of the time (e.g., Cell Theory, sonar, SCUBA, underwater robotics).

**PO 3.** Analyze the impact of a major scientific development occurring within the past decade.

**PO 4.** Describe the use of technology in science-related careers.



#### Concept 2: Nature of Scientific Knowledge

Understand how science is a process for generating knowledge.

**PO 1.** Describe how science is an ongoing process that changes in response to new information and discoveries.

**PO 2.** Describe how scientific knowledge is subject to change as new information and/or technology challenges prevailing theories.

**PO 3.** Apply the following scientific processes to other problem solving or decision making situations:

- observing
- questioning
- communicating
- comparing
- measuring
- classifying
- predicting
- organizing data
- inferring
- generating hypotheses
- identifying variables

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.



#### Concept 1: Changes in Environments

Describe the interactions between human populations, natural hazards, and the environment.

PO 1. Evaluate the effects of the following natural hazards:

- sandstorm
- hurricane
- tornado
- ultraviolet light
- lightning-caused fire

PO 2. Describe how people plan for, and respond to, the following natural disasters:

- drought
- flooding
- tornadoes



#### Concept 2: Science and Technology in Society

Develop viable solutions to a need or problem.

PO 1. Propose viable methods of responding to an identified need or problem.

PO 2. Compare possible solutions to best address an identified need or problem.

PO 3. Design and construct a solution to an identified need or problem using simple classroom materials.

PO 4. Describe a technological discovery that influences science.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

### Strand 4: Life Science

Life Science expands students' biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.



#### Concept 1: Structure and Function in Living Systems

Understand the relationships between structures and functions of organisms.

**PO 1.** Explain the importance of water to organisms.

**PO 2.** Describe the basic structure of a cell, including:

- cell wall
- cell membrane
- nucleus

**PO 3.** Describe the function of each of the following cell parts:

- cell wall
- cell membrane
- nucleus

**PO 4.** Differentiate between plant and animal cells.

**PO 5.** Explain the hierarchy of cells, tissues, organs, and systems.

**PO 6.** Relate the following structures of living organisms to their functions:

#### Animals

- respiration – gills, lungs
- digestion – stomach, intestines
- circulation – heart, veins, arteries, capillaries
- locomotion – muscles, skeleton

#### Plants

- transpiration – stomata, roots, xylem, phloem
- absorption – roots, xylem, phloem
- response to stimulus (phototropism, hydrotropism, geotropism) – roots, xylem, phloem

**PO 7.** Describe how the various systems of living organisms work together to perform a vital function:

- respiratory and circulatory
- muscular and skeletal
- digestive and excretory

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

### Concept 2: Reproduction and Heredity

Understand the basic principles of heredity.

No performance objectives at this grade level



### Concept 3: Populations of Organisms in an Ecosystem

Analyze the relationships among various organisms and their environment.

**PO 1.** Explain that sunlight is the major source of energy for most ecosystems.  
(See Strand 5 Concept 3 and Strand 6 Concept 2)

**PO 2.** Describe how the following environmental conditions affect the quality of life:

- water quality
- climate
- population density
- smog

### Concept 4: Diversity, Adaptation, and Behavior

Identify structural and behavioral adaptations.

No performance objectives at this grade level

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

### Strand 5: Physical Science

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

#### Concept 1: Properties and Changes of Properties in Matter

Understand physical and chemical properties of matter.

No performance objectives at this grade level

#### Concept 2: Motion and Forces

Understand the relationship between force and motion.

No performance objectives at this grade level



#### Concept 3: Transfer of Energy

Understand that energy can be stored and transferred.

PO 1. Identify various ways in which electrical energy is generated using renewable and nonrenewable resources (e.g., wind, dams, fossil fuels, nuclear reactions).

PO 2. Identify several ways in which energy may be stored.

PO 3. Compare the following ways in which energy may be transformed:

- mechanical to electrical
- electrical to thermal

PO 4. Explain how thermal energy (heat energy) can be transferred by:

- conduction
- convection
- radiation

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

### Strand 6: Earth and Space Science

Earth and Space Science provides the foundation for students to develop an understanding of the Earth, its history, composition, and formative processes, and an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic laws, theories, and models that explain the world (NSES, 1995). By studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.



#### Concept 1: Structure of the Earth

Describe the composition and interactions between the structure of the Earth and its atmosphere.

PO 1. Describe the properties and the composition of the layers of the atmosphere.

PO 2. Explain the composition, properties, and structure of the Earth's lakes and rivers.

PO 3. Explain the composition, properties, and structures of the oceans' zones and layers.

PO 4. Analyze the interactions between the Earth's atmosphere and the Earth's bodies of water (water cycle).

PO 5. Describe ways scientists explore the Earth's atmosphere and bodies of water.  
(See Strand 2 Concept 1)



#### Concept 2: Earth's Processes and Systems

Understand the processes acting on the Earth and their interaction with the earth systems.

PO 1. Explain how water is cycled in nature.

PO 2. Identify the distribution of water within or among the following:

- atmosphere
- lithosphere
- hydrosphere

PO 3. Analyze the effects that bodies of water have on the climate of a region.

PO 4. Analyze the following factors that affect climate:

- ocean currents
- elevation
- location

PO 5. Analyze the impact of large-scale weather systems on the local weather.

PO 6. Create a weather system model that includes:

- the Sun
- the atmosphere
- bodies of water

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 6

### **Concept 3: Earth in the Solar System**

Understand the relationships of the Earth and other objects in the solar system.

No performance objectives at this grade level

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7

The goal in the development of the standard was to assure that the six strands and five unifying concepts are interwoven into a fabric of science that represents the true nature of science. Students have the opportunity to develop both the skills and content knowledge necessary to be scientifically literate members of the community.

Strands 1, 2, and 3 are designed to be explicitly taught *and* embedded *within* each of the content strands 4, 5, and 6, and are not intended to be taught in isolation. The processes, skills, and content of the first three strands are designed to “umbrella” and complement the content of Life Science, Physical Science, and Earth and Space Science.

### Strand 1: Inquiry Process

Inquiry Process establishes the basis for students’ learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.



#### Concept 1: Observations, Questions, and Hypotheses

Formulate predictions, questions, or hypotheses based on observations. Locate appropriate resources.

*PO 1. Formulate questions based on observations that lead to the development of a hypothesis.  
(See M07-S2C1-01)*

*PO 2. Select appropriate resources for background information related to a question, for use in the design of a controlled investigation.  
(See W-E8-01)*

*PO 3. Explain the role of a hypothesis in a scientific inquiry.*



#### Concept 2: Scientific Testing (Investigating and Modeling)

Design and conduct controlled investigations.

