Essential Concepts and Skills of a World-Class Curriculum

Science

"As the workplace becomes more sophisticated and the world becomes smaller, Iowa high schools are challenged to equip their students with the knowledge and skills necessary to succeed in this rapidly changing environment. As Governor Vilsack recently testified to Congress, the need to reinvent the high school is well documented. Graduation rates are too low, too may learners continue to struggle, and much of the curriculum needs to be revamped to better prepare our youth - not just to become employed, but also to be informed, concerned and productive citizens."

High Schools: Brighter Futures, 2005

The need for scientific literacy in today's increasingly technological world, for fundamental reforms in how science is taught, and for well validated models that districts might emulate are by now well known and documented. Expressions of concern from business leaders, scientists and educators have led to national, state, and local initiatives. The Iowa Model Core Curriculum rose from those concerns. It has been a two-decade process in which the Department of Education initiated conversations and produced documents that laid the groundwork for this model. Each of those early efforts led us closer to the design that would produce the clearest picture and become the most useful. This committee used both national and state level documents in this process. The final standards are drawn from the respected work of the National Research Council's (NRC) National Science Education Standards (NSES). The Iowa Model Core Curriculum is a common set of expectations designed to clarify and raise expectations for all students. It is a tool for Iowa educators to use to assure that essential subject matter is being taught and essential knowledge and skills are being learned.

As the amount of scientific knowledge expands the need for ALL students to have a deep understanding of Essential Concepts increases. Technological advances have made information more readily available and decreased the need to memorize vocabulary and formulas. The scientific community agrees that we should teach fewer concepts at greater depth. The Iowa Science Model Core Curriculum of Essential Concepts and abilities is a rich yet manageable set that will give each district a comprehensive model to evaluate local curricula.

We believe that the scientifically literate person is one who is aware that science, mathematics and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes.

Science for All Americans, 1990

The Iowa Science Model Core Curriculum reflects the beliefs that ALL students should experience science through a curriculum that is rigorous, relevant, global in its perspective, collaborative in nature, and connected by strong visible links to other areas of study. This document follows the format and content of the National Science Education Standards (NSES) in which there are eight categories of standards. Four of the categories (Science as Inquiry, Physical Science; Earth and Space Science, and Life Science) are content specific, while the remaining categories (Science and Technology, Science in Personal and Social Perspectives and The History and Nature of Science) address the application of knowledge. Science as Inquiry and the application standards from the NSES are integrated into the knowledge base by design. The content category of Unifying Concepts and Processes complement the other standards. The concepts and procedures in this category provide students with productive and insightful ways of thinking about and integrating basic ideas that explain the natural and designed world. These concepts and processes include the following:

- *Systems, order and organization*
- *Evidence, models and explanation*
- *Constancy, change and measurement*
- *Evolution and equilibrium*
- *Form and function*

Science is more than a body of knowledge. It is a way of thinking and a way of investigating. Students must have the opportunity to examine the impact science has had and will continue to have on the environment and society. These opportunities are the focus of the integrated standards.

The Iowa Science Model Core Curriculum emphasizes student inquiry. The depth of understanding required of our students is not possible with lectures, readings, cookbook labs, and plug-and-chug problem solving. Students must be actively investigating: designing experiments, observing, questioning, exploring, making and testing hypotheses, making and comparing predictions, evaluating data, and communicating and defending conclusions. The science instruction should be engaging and relevant for the students. Strong connections between the lessons and the students' daily lives must be made. This core curriculum reflects high standards of science achievement for ALL students and not just those who have traditionally succeeded in science classes.

The challenge of this document is to create an educational system that connects students to the scientific world. The broad range of understandings and skills possessed by students when they enter 9th grade will require a system that is clearly articulated and masterfully implemented from kindergarten through grade twelve. Teachers will need support and time to ramp up to this challenge. This is a first bold step toward a vision of scientific literacy for all.

Guide to the Model Core Format

<table>
<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="2">This column will contain the larger essential concept headings.</td><td rowspan="2">This column will contain the topic headings (Essential Concepts and principles that underlie the standard).</td><td rowspan="2">The content integrated throughout the document includes the following standards categories from the National Education Standards (NRC):

Science As Inquiry

Science and Technology

Science in Personal and Social Perspectives

History and Nature of Science</td><td>These 4 quadrants contain example activities for each essential concept. These are samples only and not a complete curriculum.</td><td>The 4 quadrants move from lower to higher rigor and relevance. Higher rigor activities are in quadrants C and D. Higher relevance is illustrated in B and D.</td></tr>
<tr><td>The Unifying Concepts from NSES weave through each activity. When an activity is a particularly strong exemplar for one unifying concept it is noted at the bottom of the quadrant with an asterisk (*). Clicking on that notation will link to the NSES document site where the Unifying Concepts are explained in greater depth.</td><td></td></tr>
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**Unifying Concept (NSES) represented in this activity. Unifying concepts cross discipline areas and provide students with productive and insightful ways of thinking about and integrating basic ideas that explain the natural and designed world.*

Science as Inquiry

<table>
<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="2">Identifying questions and concepts that guide scientific investigations</td><td rowspan="2">Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations. The key is that the student demonstrates knowledge of the scientific concepts through the investigation.</td><td rowspan="2"><u>Science & Technology</u>
• Abilities of technological design
• Understandings about science and technology
<u>Science in Personal & Social Perspectives</u>
• Population growth
• Natural resources
• Environmental quality
• Natural and human induced hazards
• Science & technology in society
<u>History & Nature of Science</u>
• Science as a human endeavor
• Nature of scientific knowledge
• Historical perspectives</td><td>Assimilation (C)
Sample water from a variety of streams for nitrate levels before and after a spring rain. Analyze the information and explain what steps are needed to reduce nitrates in water sources.