*PO 1. Demonstrate safe behavior and appropriate procedures (e.g., use and care of technology, materials, organisms) in all science inquiry.*

*PO 2. Design an investigation to test individual variables using scientific processes.*

*PO 3. Conduct a controlled investigation, utilizing multiple trials, to test a hypothesis using scientific processes.*

*PO 4. Perform measurements using appropriate scientific tools (e.g., balances, microscopes, probes, micrometers).*

*PO 5. Keep a record of observations, notes, sketches, questions, and ideas using tools such as written and/or computer logs.*

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7



### Concept 3: Analysis and Conclusions

Analyze and interpret data to explain correlations and results; formulate new questions.

*PO 1. Analyze data obtained in a scientific investigation to identify trends.*

*(See M07-S2C1-08)*

**PO 2.** *Form a logical argument about a correlation between variables or sequence of events (e.g., construct a cause-and-effect chain that explains a sequence of events).*

**PO 3.** Analyze results of data collection in order to accept or reject the hypothesis.

**PO 4.** Determine validity and reliability of results of an investigation.

**PO 5.** Formulate a conclusion based on data analysis.

**PO 6.** Refine hypotheses based on results from investigations.

**PO 7.** Formulate new questions based on the results of a previous investigation.



### Concept 4: Communication

Communicate results of investigations.

*PO 1. Choose an appropriate graphic representation for collected data:*

- *line graph*
- *double bar graph*
- *stem and leaf plot*
- *histogram*

*(See M07-S2C1-03)*

*PO 2. Display data collected from a controlled investigation.*

*(See M07-S2C1-03)*

**PO 3.** *Communicate the results of an investigation with appropriate use of qualitative and quantitative information.*  
*(See W-E6-PO1)*

**PO 4.** Write clear, step-by-step instructions for following procedures (without the use of personal pronouns).

**PO 5.** *Communicate the results and conclusion of the investigation.*

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7

### Strand 2: History and Nature of Science

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.



#### Concept 1: History of Science as a Human Endeavor

Identify individual, cultural, and technological contributions to scientific knowledge.

- PO 1.** *Identify how diverse people and/or cultures, past and present, have made important contributions to scientific innovations (e.g., Rachel Carson [scientist], supports Strand 4; Luis Alvarez [scientist] and Walter Alvarez [scientist], support Strand 6; Percival Lowell [scientist], supports Strand 6; Copernicus [scientist], supports Strand 6).*
- PO 2.** *Describe how a major milestone in science or technology has revolutionized the thinking of the time (e.g., global positioning system, telescopes, seismographs, photography).*
- PO 3.** *Analyze the impact of a major scientific development occurring within the past decade.*
- PO 4.** *Analyze the use of technology in science-related careers.*



#### Concept 2: Nature of Scientific Knowledge

Understand how science is a process for generating knowledge.

- PO 1.** *Describe how science is an ongoing process that changes in response to new information and discoveries.*
- PO 2.** *Describe how scientific knowledge is subject to change as new information and/or technology challenges prevailing theories.*
- PO 3.** *Apply the following scientific processes to other problem solving or decision making situations:*
- *observing*
  - *questioning*
  - *communicating*
  - *comparing*
  - *measuring*
  - *classifying*
  - *predicting*
  - *organizing data*
  - *inferring*
  - *generating hypotheses*
  - *identifying variables*

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7

### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.



#### Concept 1: Changes in Environments

Describe the interactions between human populations, natural hazards, and the environment.

**PO 1.** Analyze environmental risks (e.g., pollution, destruction of habitat) caused by human interaction with biological or geological systems.

**PO 2.** Analyze environmental benefits of the following human interactions with biological or geological systems:

- reforestation
- habitat restoration
- construction of dams

**PO 3.** Propose possible solutions to address the environmental risks in biological or geological systems.



#### Concept 2: Science and Technology in Society

Develop viable solutions to a need or problem.

*PO 1. Propose viable methods of responding to an identified need or problem.*

**PO 2.** *Compare solutions to best address an identified need or problem.*

**PO 3.** *Design and construct a solution to an identified need or problem using simple classroom materials.*

**PO 4.** Describe a scientific discovery that influences technology.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7

### Strand 4: Life Science

Life Science expands students' biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

#### Concept 1: Structure and Function in Living Systems

Understand the relationships between structures and functions of organisms.

No performance objectives at this grade level

#### Concept 2: Reproduction and Heredity

Understand the basic principles of heredity.

No performance objectives at this grade level



#### Concept 3: Populations of Organisms in an Ecosystem

Analyze the relationships among various organisms and their environment.

**PO 1.** Compare food chains in a specified ecosystem and their corresponding food web.

**PO 2.** Explain how organisms obtain and use resources to develop and thrive in:

- niches
- predator/prey relationships

**PO 3.** Analyze the interactions of living organisms with their ecosystems:

- limiting factors
- carrying capacity

**PO 4.** Evaluate data related to problems associated with population growth (e.g., overgrazing, forest management, invasion of non-native species) and the possible solutions.

**PO 5.** Predict how environmental factors (e.g., floods, droughts, temperature changes) affect survival rates in living organisms.

**PO 6.** Create a model of the interactions of living organisms within an ecosystem.

#### Concept 4: Diversity, Adaptation, and Behavior

Identify structural and behavioral adaptations.

No performance objectives at this grade level

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7

### Strand 5: Physical Science

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

#### **Concept 1: Properties and Changes of Properties in Matter**

Understand physical and chemical properties of matter.

No performance objectives at this grade level

#### **Concept 2: Motion and Forces**

Understand the relationship between force and motion.

No performance objectives at this grade level

#### **Concept 3: Transfer of Energy**

Understand that energy can be stored and transferred.

No performance objectives at this grade level

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7

### Strand 6: Earth and Space Science

Earth and Space Science provides the foundation for students to develop an understanding of the Earth, its history, composition, and formative processes, and an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic laws, theories, and models that explain the world (NSES, 1995). By studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.



#### Concept 1: Structure of the Earth

Describe the composition and interactions between the structure of the Earth and its atmosphere.

**PO 1.** Classify rocks and minerals by the following observable properties:

- grain
- color
- texture
- hardness

**PO 2.** Describe the properties and the composition of the following major layers of the Earth:

- crust
- mantle
- core

**PO 3.** Explain the following processes involved in the formation of the Earth's structure:

- erosion
- deposition
- plate tectonics
- volcanism

**PO 4.** Describe how the rock and fossil record show that environmental conditions have changed over geologic and recent time.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 7



### Concept 2: Earth's Processes and Systems

Understand the processes acting on the Earth and their interaction with the earth systems.

**PO 1.** Explain the rock cycle.

**PO 2.** Distinguish the components and characteristics of the rock cycle for the following types of rocks:

- igneous
- metamorphic
- sedimentary

**PO 3.** Analyze the evidence that lithospheric plate movements occur.

**PO 4.** Explain lithospheric plate movement as a result of convection.

**PO 5.** Relate plate boundary movements to their resulting landforms, including:

- mountains
- faults
- rift valleys
- trenches
- volcanoes

**PO 6.** Describe how earthquakes are measured.



### Concept 3: Earth in the Solar System

Understand the relationships of the Earth and other objects in the solar system.