* Constancy and Change</td><td>Adaptation (D)
When people move from one country to another, cancer rates follow the patterns of the country in which they currently reside. Explain this in terms of environmental factors influence on cancer.</td></tr>
<tr><td>Acquisition (A)
What nutrients are present in the foods I eat?
Perform simple nutrient tests on foods to find which basic food molecules are present (proteins, fats, sugars, complex carbohydrates).</td><td>Application (B)
How do the nutrients in my food compare to the food my Grandmother ate? Examine food labels and nutrient information for foods eaten in one meal. Compare this to a meal that your grandmother ate when she was young. Develop a graphic organizer describing the differences you found and explain the social/economic circumstances surrounding each meal.</td></tr>
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<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="2">Design and conduct a scientific investigation</td><td rowspan="2">Designing and conducting a scientific investigation requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers. Regardless of the scientific investigation performed, students must use evidence, apply logic, and construct an argument for their proposed explanations.</td><td rowspan="2"><u>Science & Technology</u>
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Design, conduct, and analyze an experiment investigating O2 and CO2 production from a variety of organisms: elodea, fish and snail. Describe how their needs vary in light and darkness and explain these differences. Explain the differences between energy production in photosynthetic autotrophs and chemosynthetic autotrophs</td><td>Adaptation (D)
Students will construct a model bungee jump built with rubber bands to investigate what adjustments need to be made to have people with different weights fall the same maximum distance measured from a fixed position on the diving tower. Students may use a variety of resources including the internet to learn how these adjustments are accomplished at these jumping stations.</td></tr>
<tr><td>Acquisition (A)
Students will investigate the effect of temperature on the reaction rate of effervescent antacid tablets placed in containers of water.</td><td>Application (B)
Students will research how water softeners work and design an experiment to test the effectiveness of a water softener in removing ions from tap water.</td></tr>
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<tr><td rowspan="2">Use appropriate tools and techniques to gather, analyze, and interpret data</td><td rowspan="2">A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results.</td><td rowspan="2"><u>Science & Technology</u>
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Sample water from a variety of streams for nitrate levels before and after a spring rain. Analyze the information and explain what steps are needed to reduce nitrates in water sources.
* constancy and change</td><td>Adaptation (D)
Students will conduct an experiment on the effect of temperature on the light emitted by fireflies using light sticks as a model for fireflies. Students will discuss their results and the limitations of applying this model to fireflies.</td></tr>
<tr><td>Acquisition (A)
Write the simple equation for photosynthesis.

Calculate the number of bonds hydrolyzed to convert $C_{60}H_{120}O_{60}$ into simple glucose molecules

Construct a graphic organizer that illustrates the conversion of light energy to energy stored in a macromolecule to energy in ATP</td><td>Application (B)
Students will apply the predictable rate of nuclear decay to estimate the age of archaeological remains and fossils. Students will also use a Geiger counter to collect and categorize the types of radiation emitted by common consumer products (i.e. fiesta plate ware, smoke detectors, lantern mantles).</td></tr>
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<tr><td rowspan="2">Develop descriptions, explanations, predictions, and models using evidence</td><td rowspan="2">Student inquiries should culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical. In the process of answering the questions, the students should engage in discussions and arguments that result in the revision of their explanations. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation.</td><td rowspan="2"><u>Science & Technology</u>
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Explain which methods for dating ancient artifacts would be the most effective and why.
• A human mummy found high in an Andean mountain cave.
• A fossil shell found in a quarry in eastern Iowa.
• A moon rock brought back by astronauts.
• Wooden support timbers from a Native American cliff dwelling.
• Very old rocks found in NE Canada
*Evidence, Models and Explanation</td><td>Adaptation (D)
Students will make and explain how a cold pack/hot pack works using safe and available chemicals and with all necessary safety precautions. They will make recommendations of how much of each chemical to use to maximize the temperature change and control the cost of the hot or cold pack.</td></tr>
<tr><td>Acquisition (A)
Students are asked to build a model, using different colors of clay, to demonstrate earth plates and plate tectonic movements.

*Evidence, Models and Explanation</td><td>Application (B)
Students are asked to choose either the Nitrogen or the Carbon cycle, draw and label the cycle then explain it to other students using the drawing as a visual aid. Students should be sure to point out the role that people play in the cycle.

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<tr><td rowspan="2">Think critically and logically to make the relationships between evidence and explanations</td><td rowspan="2">Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment.</td><td rowspan="2"><u>Science as Inquiry</u>
• Identify questions that can be answered through scientific investigations
• Design and conduct a scientific investigation
• Use appropriate tools and techniques to gather, analyze, and
<u>Science & Technology</u>
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Students will use a simple electric motor to investigate the relationships between the electric field, magnetic field, and the force on moving charges. They will be able to explain these relationships by using the right-hand rule.</td><td>Adaptation (D)
At least two major disasters have occurred recently (2004-2005) that were caused by the movement of the earth’s plates. Where were these located? How were their causes alike and different? How could these disasters be better predicted, both in scope and location? What recommendations would you provide to government and relief agencies in order for them to be better prepared to serve people’s needs before and after such emergencies?</td></tr>
<tr><td>Acquisition (A)
Students will use an ammeter and voltmeter (or a current and voltage probe with computer-based laboratory tools) to investigate the relationship between current and voltage for various resistors.</td><td>Application (B)
Students are asked to create sketches on a black or white board to describe how convection currents in the mantle drive the movements of tectonic plates on the surface. Use a large beaker of boiling water to help illustrate your sketches if you need.