**PO 1.** Explain the phases of the Moon in terms of the relative positions of the Earth, Sun, and Moon.

**PO 2.** Construct a model for the relative positions of the Earth, Sun, and Moon as they relate to corresponding eclipses.

**PO 3.** Explain the interrelationship between the Earth's tides and the Moon.

**PO 4.** Explain the seasons in the Northern and Southern Hemispheres in terms of the tilt of the Earth's axis relative to the Earth's revolution around the Sun.

**PO 5.** Identify the following major constellations visible (seasonally) from the Northern Hemisphere:

- Orion
- Ursa Major (Great Bear)
- Cygnus
- Scorpius
- Cassiopeia

**PO 6.** Explain the relationship among common objects in the solar system, galaxy, and the universe.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8

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### Strand 1: Inquiry Process

Inquiry Process establishes the basis for students’ learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.



#### Concept 1: Observations, Questions, and Hypotheses

Formulate predictions, questions, or hypotheses based on observations. Locate appropriate resources.

**PO 1.** *Formulate questions based on observations that lead to the development of a hypothesis.*  
(See M08-S2C1-01)

**PO 2.** Use appropriate research information, not limited to a single source, to use in the development of a testable hypothesis.  
(See R08-S3C2-03 and W-E8-01)

**PO 3.** Generate a hypothesis that can be tested.



#### Concept 2: Scientific Testing (Investigating and Modeling)

Design and conduct controlled investigations.

**PO 1.** *Demonstrate safe behavior and appropriate procedures (e.g., use and care of technology, materials, organisms) in all science inquiry.*

**PO 2.** Design a controlled investigation to support or reject a hypothesis.

**PO 3.** Conduct a controlled investigation to support or reject a hypothesis.

**PO 4.** *Perform measurements using appropriate scientific tools (e.g., balances, microscopes, probes, micrometers).*

**PO 5.** *Keep a record of observations, notes, sketches, questions, and ideas using tools such as written and/or computer logs.*

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8



### Concept 3: Analysis and Conclusions

Analyze and interpret data to explain correlations and results; formulate new questions.

*PO 1. Analyze data obtained in a scientific investigation to identify trends.*

*(See M08-S2C1-08)*

**PO 2.** *Form a logical argument about a correlation between variables or sequence of events (e.g., construct a cause-and-effect chain that explains a sequence of events).*

PO 3. Interpret data that show a variety of possible relationships between two variables, including:

- positive relationship
- negative relationship
- no relationship

**PO 4.** Formulate a future investigation based on the data collected.

**PO 5.** Explain how evidence supports the validity and reliability of a conclusion.

**PO 6.** Identify the potential investigational error that may occur (e.g., flawed investigational design, inaccurate measurement, computational errors, unethical reporting).

**PO 7.** Critique scientific reports from periodicals, television, or other media.

*PO 8. Formulate new questions based on the results of a previous investigation.*



### Concept 4: Communication

Communicate results of investigations.

**PO 1.** Communicate the results of an investigation.

*PO 2. Choose an appropriate graphic representation for collected data:*

- *line graph*
- *double bar graph*
- *stem and leaf plot*
- *histogram*

*(See M08-S2C1-03)*

**PO 3.** Present analyses and conclusions in clear, concise formats.

*(See W-E6-PO1)*

**PO 4.** Write clear, step-by-step instructions for conducting investigations or operating equipment (without the use of personal pronouns).

**PO 5.** *Communicate the results and conclusion of the investigation.*

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*The bulleted items within a performance objective indicate specific content to be taught.*

# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8

### Strand 2: History and Nature of Science

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.



#### Concept 1: History of Science as a Human Endeavor

Identify individual, cultural, and technological contributions to scientific knowledge.

**PO 1.** *Identify how diverse people and/or cultures, past and present, have made important contributions to scientific innovations (e.g., Watson and Crick [scientists], support Strand 4; Rosalind Franklin [scientist], supports Strand 4; Charles Darwin [scientist], supports Strand 4; George Washington Carver [scientist, inventor], supports Strand 4; Joseph Priestley [scientist], supports Strand 5; Sir Frances Bacon [philosopher], supports Strand 5; Isaac Newton [scientist], supports Strand 5).*

**PO 2.** Evaluate the effects of the following major scientific milestones on society:

- Mendelian Genetics
- Newton's Laws

**PO 3.** Evaluate the impact of a major scientific development occurring within the past decade.

**PO 4.** Evaluate career opportunities related to life and physical sciences.



#### Concept 2: Nature of Scientific Knowledge

Understand how science is a process for generating knowledge.

**PO 1.** *Apply the following scientific processes to other problem solving or decision making situations:*

- *observing*
- *questioning*
- *communicating*
- *comparing*
- *measuring*
- *classifying*
- *predicting*
- *organizing data*
- *inferring*
- *generating hypotheses*
- *identifying variables*

**PO 2.** *Describe how scientific knowledge is subject to change as new information and/or technology challenges prevailing theories.*

**PO 3.** Defend the principle that accurate record keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society.

**PO 4.** Explain why scientific claims may be questionable if based on very small samples of data, biased samples, or samples for which there was no control.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8

### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.



#### Concept 1: Changes in Environments

Describe the interactions between human populations, natural hazards, and the environment.

**PO 1.** Analyze the risk factors associated with natural, human induced, and/or biological hazards, including:

- waste disposal of industrial chemicals
- greenhouse gases

**PO 2.** Analyze possible solutions to address the environmental risks associated with chemicals and biological systems.



#### Concept 2: Science and Technology in Society

Develop viable solutions to a need or problem.

*PO 1. Propose viable methods of responding to an identified need or problem.*

**PO 2.** *Compare solutions to best address an identified need or problem.*

**PO 3.** *Design and construct a solution to an identified need or problem using simple classroom materials.*

**PO 4.** Compare risks and benefits of the following technological advances:

- radiation treatments
- genetic engineering (See Strand 4 Concept 2)
- airbags (See Strand 5 Concept 2)

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8

### Strand 4: Life Science

Life Science expands students' biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

#### Concept 1: Structure and Function in Living Systems

Understand the relationships between structures and functions of organisms.

No performance objectives at this grade level



#### Concept 2: Reproduction and Heredity

Understand the basic principles of heredity.

**PO 1.** Explain the purposes of cell division:

- growth and repair
- reproduction

**PO 2.** Explain the basic principles of heredity using the human examples of:

- eye color
- widow's peak
- blood type

**PO 3.** Distinguish between the nature of dominant and recessive traits in humans.

#### Concept 3: Populations of Organisms in an Ecosystem

Analyze the relationships among various organisms and their environment.

No performance objectives at this grade level

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8



### Concept 4: Diversity, Adaptation, and Behavior

Identify structural and behavioral adaptations.