*Evidence, Models and Explanation</td></tr>
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Essential Concepts	Principles that Underlie the Standard	Integrated Standards	Sample Activities	
Recognize and analyze alternative explanations and predictions	This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations.	**Science as Inquiry** • Identify questions that can be answered through scientific investigations • Design and conduct a scientific investigation • Use appropriate tools and techniques to gather, analyze, and **Science & Technology** • Abilities of technological design • Understandings about science and technology **Science in Personal & Social Perspectives** • Population growth • Natural resources • Environmental quality • Natural and human induced hazards • Science & technology in society **History & Nature of Science** • Science as a human endeavor • Nature of scientific knowledge • Historical perspectives	**Assimilation (C)** Students are asked to use a long strip of paper to construct a time line divided into two parts. The first line should show the history of technological aids used by people to observe outer space. Start with visual observation and move on to Galileo's telescope, modern observatories, space-based observatories and other important types of hardware. The second (parallel) line should show the discoveries made as better and different types of technological equipment were put to use. Take a few minutes to show and explain your dual timeline to an adult.	**Adaptation (D)** Students will participate in a debate on whether or not nuclear reactors should be abandoned as a source of energy because of the disposal problem for the produced wastes that contain isotopes with half-lives measured in the thousands or hundreds of thousands of years.
			Acquisition (A) List five examples in your home areas where humans have modified the natural environment.	**Application (B)** Research – how has the classification system changed (historically) from 2 kingdoms to the present system? Why have these changes occurred? How have technological advances changed classification systems? *Systems, Order, Organization

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<tr><td rowspan="2">Communicate and defend scientific procedures and explanations</td><td rowspan="2">Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments.</td><td rowspan="2"><u>Science & Technology</u>
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You are a member of business team charged with developing energy sources that will be used to decrease the emission of carbon dioxide. Students are asked to respond to the following questions based on this scenario: What energy systems will you select as those to support for development? What are the pros and cons of each method? What are the short-term advantages and disadvantages of each? Long-term advantages/ disadvantages? The feasibility of their uses by developed and developing nations?</td></tr>
<tr><td>Acquisition (A)
Compare the time line (in minutes) for a normal cell cycle to that of a cancerous cell. How are they different? Which parts of the cell cycle are different?</td><td>Application (B)
Develop a proposal for Iowa with techniques and practices that could be adopted to reduce nitrates in surface water and groundwater.</td></tr>
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<tr><td rowspan="2">Use mathematics in all aspects of scientific inquiry</td><td rowspan="2">Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.</td><td rowspan="2"><u>Science & Technology</u>
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Students will students will experimentally classify solubility as either endothermic or exothermic buy measuring temperature increases or decreases in a micro scale calorimeter. Using the calorimeter, students will then explore reactions with acids and metals, determine the ÆH for the reaction, and rank those results.</td><td>Adaptation (D)
Students will make and explain how a cold pack/hot pack works using safe and available chemicals and with all necessary safety precautions. They will make recommendations of how much of each chemical to use to maximize the temperature change and control the cost of the hot or cold pack.</td></tr>
<tr><td>Acquisition (A)
Students will explain that elements exist as isotopes, which may be stable or unstable and calculate the atomic mass of an element given the percentages and masses of isotopes of that element.</td><td>Application (B)
Calculate the potential yields of corn for different irrigation and precipitation rates over the corn belt.
Investigate the price of corn and beans over the past 50 years. Describe the impact of these prices on the economy of Iowa.</td></tr>
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Earth Science

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<td rowspan="2">Energy in the earth system</td>
<td rowspan="2">

Internal sources of energy
External sources of energy
Plate tectonics
Energy transfer in the atmosphere and ocean

Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.

The outward transfer of earth's internal heat drives convection circulation in the mantle that propels the plates comprising earth's surface across the face of the globe.

Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans.
</td>
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<u>Science as Inquiry</u>

Identify questions that can be answered through scientific investigations
Design and conduct a scientific investigation
Use appropriate tools and techniques to gather, analyze, and interpret data
Develop descriptions, explanations, predictions, and models using evidence
Think critically and logically to make the relationships between evidence and explanations
Recognize and analyze alternative explanations and predictions
Communicate scientific procedures and explanations
Use mathematics in all aspects of scientific inquiry

<u>Science & Technology</u>

Abilities of technological design
Understandings about science and technology

<u>Science in Personal & Social Perspectives</u>

Population growth
Natural resources
Environmental quality
Natural and human induced hazards

<u>History & Nature of Science</u>

Science as a human endeavor
Nature of scientific knowledge
Historical perspectives

</td>
<td>Assimilation (C)

Students are asked to write an explanation of why earthquakes and volcanic eruptions tend to “cluster” in certain belts and areas of the Earth’s crust and not in others. Use your knowledge of convection in the crust and plate tectonics to predict where such disasters might affect North and Central America.</td>
<td>Adaptation (D)
At least two major disasters have occurred recently (2004-2005) that were caused by the movement of the earth’s plates. Where were these located? How were their causes alike and different? How could these disasters be better predicted, both in scope and location? What recommendations would you provide to government and relief agencies in order for them to be better prepared to serve people’s needs before and after such emergencies?</td>
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Students are asked to build a model, using different colors of clay, to demonstrate earth plates and plate tectonic movements.

*Evidence, Models and Explanation</td>
<td>Application (B)
Students are asked to create sketches on a black or white board to describe how convection currents in the mantle drive the movements of tectonic plates on the surface. Use a large beaker of boiling water to help illustrate your sketches if you need.

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<td rowspan="2">Geochemical cycles</td>
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Elements/atoms within earth reservoirs: solid earth, oceans, atmosphere, and organisms
Movement of elements/atoms between reservoirs

The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles.

Movement of matter between reservoirs is driven by the earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life.
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<u>History & Nature of Science</u>

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<td>Assimilation (C)
The carbon cycle is an important life supporting cycle. Some say the cycle has been shifted to an unbalanced system, one in which the shift has gone toward an overabundance of CO_2. Provide information to support or refute this belief.</td>
<td>Adaptation (D)
You are a member of business team charged with developing energy sources that will be used to decrease the emission of carbon dioxide. Students are asked to respond to the following questions based on this scenario: What energy systems will you select as those to support for development? What are the pros and cons of each method? What are the short-term advantages and disadvantages of each? Long-term advantages/ disadvantages? The feasibility of their uses by developed and developing nations?</td>
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<td>Acquisition (A)
Students are asked to use a textbook and/or the internet to draw up a list of elements and compounds (ex. water, nitrogen) that may be associated with cycles in the earth-ocean-atmosphere system.