**PO 1.** Explain how an organism's behavior allows it to survive in an environment.

**PO 2.** Describe how an organism can maintain a stable internal environment while living in a constantly changing external environment.

**PO 3.** Determine characteristics of organisms that could change over several generations.

**PO 4.** Compare the symbiotic and competitive relationships in organisms within an ecosystem (e.g., lichen, mistletoe/tree, clownfish/sea anemone, native/non-native species).

**PO 5.** Analyze the following behavioral cycles of organisms:

- hibernation
- migration
- dormancy (plants)

**PO 6.** Describe the following factors that allow for the survival of living organisms:

- protective coloration
- beak design
- seed dispersal
- pollination

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8

### Strand 5: Physical Science

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.



#### Concept 1: Properties and Changes of Properties in Matter

Understand physical and chemical properties of matter.

**PO 1.** Identify different kinds of matter based on the following physical properties:

- states
- density
- boiling point
- melting point
- solubility

**PO 2.** Identify different kinds of matter based on the following chemical properties:

- reactivity
- pH
- oxidation (corrosion)

**PO 3.** Identify the following types of evidence that a chemical reaction has occurred:

- formation of a precipitate
- generation of gas
- color change
- absorption or release of heat

**PO 4.** Classify matter in terms of elements, compounds, or mixtures.

**PO 5.** Classify mixtures as being homogeneous or heterogeneous.

**PO 6.** Explain the systematic organization of the periodic table.

**PO 7.** Investigate how the transfer of energy can affect the physical and chemical properties of matter.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8



### Concept 2: Motion and Forces

Understand the relationship between force and motion.

PO 1. Demonstrate velocity as the rate of change of position over time.

**PO 2.** Identify the conditions under which an object will continue in its state of motion (Newton's 1<sup>st</sup> Law of Motion).

**PO 3.** Describe how the acceleration of a body is dependent on its mass and the net applied force (Newton's 2<sup>nd</sup> Law of Motion).

**PO 4.** Describe forces as interactions between bodies (Newton's 3<sup>rd</sup> Law of Motion).

PO 5. Create a graph devised from measurements of moving objects and their interactions, including:

- position-time graphs
- velocity-time graphs

### Concept 3: Transfer of Energy

Understand that energy can be stored and transferred.

No performance objectives at this grade level

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## GRADE 8

### Strand 6: Earth and Space Science

Earth and Space Science provides the foundation for students to develop an understanding of the Earth, its history, composition, and formative processes, and an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic laws, theories, and models that explain the world (NSES, 1995). By studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.

#### **Concept 1: Structure of the Earth**

Describe the composition and interactions between the structure of the Earth and its atmosphere.

No performance objectives at this grade level

#### **Concept 2: Earth's Processes and Systems**

Understand the processes acting on the Earth and their interaction with the earth systems.

No performance objectives at this grade level

#### **Concept 3: Earth in the Solar System**

Understand the relationships of the Earth and other objects in the solar system.

No performance objectives at this grade level

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL

The Arizona high school science standard was designed to support the instruction and assessment of students. Science instruction should involve students actively using scientific processes to understand course content and make connections to real life and related areas of study. The goal in the development of the standard was to assure that the six strands and five unifying concepts are interwoven into a fabric of science that represents the true nature of science. Students have the opportunity to develop both the skills and content knowledge necessary to be scientifically literate members of the community.

Strands 1, 2, and 3 (Inquiry Process, History and Nature of Science, and Science in Personal and Social Perspective) contain the processes and connections desired of Arizona students and must, therefore, be reflected in all science courses. These strands are designed to be explicitly taught *and embedded within* each of the content strands 4, 5, and 6, and are not intended to be taught in isolation. The processes, skills, and content of the first three strands are designed to “umbrella” and complement the content of Life Science, Physical Science, and Earth and Space Science.

At the high school level, Strands 4, 5, and 6 (Life Science, Physical Science, and Earth and Space Science) contain content area knowledge and skills that are, by nature, course specific. These strands were written to provide frameworks for complete courses in Life, Physics, Chemistry, and Earth and Space sciences.

The high school science Arizona Instrument to Measure Standards (AIMS) will be based on content from all six strands. All performance objectives in strands 1, 2, and 3 may be included on the high school AIMS. In strands 4, 5 and 6, some, but not all, of the performance objectives will be measured. Within these content strands, the performance objectives with asterisks are identified for possible inclusion on the high school AIMS. A blueprint of the Science AIMS will be available following test development.

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*The bulleted items within a performance objective indicate specific content to be taught.*

*For Strands 4-6, high school performance objectives with asterisks are identified for possible inclusion on the AIMS.*

# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL

### Strand 1: Inquiry Process

Inquiry Process establishes the basis for students' learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.



#### Concept 1: Observations, Questions, and Hypotheses

Formulate predictions, questions, or hypotheses based on observations. Evaluate appropriate resources.

PO 1. Evaluate scientific information for relevance to a given problem.

PO 2. Develop questions from observations that transition into testable hypotheses.

PO 3. Formulate a testable hypothesis.

PO 4. Predict the outcome of an investigation based on prior evidence, probability, and/or modeling (not guessing or inferring).



#### Concept 2: Scientific Testing (Investigating and Modeling)

Design and conduct controlled investigations.

PO 1. Demonstrate safe and ethical procedures (e.g., use and care of technology, materials, organisms) and behavior in all science inquiry.

PO 2. Identify the resources needed to conduct an investigation.

PO 3. Design an appropriate protocol (written plan of action) for testing a hypothesis:

- Identify dependent and independent variables in a controlled investigation.
- Determine an appropriate method for data collection (e.g., using balances, thermometers, microscopes, spectrophotometer, using qualitative changes).
- Determine an appropriate method for recording data (e.g., notes, sketches, photographs, videos, journals (logs), charts, computers/calculators).

PO 4. Conduct a scientific investigation that is based on a research design.

PO 5. Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs, and computers.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 3: Analysis, Conclusions, and Refinements

Evaluate experimental design, analyze data to explain results and propose further investigations.  
Design models.

**PO 1.** *Interpret data that show a variety of possible relationships between variables, including:*

- positive relationship
- negative relationship
- no relationship

**PO 2.** Evaluate whether investigational data support or do not support the proposed hypothesis.

**PO 3.** Critique reports of scientific studies (e.g., published papers, student reports).

**PO 4.** Evaluate the design of an investigation to identify possible sources of procedural error, including:

- sample size
- trials
- controls
- analyses

**PO 5.** Design models (conceptual or physical) of the following to represent "real world" scenarios:

- carbon cycle
- water cycle
- phase change
- collisions

**PO 6.** Use descriptive statistics to analyze data, including:

- mean
  - frequency
  - range
- (See MHS-S2C1-10)

**PO 7.** Propose further investigations based on the findings of a conducted investigation.



### Concept 4: Communication

Communicate results of investigations.

**PO 1.** For a specific investigation, choose an appropriate method for communicating the results.

**PO 2.** Produce graphs that communicate data. (See MHS-S2C1-02)

**PO 3.** Communicate results clearly and logically.

**PO 4.** Support conclusions with logical scientific arguments.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL HIGH SCHOOL

## Strand 2: History and Nature of Science

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.

### **Concept 1: History of Science as a Human Endeavor**

Identify individual, cultural, and technological contributions to scientific knowledge.

**PO 1.** Describe how human curiosity and needs have influenced science, impacting the quality of life worldwide.

**PO 2.** *Describe how diverse people and/or cultures, past and present, have made important contributions to scientific innovations.*

**PO 3.** Analyze how specific changes in science have affected society.

**PO 4.** Analyze how specific cultural and/or societal issues promote or hinder scientific advancements.

### **Concept 2: Nature of Scientific Knowledge**

Understand how science is a process for generating knowledge.

**PO 1.** Specify the requirements of a valid, scientific explanation (theory), including that it be:

- logical
- subject to peer review
- public
- respectful of rules of evidence

**PO 2.** Explain the process by which accepted ideas are challenged or extended by scientific innovation.

**PO 3.** Distinguish between pure and applied science.

**PO 4.** Describe how scientists continue to investigate and critically analyze aspects of theories.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL

### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.



#### Concept 1: Changes in Environments

Describe the interactions between human populations, natural hazards, and the environment.

**PO 1.** Evaluate how the processes of natural ecosystems affect, and are affected by, humans.

**PO 2.** Describe the environmental effects of the following natural and/or human-caused hazards:

- flooding
- drought
- earthquakes
- fires
- pollution
- extreme weather

**PO 3.** Assess how human activities (e.g., clear cutting, water management, tree thinning) can affect the potential for hazards.

**PO 4.** Evaluate the following factors that affect the quality of the environment:

- urban development
- smoke
- volcanic dust

**PO 5.** Evaluate the effectiveness of conservation practices and preservation techniques on environmental quality and biodiversity.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 2: Science and Technology in Society

Develop viable solutions to a need or problem.

**PO 1.** Analyze the costs, benefits, and risks of various ways of dealing with the following needs or problems:

- various forms of alternative energy
- storage of nuclear waste
- abandoned mines
- greenhouse gases
- hazardous wastes

**PO 2.** Recognize the importance of basing arguments on a thorough understanding of the core concepts and principles of science and technology.

**PO 3.** Support a position on a science or technology issue.

**PO 4.** Analyze the use of renewable and nonrenewable resources in Arizona:

- water
- land
- soil
- minerals
- air

**PO 5.** Evaluate methods used to manage natural resources (e.g., reintroduction of wildlife, fire ecology).



### Concept 3: Human Population Characteristics

Analyze factors that affect human populations.

**PO 1.** Analyze social factors that limit the growth of a human population, including:

- affluence
- education
- access to health care
- cultural influences

**PO 2.** Describe biotic (living) and abiotic (nonliving) factors that affect human populations.

**PO 3.** Predict the effect of a change in a specific factor on a human population.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL

### Strand 4: Life Science

Life Science expands students' biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

#### Concept 1: The Cell

Understand the role of the cell and cellular processes.

PO 1. Describe the role of energy in cellular growth, development, and repair.

PO 2. Compare the form and function of prokaryotic and eukaryotic cells and their cellular components.

PO 3. Explain the importance of water to cells.

PO 4. Analyze mechanisms of transport of materials (e.g., water, ions, macromolecules) into and out of cells:

- passive transport
- active transport

PO 5. Describe the purposes and processes of cellular reproduction.

#### Concept 2: Molecular Basis of Heredity

Understand the molecular basis of heredity and resulting genetic diversity.

\*PO 1. Analyze the relationships among nucleic acids (DNA, RNA), genes, and chromosomes.

PO 2. Describe the molecular basis of heredity, in viruses and living things, including DNA replication and protein synthesis.

PO 3. Explain how genotypic variation occurs and results in phenotypic diversity.

PO 4. Describe how meiosis and fertilization maintain genetic variation.

#### Concept 3: Interdependence of Organisms

Analyze the relationships among various organisms and their environment.

PO 1. Identify the relationships among organisms within populations, communities, ecosystems, and biomes.

\*PO 2. Describe how organisms are influenced by a particular combination of biotic (living) and abiotic (nonliving) factors in an environment.

\*PO 3. Assess how the size and the rate of growth of a population are determined by birth rate, death rate, immigration, emigration, and carrying capacity of the environment.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 4: Biological Evolution

Understand the scientific principles and processes involved in biological evolution.

**PO 1.** Identify the following components of natural selection, which can lead to speciation:

- potential for a species to increase its numbers
- genetic variability and inheritance of offspring due to mutation and recombination of genes
- finite supply of resources required for life
- selection by the environment of those offspring better able to survive and produce offspring

**PO 2.** Explain how genotypic and phenotypic variation can result in adaptations that influence an organism's success in an environment.

**\*PO 3.** Describe how the continuing operation of natural selection underlies a population's ability to adapt to changes in the environment and leads to biodiversity and the origin of new species.

**\*PO 4.** Predict how a change in an environmental factor (e.g., rainfall, habitat loss, non-native species) can affect the number and diversity of species in an ecosystem.

**PO 5.** Analyze how patterns in the fossil record, nuclear chemistry, geology, molecular biology, and geographical distribution give support to the theory of organic evolution through natural selection over billions of years and the resulting present day biodiversity.

**PO 6.** Analyze, using a biological classification system (i.e., cladistics, phylogeny, morphology, DNA analysis), the degree of relatedness among various species.



### Concept 5: Matter, Energy, and Organization in Living Systems (Including Human Systems)

Understand the organization of living systems, and the role of energy within those systems.

**PO 1.** Compare the processes of photosynthesis and cellular respiration in terms of energy flow, reactants, and products.

**PO 2.** Describe the role of organic and inorganic chemicals (e.g., carbohydrates, proteins, lipids, nucleic acids, water, ATP) important to living things.

**\*PO 3.** Diagram the following biogeochemical cycles in an ecosystem:

- water
- carbon
- nitrogen

**\*PO 4.** Diagram the energy flow in an ecosystem through a food chain.

**PO 5.** Describe the levels of organization of living things from cells, through tissues, organs, organ systems, organisms, populations, and communities to ecosystems.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL HIGH SCHOOL

## Strand 5: Physical Science

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.



### Concept 1: Structure and Properties of Matter

Understand physical, chemical, and atomic properties of matter.

- \*PO 1. Describe substances based on their physical properties.
- \*PO 2. Describe substances based on their chemical properties.
- \*PO 3. Predict properties of elements and compounds using trends of the periodic table (e.g., metals, non-metals, bonding – ionic/covalent).
- PO 4. Separate mixtures of substances based on their physical properties.
- PO 5. Describe the properties of electric charge and the conservation of electric charge.
- \*PO 6. Describe the following features and components of the atom:
  - protons
  - neutrons
  - electrons
  - mass
  - number and type of particles
  - structure
  - organization
- PO 7. Describe the historical development of models of the atom.
- PO 8. Explain the details of atomic structure (e.g., electron configuration, energy levels, isotopes).