*Evolution and Equilibrium</td>
<td>Application (B)
Students are asked to choose either the Nitrogen or the Carbon cycle, draw and label the cycle then explain it to other students using the drawing as a visual aid. Students should be sure to point out the role that people play in the cycle.

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<td>Origin and evolution of the earth system</td>
<td>

Formation of solar system
Geologic time
Interactions among hydrosphere, lithosphere & atmosphere
Life: origin, evolution and effect on earth systems

The sun, the earth, and the rest of the solar system formed from a nebular cloud of dust and gas 10 to 15 billion years ago. The early earth was very different from the planet we live on today.
Geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations. Current methods for measuring geologic time include using the known decay rates of radioactive isotopes present in rocks to measure the time since the rock was formed.
Interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years.
Evidence for one-celled forms of life--the microbes--extends back more than 3.5 billion years. The evolution of life caused dramatic changes in the composition of the earth's atmosphere, which did not originally contain oxygen.
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<u>Science as Inquiry</u>

Identify questions that can be answered through scientific investigations
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<u>Science & Technology</u>

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<u>History & Nature of Science</u>

Science as a human endeavor
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<td>Assimilation (C)
Explain which evidence for dating ancient artifacts would be the most effective and why.

A human mummy found high in an Andean mountain cave.
A fossil shell found in a quarry in eastern Iowa.
A moon rock brought back by astronauts.
Wooden support timbers from a Native American cliff dwelling.
Very old rocks found in NE Canada

*Evidence, Models and Explanation</td>
<td>Adaptation (D)
You are member of a team asked to plan the next human exploratory trip beyond the inner planets. How will you plan for the “expected” in such a journey and what would be “unexpected” problems as part of the exploratory journey? How will you plan for all types of situations?</td>
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<td>Acquisition (A)
Students are asked to describe the current scientific explanation for the origin of the solar system.
*Evidence, Models and Explanation</td>
<td>Application (B)
NASA has a goal of sending “pioneers” to build a base for humans on the moon as a take-off point for future planetary exploration. Design a lunar base for future inhabitants based on your knowledge of the moon’s properties and human’s basic needs for survival in such an environment.
*Systems, Order and Organization</td>
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<td>Origin and evolution of the universe</td>
<td>

Age & origin of the universe
Universe & galaxies
Star formation

The origin of the universe remains one of the greatest questions in science. The "big bang" theory places the origin between 10 and 20 billion years ago, when the universe began in a hot dense state; according to this theory, the universe has been expanding ever since.

Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars. Billions of galaxies, each of which is a gravitationally bound cluster of billions of stars, now form most of the visible mass in the universe.

Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all the other elements.
</td>
<td>
<u>Science as Inquiry</u>

Identify questions that can be answered through scientific investigations
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Think critically and logically to make the relationships between evidence and explanations
Recognize and analyze alternative explanations and predictions
Communicate scientific procedures and explanations
Use mathematics in all aspects of scientific inquiry

<u>Science & Technology</u>

Abilities of technological design
Understandings about science and technology

<u>History & Nature of Science</u>

Science as a human endeavor
Nature of scientific knowledge
Historical perspectives

</td>
<td>
<table>
<tr>
<td>Assimilation (C)
Students are asked to use a long strip of paper to construct a time line divided into two parts. The first line should show the history of technological aids used by people to observe outer space. Start with visual observation and move on to Galileo’s telescope, modern observatories, space-based observatories and other important types of hardware. The second (parallel) line should show the discoveries made as better and different types of technological equipment were put to use. Take a few minutes to show and explain your dual timeline to an adult.</td>
<td>Adaptation (D)
You are a NASA official who has been asked to prepare a prioritized list of unmanned projects as not all projects can be funded. Your list should include such things as space-based and land-based optical, X-ray, IR, UV and gamma ray instruments. Be prepared to defend your prioritized list and budget requests before a committee of fellow students and/or adults.</td>
</tr>
<tr>
<td>Acquisition (A)
Students are asked to explain the current scientific explanation for the origin of the universe.</td>
<td>Application (B)
Students are asked to demonstrate how to set up, align, and use a refracting telescope, a Newtonian reflecting telescope and a star finder.

*Form and Function</td>
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<table>
<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="2">Structure of Atoms</td><td rowspan="2">• Atomic Structure

Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.</td><td rowspan="2"><u>Science as Inquiry</u>
▪ Abilities necessary to do scientific inquiry
▪ Understandings about scientific inquiry
<u>Science and Technology</u>
▪ Understandings about science and technology
<u>Science in Personal and Social Perspectives</u>
▪ Science and technology in local, national, and global challenges
<u>History and Nature of Science</u>
▪ Science as a human endeavor
▪ Nature of scientific knowledge
• Historical perspectives</td><td>Assimilation (C)

Students will find the length of one oleic acid molecule by spreading a small amount over the surface of water and measuring the diameter of the circle. The oleic acid spreads itself into a one-molecule thick layer in the shape of a VERY flat cylinder.</td><td>Adaptation (D)
Students will use the internet and other resources to construct a time-line that traces the historical development of the model of the atom including John Dalton, J.J. Thomson, Ernest Rutherford, and Neils Bohr with the scientific and technological developments of the time that may have contributed to the development of these models</td></tr>
<tr><td>Acquisition (A)
Students will use tools including microscopes to investigate the physical and chemical properties of various materials that provide evidence for the existence and structure of atoms (e.g., crystalline structure of various minerals).

*Evidence, Models and Explanation</td><td>Application (B)
Students will model the importance of indirect evidence in identifying the existence and structure of atoms by determining the size and shape of an unknown object inside a closed container without direct observation (e.g., obscertainers). They will then make connections to how this is related to modern science tools (i.e. scanning tunneling microscope and atomic force microscope) that are used for imaging atoms on a surface</td></tr>
</table>

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<td>Structure of atoms</td>
<td>

Atomic Nucleus (composition and size)
Isotopes

The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.
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<table>
<tr><td>Assimilation (C)
Students will identify the charge, component particles, and relative mass of the nucleus for elements in the periodic table.</td><td>Adaptation (D)
Students will trace the development of nuclear models including the contributions of Marie and Pierre Curie, Lise Meitner, and Enrico Fermi. They will also conduct research on the importance of radioactive isotopes in medical applications.</td></tr>
<tr><td>Acquisition (A)
Students will explain that elements exist as isotopes, which may be stable or unstable and calculate the atomic mass of an element given the percentages and masses of isotopes of that element.</td><td>Application (B)
Students will use a model of an atom that involves using different colors of beads to represent component particles to investigate the relationships that exist between the component particles, charge, relative mass of the nucleus, and isotopes.</td></tr>
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<td rowspan="2">Structure of atoms</td>
<td rowspan="2">▪ Nuclear Forces:
Fission and Fusion

The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars.</td>
<td rowspan="2"><u>Science as Inquiry</u>
• Analyze, and interpret data
• Develop descriptions, explanations, predictions, and models using evidence
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• Historical perspectives</td>
<td>Assimilation (C)
Students will write nuclear equations describing fission and fusion.</td>
<td>Adaptation (D)
Students will participate in a debate on whether or not nuclear reactors should be abandoned as a source of energy because of the disposal problem for the produced wastes that contain isotopes with half-lives measured in the thousands or hundreds of thousands of years.</td>
</tr>
<tr>
<td>Acquisition (A)
Students will demonstrate a simulation of a chain reaction to introduce the concept of fission and nuclear decay. Students, standing in a grid pattern, will be provided two balls of paper (neutrons). One student will be designated with a ball of paper of a different paper (thermal neutron). This student will begin the reaction by tossing his ball toward the students. When a student is “hit” with any ball, he/she tosses his/her two balls in a random direction and then quickly sits down. The reaction dies when neutrons no longer hit students. Students can repeat the simulation for the case when students are packed closer together.</td>
<td>Application (B)
Students will play a game of nuclear checkers using a piece of graph paper with the Atomic Mass Number on the y-axis and Atomic Number on the x-axis. The y-axis will be numbered from 202 to 238 with the x-axis being numbered from 80 to 95. An unknown element, $^{238}_{92}Q$, represented by a quarter that is placed on the appropriate location on the board, is a heavy nucleus that decays into a series of lighter nuclei. The final daughter product of the series is a stable unknown isotope, $^{206}_{82}D$, represented by a dime. It is placed on the appropriate location on the board. The students are asked to trace the path of the resulting daughter products with pennies being limited to making two types of moves that correspond to alpha and beta decay. Students are asked to record all daughter nuclei produced with their atomic masses and atomic numbers and to compare their results with other students. This activity allows students to simulate the decay of U-238.</td>
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<tr><td rowspan="2">Structure of atoms</td><td rowspan="2">▪ Radioactive Isotopes
Predictable rates of decay

Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes.
Radioactive Decay</td><td rowspan="2"><u>Science as Inquiry</u>
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Students will balance chemical equations that involve radioactive isotopes, which undergo spontaneous nuclear reactions indicating both charge and mass number are conserved.</td><td>Adaptation (D)
Students will construct a model using various types of candy (i.e. M&M’s, Skittles, jelly beans) and/or various colors of counting cubes with varying number of dots to represent radioactive atoms and their daughter products to simulate nuclear decay and evaluate its effectiveness in modeling nuclear decay.</td></tr>
<tr><td>Acquisition (A)
Students will explain that unstable isotopes undergo spontaneous nuclear decay, emitting energy or particles and energy. They will identify the resulting particles and/or wavelike radiation. They will define half-life.</td><td>Application (B)
Students will apply the predictable rate of nuclear decay to estimate the age of archaeological remains and fossils. Students will also use a Geiger counter to collect and categorize the types of radiation emitted by common consumer products (i.e. fiesta plate ware, smoke detectors, lantern mantles).</td></tr>
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<tr>
<td>Structure and Properties of Matter</td>
<td>▪ Valence Electrons
▪ Chemical Bonds

Atoms interact with one another by transferring o sharing electrons that are the furthest from the nucleus. These outer electrons govern the chemical properties of the element.</td>
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<tr><td>Assimilation (C)
Students will construct electron dot structures for any randomly chosen element found on the periodic table and use them to determine formulas of possible ionic compounds.</td><td>Adaptation (D)
Students will research the molecular compound H2O and use bonding theory to explain the properties of water that make it the “universal solvent” and so important to life on Earth.</td></tr>
<tr><td>Acquisition (A)
Students will identify the total number of electrons and the number of valence electrons for any randomly chosen element found on the periodic table.</td><td>Application (B)
Students will research how water softeners work and design an experiment to test the effectiveness of a water softener in removing ions from tap water.</td></tr>
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<tr><td rowspan="2">Structure and Properties of Matter</td><td rowspan="2">▪ Periodic Table
▪ Periodic Trends

An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "Periodic Table" is a consequence of the repeating pattern of outermost electrons and their permitted energies.</td><td rowspan="2"><u>Science as Inquiry</u>
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Students will graph several periodic properties (i.e. electronic structure, electronegativity, first ionization energy) and explain the connection to the pattern they see in the graph to the placement of elements in the periodic table.

*Systems, Order and Organization</td><td>Adaptation (D)
Students will use the periodic table to predict the properties of a yet to be discovered element.