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 2: Motions and Forces

Analyze relationships between forces and motion.

\*PO 1. Determine the rate of change of a quantity (e.g., rate of erosion, rate of reaction, rate of growth, velocity).

PO 2. Analyze the relationships among position, velocity, acceleration, and time:

- graphically
- mathematically

PO 3. Explain how Newton's 1<sup>st</sup> Law applies to objects at rest or moving at constant velocity.

PO 4. Using Newton's 2<sup>nd</sup> Law of Motion, analyze the relationships among the net force acting on a body, the mass of the body, and the resulting acceleration:

- graphically
- mathematically

\*PO 5. Use Newton's 3<sup>rd</sup> Law to explain forces as interactions between bodies (e.g., a table pushing up on a vase that is pushing down on it; an athlete pushing on a basketball as the ball pushes back on her).

PO 6. Analyze the two-dimensional motion of objects by using vectors and their components.

PO 7. Give an example that shows the independence of the horizontal and vertical components of projectile motion.

PO 8. Analyze the general relationships among force, acceleration, and motion for an object undergoing uniform circular motion.

PO 9. Represent the force conditions required to maintain static equilibrium.

PO 10. Describe the nature and magnitude of frictional forces.

PO 11. Using the Law of Universal Gravitation, predict how the gravitational force will change when the distance between two masses changes or the mass of one of them changes.

PO 12. Using Coulomb's Law, predict how the electrical force will change when the distance between two point charges changes or the charge of one of them changes.

PO 13. Analyze the impulse required to produce a change in momentum.

PO 14. Quantify interactions between objects to show that the total momentum is conserved in both collision and recoil situations.

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Arizona Department of Education – Standards Based Teaching and Learning

Approved 5.24.04

# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 3: Conservation of Energy and Increase in Disorder

Understand ways that energy is conserved, stored, and transferred.

\*PO 1. Describe the following ways in which energy is stored in a system:

- mechanical
- electrical
- chemical
- nuclear

\*PO 2. Describe various ways in which energy is transferred from one system to another (e.g., mechanical contact, thermal conduction, electromagnetic radiation.)

\*PO 3. Recognize that energy is conserved in a closed system.

PO 4. Calculate quantitative relationships associated with the conservation of energy.

PO 5. Analyze the relationship between energy transfer and disorder in the universe (2<sup>nd</sup> Law of Thermodynamics).

PO 6. Distinguish between heat and temperature.

\*PO 7. Explain how molecular motion is related to temperature and phase changes.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 4: Chemical Reactions

Investigate relationships between reactants and products in chemical reactions.

\*PO 1. Apply the law of conservation of matter to changes in a system.

\*PO 2. Identify the indicators of chemical change, including formation of a precipitate, evolution of a gas, color change, absorption or release of heat energy.

PO 3. Represent a chemical reaction by using a balanced equation.

PO 4. Distinguish among the types of bonds (i.e., ionic, covalent, metallic, hydrogen bonding).

PO 5. Describe the mole concept and its relationship to Avogadro's number.

PO 6. Solve problems involving such quantities as moles, mass, molecules, volume of a gas, and molarity using the mole concept and Avogadro's number.

PO 7. Predict the properties (e.g., melting point, boiling point, conductivity) of substances based upon bond type.

PO 8. Quantify the relationships between reactants and products in chemical reactions (e.g., stoichiometry, equilibrium, energy transfers).

PO 9. Predict the products of a chemical reaction using types of reactions (e.g., synthesis, decomposition, replacement, combustion).

PO 10. Explain the energy transfers within chemical reactions using the law of conservation of energy.

PO 11. Predict the effect of various factors (e.g., temperature, concentration, pressure, catalyst) on the equilibrium state and on the rates of chemical reaction.

PO 12. Compare the nature, behavior, concentration, and strengths of acids and bases.

PO 13. Determine the transfer of electrons in oxidation/reduction reactions.

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*For Strands 4-6, high school performance objectives with asterisks are identified for possible inclusion on the AIMS.*

# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 5: Interactions of Energy and Matter

Understand the interactions of energy and matter.

\*PO 1. Describe various ways in which matter and energy interact (e.g., photosynthesis, phase change).

PO 2. Describe the following characteristics of waves:

- wavelength
- frequency
- period
- amplitude

PO 3. Quantify the relationships among the frequency, wavelength, and the speed of light.

PO 4. Describe the basic assumptions of kinetic molecular theory.

PO 5. Apply kinetic molecular theory to the behavior of matter (e.g., gas laws).

PO 6. Analyze calorimetric measurements in simple systems and the energy involved in changes of state.

PO 7. Explain the relationship between the wavelength of light absorbed or released by an atom or molecule and the transfer of a discrete amount of energy.

PO 8. Describe the relationship among electric potential, current, and resistance in an ohmic system.

PO 9. Quantify the relationships among electric potential, current, and resistance in an ohmic system.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL

### Strand 6: Earth and Space Science

Earth and Space Science provides the foundation for students to develop an understanding of the Earth, its history, composition, and formative processes, and an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic laws, theories, and models that explain the world (NSES, 1995). By studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.



#### Concept 1: Geochemical Cycles

Analyze the interactions between the Earth's structures, atmosphere, and geochemical cycles.

- PO 1. Identify ways materials are cycled within the earth system (i.e., carbon cycle, water cycle, rock cycle).
- PO 2. Demonstrate how dynamic processes such as weathering, erosion, sedimentation, metamorphism, and orogenesis relate to redistribution of materials within the earth system.
- PO 3. Explain how the rock cycle is related to plate tectonics.
- PO 4. Demonstrate how the hydrosphere links the biosphere, lithosphere, cryosphere, and atmosphere.
- \*PO 5. Describe factors that impact current and future water quantity and quality including surface, ground, and local water issues.
- PO 6. Analyze methods of reclamation and conservation of water.
- PO 7. Explain how the geochemical processes are responsible for the concentration of economically valuable minerals and ores in Arizona and worldwide.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 2: Energy in the Earth System (Both Internal and External)

Understand the relationships between the Earth's land masses, oceans, and atmosphere.

\*PO 1. Describe the flow of energy to and from the Earth.

\*PO 2. Explain the mechanisms of heat transfer (convection, conduction, radiation) among the atmosphere, land masses, and oceans.

\*PO 3. Distinguish between weather and climate.

#### Internal Energy:

PO 4. Demonstrate the relationship between the Earth's internal convective heat flow and plate tectonics.

PO 5. Demonstrate the relationships among earthquakes, volcanoes, mountain ranges, mid-oceanic ridges, deep sea trenches, and tectonic plates.

PO 6. Distinguish among seismic S, P, and surface waves.