*Systems, Order and Organization</td></tr>
<tr><td>Acquisition (A)
Students will explore the periodic table. They will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure.

*Systems, Order and Organization</td><td>Application (B)
Students will apply the patterns seen on the periodic table to design a periodic table of some group of common objects (i.e. vegetables, sports teams, movies, candy, books). The items will be grouped to show trends in vertical columns and horizontal rows.

*Systems, Order and Organization</td></tr>
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<td>Structure and Properties of Matter</td>
<td>

Molecular and Ionic Structures
Physical Properties of Chemical Compounds

Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.
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Personal and community health

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<tr><td>Assimilation (C)
Students will observe some of the differences in macroscopic properties between ionic and covalent compounds. In particular, they compare solubility in water, solubility in methanol, relative melting points, and solution conductivity.</td><td>Adaptation (D)
Students will use knowledge of ionic, covalent and polar covalent molecules to explain how the body absorbs vitamins A, E, C and calcium.</td></tr>
<tr><td>Acquisition (A)
Students will use electronegativity values to determine the percent of ionic or covalent character present in a bond between atoms.</td><td>Application (B)
Students will use knowledge of ionic, covalent and polar covalent molecules to explain how detergents work to remove various types of stains and then perform a test to show how certain stain removers are more effective on non-polar stains.</td></tr>
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<tr><td rowspan="2">Structure and Properties of Matter</td><td rowspan="2">▪ States of Matter
▪ Gas Laws

Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart.</td><td rowspan="2"><u>Science as Inquiry</u>
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Students will conduct an experiment to determine the mathematical relationship between the volume and pressure of air trapped inside a plastic syringe by using a biology gas pressure sensor and computer-based laboratory tools.</td><td>Adaptation (D)
Students will explain what they observe when a few raisins are dropped into a container full of a clear carbonated beverage and relate this phenomena to scuba diving. Why is rule number one in scuba diving that divers are NOT to hold their breath? What are the bends? What do the gas laws have to do with diving?</td></tr>
<tr><td>Acquisition (A)
Students will investigate how the volume of a gas changes as its temperature or pressure is altered by conducting a series of experiments involving a flask with a balloon stretched over the opening with the flask placed in containers of hot and cold water, a large closed syringe with a small marshmallow placed inside with the plunger being pulled back and pushed in, etc.</td><td>Application (B)
Apply the gas laws to explain what you expect to observe as a closed metal can of paint stripper sits in the sun. Paint stripper contains chemicals that are usually volatile.</td></tr>
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<tr>
<td>Structure and Properties of Matter</td>
<td>▪ Hydrocarbon Compounds

Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life

.</td>
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• National resources</td>
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<table>
<tr><td>Assimilation (C)
Students will use balls and sticks to construct models of hydrocarbon compounds with specific functional groups (alcohols, ethers, aldehydes, ketones, esters, amines etc.)

*Form and Function</td><td>Adaptation (D)
Students will prepare soap or an aromatic compound in the laboratory and apply their knowledge of organic compounds to explore and explain what part hydrocarbons play in the materials.</td></tr>
<tr><td>Acquisition (A)
Students will use balls and sticks to construct models of simple aliphatic, aromatic and cyclic hydrocarbon compounds</td><td>Application (B)
Students will create a guide to hydrocarbon compounds and classify common hydrocarbons based on use. They will identify which specific functional groups are found in use categories.</td></tr>
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<td>Chemical Reactions</td>
<td>

Conservation of Matter
Common Reactions

“Chemical reactions” is an essential concept of a world-class secondary science curriculum. Included in “chemical reactions” is the following content:
Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.
</td>
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National resources
Environmental quality
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<u>History & Nature of Science</u>

Science as a human endeavor

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<td>
<table>
<tr><td>Assimilation (C)
Students will write and balance various reactions from student’s everyday lives</td><td>Adaptation (D)
Students will research electrochemical cells and use the information they find to analyze the cost effectiveness of hybrid vs. gas engines.</td></tr>
<tr><td>Acquisition (A)
Students will identify examples of various types of chemical reactions found in student’s everyday lives.</td><td>Application (B)
Students will identify and explain the reactions taking place in a car engine (including catalytic converter and combustion).</td></tr>
</table>
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<tr><td rowspan="2">Chemical Reactions</td><td rowspan="2">▪ Thermochemistry

Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.</td><td rowspan="2"><u>Science as Inquiry</u>
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Students will experimentally classify solubility as either endothermic or exothermic by measuring temperature increases or decreases in a micro scale calorimeter. Using the calorimeter, students will then explore reactions with acids and metals, determine the ÆH for the reaction, and rank those results.</td><td>Adaptation (D)
Students will make and explain how a cold pack/hot pack works using safe and available chemicals and with all necessary safety precautions. They will make recommendations of how much of each chemical to use to maximize the temperature change and control the cost of the hot or cold pack.</td></tr>
<tr><td>Acquisition (A)
Students will develop a definition for endothermic and exothermic reactions and give examples of each.</td><td>Application (B)
Students will use a calorimeter to measure the energy given off by various food items (i.e. peanut) and compare to the calories provided on labels.</td></tr>
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<td>Chemical Reactions</td>
<td>Types of reactions

• Acids and bases
• Radical reactions
• Common reactions in living systems
• Electrochemistry

A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions</td>
<td><u>Science as Inquiry</u>
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<table>
<tr><td>Assimilation (C)
Students will predict the products of simple chemical reactions based on reaction types.</td><td>Adaptation (D)
Students will use chemistry to analyze the dangerous reactions (and products produced) that might occur if cleaning products found in most homes are mixed.</td></tr>
<tr><td>Acquisition (A)
Students will define, describe and identify chemical reactions as replacement (single and double), synthesis, or decomposition.</td><td>Application (B)
Students will investigate and classify common chemical reactions they encounter such as rusting, bleaching, and burning.</td></tr>
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<td>Chemical Reactions</td>
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Reaction Rates and Equilibrium
Catalysts
Enzymes

Chemical reactions can take place in time periods ranging from the few femtoseconds (10-15 seconds) required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years. Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties--including shape--of the reacting species.
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<table>
<tr><td>Assimilation (C)
Students will use a computer simulation or some other means to model and describe how rates of chemical reactions are related to colliding atoms, ions, and molecules.</td><td>Adaptation (D)
Students will conduct an experiment on the effect of temperature on the light emitted by fireflies using light sticks as models for fireflies. Students will discuss their results and the limitations of applying this model to fireflies.</td></tr>
<tr><td>Acquisition (A)
Students will investigate the effect of temperature on the reaction rate of effervescent antacid tablets placed in containers of water.</td><td>Application (B)
Students will explain how the corrosion reaction of an iron-magnesium alloy with salt water can produce a hot meal for individuals who want a hot meal but have no place to cook it (such as soldiers and truck drivers).</td></tr>
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<tr><td rowspan="2">Motion And Forces</td><td rowspan="2">▪ Motions
▪ Forces
▪ Newton’s Laws

Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.</td><td rowspan="2"><u>Science as Inquiry</u>
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• Develop descriptions, explanations, predictions, and models using evidence
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Students will be able to solve one- and two-dimensional motion problems that involve uniform acceleration quantitatively and graphically.

*Systems, Order and Organization</td><td>Adaptation (D)
Students will be able to construct a model that will allow them to determine when emergency rations should be released from a rescue plane traveling horizontally at a given speed and height above the ground in order for the rations to reach a stranded party of explorers on the ground.

*Systems, Order and Organization</td></tr>
<tr><td>Acquisition (A)
Students will be able to define and describe different types of motion.</td><td>Application (B)
Students will be able to construct, analyze, and interpret various representations of linear motion including those that are mathematical, pictorial, and graphical in nature using such tools as ticker tape timers and calculator- and computer-based laboratory tools. Students should also be able to make connections to how law enforcement officials and bats respectively use sonar to determine the speed of automobiles and to locate objects.

*Systems, Order and Organization</td></tr>
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<table>
<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th>Sample Activities</th></tr>
<tr>
<td>Motion And Forces</td>
<td>

Gravitation
Mass Vs Weight

Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.
</td>
<td>
<u>Science as Inquiry</u>

Identify questions that can be answered through scientific investigations
Design and conduct a scientific investigation
Use appropriate tools and techniques to gather, analyze, and interpret data
Develop descriptions, explanations, predictions, and models using evidence
Think critically and logically to make the relationships between evidence and explanations
Recognize and analyze alternative explanations and predictions
Communicate scientific procedures and explanations
Use mathematics in all aspects of scientific inquiry

<u>Science & Technology</u>

Abilities of technological design
Understandings about science and technology

<u>History & Nature of Science</u>

Science as a human endeavor
Nature of scientific knowledge

</td>
<td>
<table>
<tr>
<td>Assimilation (C)
Students will be able to calculate and compare the acceleration of gravity on various celestial bodies including the earth, moon, and Jupiter. They will be able to use computer simulations from software and/or the Internet to investigate how the acceleration of gravity on these celestial bodies impacts the motion of a falling object.</td>
<td>Adaptation (D)
Students will construct a model bungee jump built with rubber bands to investigate what adjustments need to be made to have people of different weights fall the same maximum distance measured from a fixed position on the diving tower. Students may use a variety of resources including the internet to learn how these adjustments may be accomplished at these jumping stations.</td>
</tr>
<tr>
<td>Acquisition (A)
Students will investigate the properties of an object’s mass and weight and be able to describe the difference between an object’s mass and weight.</td>
<td>Application (B)
Students will construct an accelerometer using a spring or rubber band and fish weights to measure their apparent weight for various situations including riding in a car, amusement park ride, elevator, or running.</td>
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<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="2">Motion And Forces</td><td rowspan="2">▪ Electrostatics and Electric Forces

The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and, as with gravitation, inversely proportional to the square of the distance between them.</td><td rowspan="2"><u>Science as Inquiry</u>
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• Science as a human endeavor
• Nature of scientific knowledge
▪ Historical perspectives</td><td>Assimilation (C)
Students will use electroscopes constructed from insulated cups, straws, string, and aluminum foil along with golf club tubes or PVC pipe and wool cloth, to investigate the factors that affect the force between charged objects.</td><td>Adaptation (D)
Students will be given a situation in which a young entrepreneur who is in the home interior decorating business has contracted them to investigate whether a dry process can be created for wallpapering rooms in homes. Many people like to do their own decorating but don't like the mess of liquid glue on the walls and the wallpaper in the process. The entrepreneur is asking for an inventive group of students to conduct some research on what combinations of wall surface and paper will give the best results.</td></tr>
<tr><td>Acquisition (A)
Students will use various materials including transparent tape, combs, wool, salt, and pepper to explore the properties of the different types of electrical charges and how they interact with each other.</td><td>Application (B)
Students will identify the type of electrical charge on a single tape strip placed on a table surface based on the classification used by Benjamin Franklin that there are two kinds of charges. He arbitrarily called the charges "positive" and "negative". The charge obtained by the comb when rubbed with wool is the charge he would have called negative.</td></tr>
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<tr><td rowspan="2">Motion And Forces</td><td rowspan="2">▪ Nature of Electric Forces