PO 7. Analyze the seismic evidence (S and P waves) used to determine the structure of the Earth.

PO 8. Describe how radioactive decay maintains the Earth's internal temperature.

#### External Energy:

PO 9. Explain the effect of heat transfer on climate and weather.

PO 10. Demonstrate the effect of the Earth's rotation (i.e., Coriolis effect) on the movement of water and air.

PO 11. Describe the origin, life cycle, and behavior of weather systems (i.e., air mass, front, high and low systems, pressure gradients).

PO 12. Describe the conditions that cause severe weather (e.g., hurricanes, tornadoes, thunderstorms).

PO 13. Propose appropriate safety measures that can be taken in preparation for severe weather.

PO 14. Analyze how weather is influenced by both natural and artificial earth features (e.g., mountain ranges, bodies of water, cities, air pollution).

PO 15. List the factors that determine climate (e.g., altitude, latitude, water bodies, precipitation, prevailing winds, topography).

PO 16. Explain the causes and/or effects of climate changes over long periods of time (e.g., glaciation, desertification, solar activity, greenhouse effect).

PO 17. Investigate the effects of acid rain, smoke, volcanic dust, urban development, and greenhouse gases, on climate change over various periods of time.

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# SCIENCE STANDARD ARTICULATED BY GRADE LEVEL

## HIGH SCHOOL



### Concept 3: Origin and Evolution of the Earth System

Analyze the factors used to explain the history and evolution of the Earth.

#### Earth Origin/System:

- PO 1. Describe the scientific theory of the origin of the solar system (solar nebular hypothesis).
- PO 2. Describe the characteristics, location, and motions of the various kinds of objects in our solar system, including the Sun, planets, satellites, comets, meteors, and asteroids.
- PO 3. Explain the phases of the Moon, eclipses (lunar and solar), and the interaction of the Sun, Moon, and Earth (tidal effect).

#### Earth History/Evolution:

- PO 4. Interpret a geologic time scale.
- PO 5. Distinguish between relative and absolute geologic dating techniques.
- PO 6. Investigate scientific theories of how life originated on Earth (high temperature, low oxygen, clay catalyst model).
- PO 7. Describe how life on Earth has influenced the evolution of the Earth's systems.
- PO 8. Sequence major events in the Earth's evolution (e.g., mass extinctions, glacial episodes) using relative and absolute dating data.
- PO 9. Analyze patterns in the fossil record related to the theory of organic evolution.



### Concept 4: Origin and Evolution of the Universe

Analyze the factors used to explain the origin and evolution of the universe.

- \*PO 1. Describe the Big Bang Theory as an explanation for the origin of the universe.
- PO 2. Describe the fusion process that takes place in stars.
- PO 3. Analyze the evolution of various types of stars using the Hertzsprung-Russell (HR) diagram.
- PO 4. Compare the evolution (life cycles) of stars of different masses (low and high mass).
- PO 5. Explain the formation of the light elements in stars and the heavier elements (what astronomers call "metals") in supernova explosions.
- PO 6. Explain the evolution and life cycles of galaxies.

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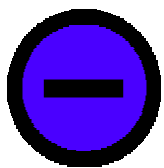


## Science Examples



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# Determining the Mass of an Electron ( $m_e$ )

J.J. Thomson  
1856-1940

Cathode ray  
experiment

Won the Nobel  
Prize in Physics  
in 1906

Showed that  
cathode rays  
were deflected  
in an electric  
field

Beam was  
attracted to the  
positive plate  
and repelled by  
the negative  
plate

Since opposites  
attract

Conclusion: the  
cathode ray was  
composed of  
negatively  
charged particles

Cathode rays  
are also  
deflected in  
magnetic fields

Particles were the same  
regardless of the  
materials used to make  
the electrodes or the type  
of gas used in the tube

Named them  
electrons

$$e/m = E/B^2r$$

E, B, and r are  
known  
quantities

$$e/m = 1.76 \times 10^{11} \text{ C/kg}$$

Conclusion: the  
negative particles  
were common to  
all kinds of atoms

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

Robert A. Millikan  
1868-1953

Oil drop  
experiment

Tiny droplets of  
mineral oil

Gravitational  
force caused the  
droplets to fall  
between two  
parallel plates

Millikan adjusted the  
electric field until  
exactly balanced with  
the gravitational force

Measured mass  
of droplet in  
absence of  
electric field

Each carried an  
electric charge

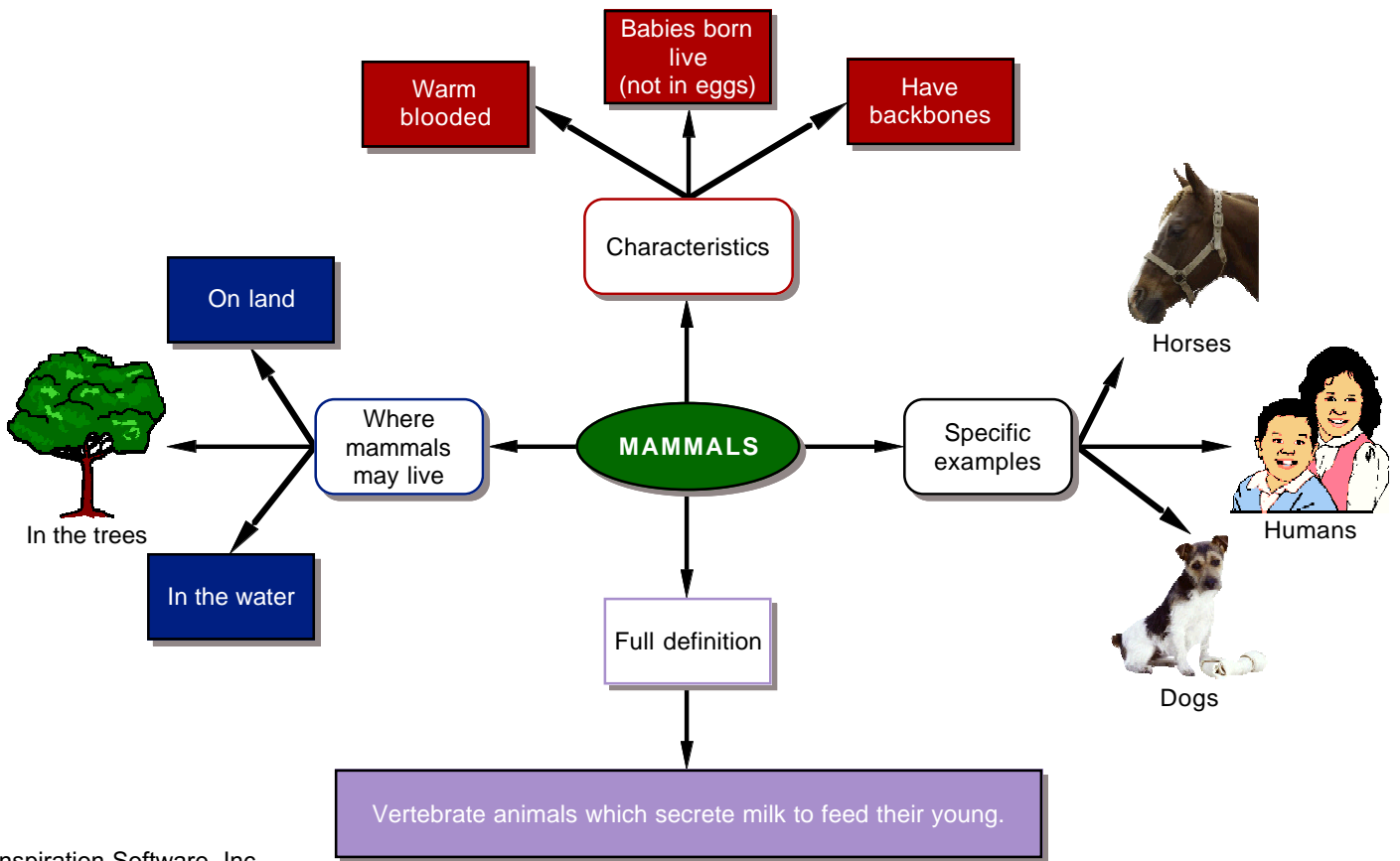
Oil droplets  
became  
suspended  
between the two  
plates

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$qE = mg$$

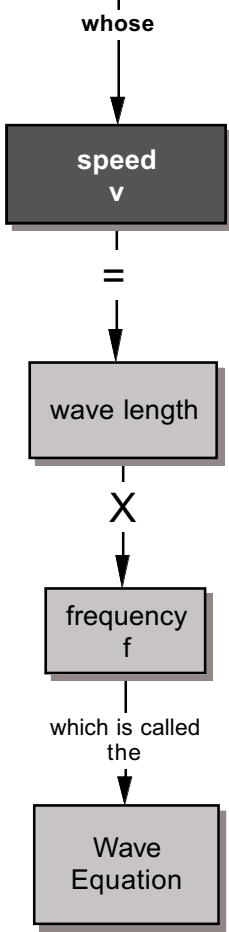
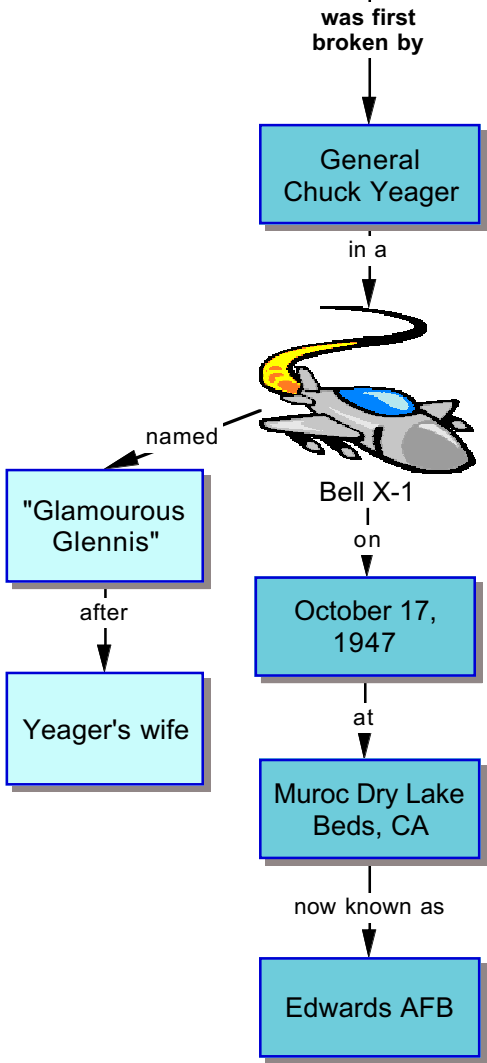
$$q = mg/E$$

m, g, and E are  
known  
quantities



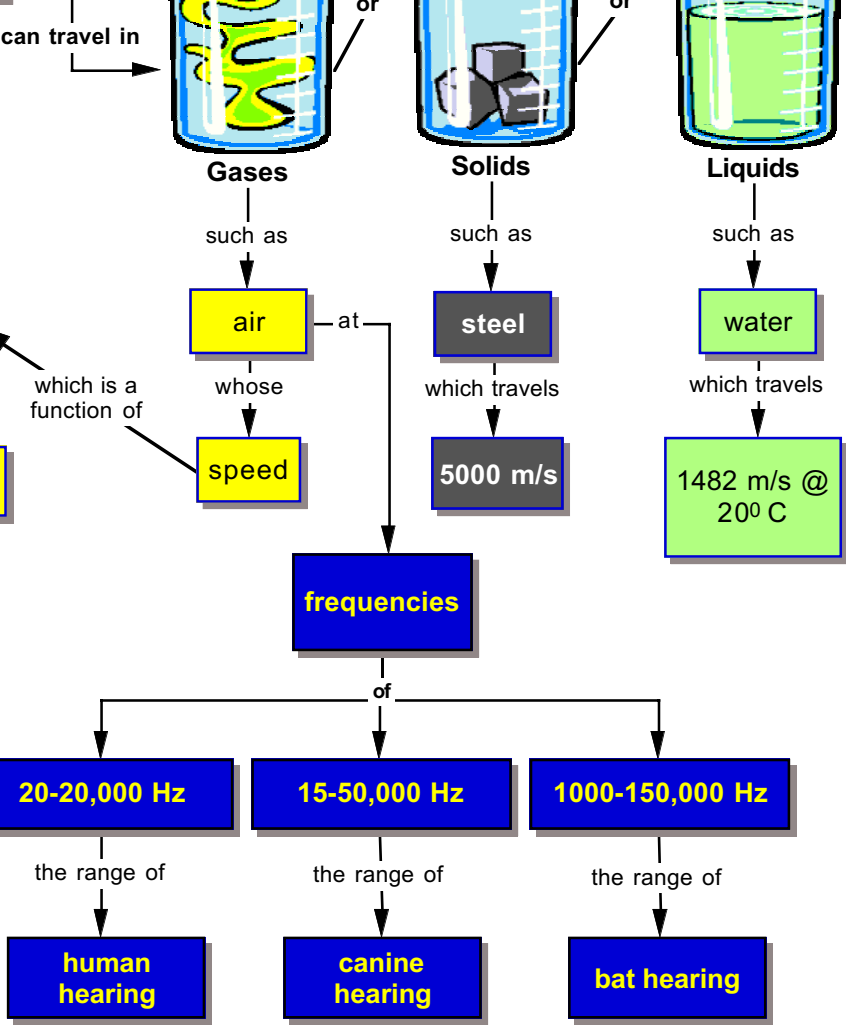
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# SOUND



is a

longitudinal wave



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