Between any two charged particles, electric force is vastly greater than the gravitational force. Most observable forces such as those exerted by a coiled spring or friction may be traced to electric forces acting between atoms and molecules.</td><td rowspan="2"><u>Science as Inquiry</u>
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• Science as a human endeavor</td><td>Assimilation (C)
Students will use Coulomb’s Law and an apparatus consisting of a two table tennis balls painted with graphite or some conducting material to determine the electrical charge of the two spheres and the number of electrons transferred. One sphere will be placed on one end of a simple balance with the other end containing a counter-weight. The second sphere will be horizontally fixed on ring stand and will be charged with a golf club tube, PVC pipe, or other objects.</td><td>Adaptation (D)
Students will use electrophoresis – a process of applying an electric field across a gel that contains substances to be identified- on the coloring from M&M’s to solve a shoplifting case that involves four suspects. These suspects deny they were involved in the crime since they were talking to friends at the local Dairy Queen. They offer as evidence empty M&M Blizzard cups that contain a small amount of residue. The local Dairy Queen does not include blue M&M’s in their ice cream products. Your task is to determine by electrophoresis whether the materials in the cup found in suspects’ car includes blue pigment.</td></tr>
<tr><td>Acquisition (A)
Students will use electroscopes constructed from insulated cups, straws, string, and aluminum foil along with golf club tubes or PVC pipe and wool clothe to explore the factors that affect the force between charged objects.</td><td>Application (B)
Students will apply their understanding of electric and gravitational forces to the idea of electric fields by mapping an electric field between two conductors from a plot of equipotential surface lines.</td></tr>
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<td rowspan="2">Motion And Forces</td>
<td rowspan="2">▪ Electricity and Magnetism

Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators.</td>
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• National resources
• Environmental quality
• Natural and human hazards
• Science and technology in local, national and global challenges</td>
<td>Assimilation (C)
Students will use a simple electric motor to investigate the relationships among the electric field, magnetic field, and the force on moving charges. They will be able to explain these relationships by using the right-hand rule.</td>
<td>Adaptation (D)
Students will conduct research on how hybrid automobiles – those vehicles that have an internal combustion engine and one or more electric motors that operate (in unison and/or independently) to propel the vehicle- operate. They will also participate in a class debate on the advantages and disadvantages of owning a hybrid automobile compared to a traditional automobile.</td>
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<tr>
<td>Acquisition (A)
Students will explore how magnets and an electric current can be used to cause objects to rotate.</td>
<td>Application (B)
Students will measure and compare the mechanical power output of an electric motor from a toy electric car with the electrical power input into the electric motor. This comparison will allow students to calculate the efficiency of the electric motor.</td>
</tr>
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<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="2">Conservation of Energy and Increase in Disorder</td><td rowspan="2">▪ Work and Energy
▪ Conservation of Energy

“Conservation of energy and increase in disorder” is an essential concept of a world-class secondary science curriculum. Included in “conservation of energy and increase in disorder” is the following content: The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.</td><td rowspan="2"><u>Science as Inquiry</u>
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<u>History & Nature of Science</u>
• Science as a human endeavor</td><td>Assimilation (C)
Students will be able to use the conservation of energy to calculate the potential and kinetic energies in the movement of a car moving along the track of a roller coaster.

*Constancy Change and Measurement</td><td>Adaptation (D)
Students will be able to work in teams to design and construct a mousetrap car that must travel a given distance in the shortest period of time. Students will be able to incorporate their understanding of the relationship between work and various energy transformations between potential and kinetic energies involved in getting the car to move. Students must also show how they have applied their understanding of other physics ideas (i.e., forces and motion) in the design and construction of their car.

*Constancy Change and Measurement</td></tr>
<tr><td>Acquisition (A)
Students will be able to make observations, predictions, and hypotheses about the motions and energies associated with objects (i.e., cars and balls) moving down Hot Wheels tracks, ramps, and loop-the-loops.</td><td>Application (B)
Students will be able to apply the conservation of energy to predict the launch speed of a water rocket, ball, or foam dart launched vertically upward.

*Constancy Change and Measurement</td></tr>
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<tr><td rowspan="2">Conservation of Energy and Increase in Disorder</td><td rowspan="2">▪ Types of Energy

All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.</td><td rowspan="2"><u>Science as Inquiry</u>
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Students will determine the amount of solar energy that passes through a square meter of surface area by constructing a device that includes water as a collector to absorb solar energy. Students will investigate the design features that maximize the absorption of the solar energy by the water.</td><td>Adaptation (D)
Students will work in teams to design a house that can be efficiently heated by the sun. Students will construct a model house using a 100 W lamp for the sun. The sun in this model will be located 30 cm from the house. The main goal is to keep the temperature of the house as warm as possible throughout the daily cycle. Students will be allowed to use cardboard, plastic wrap for windows, tape or glue for joining materials, a container placed inside the house, a floodlight, and paint.</td></tr>
<tr><td>Acquisition (A)
Students will investigate how using only solar energy can raise the temperature of a given volume of water. Students will construct a device that includes vinyl tubing to circulate the water, cardboard boxes, aluminum foil, plastic wrap, and commonly available material.</td><td>Application (B)
Students will compare the electrical energy derived from a photovoltaic cell and the kinetic energy transferred to a solar-powered toy car. A solar-powered toy car, utilizing a photovoltaic cell, which will produce a noticeable acceleration when exposed to sunlight, will be used.</td></tr>
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<td>

Heat and Temperature
Thermal Properties of Matter
Kinetic Theory of Gases

Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.
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<tr>
<td>Assimilation (C)
Students will investigate the variables that might affect the increase in temperature of substance warmed by an immersion heater.</td>
<td>Adaptation (D)
Students will devise a procedure to determine how much energy is required to pop a kernel of popcorn.</td>
</tr>
<tr>
<td>Acquisition (A)
Students will discover a rule to predict the equilibrium (or final) temperature when materials at different initial temperatures are combined.</td>
<td>Application (B)
Students will use the transfer of thermal energy to determine the specific heat capacity of a solid.</td>
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Entropy
Thermodynamics

Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation, or convection and the warming of our surroundings when we burn fuels.
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Personal and community health
Natural and human hazards
Science and technology in local, national and global challenges

<u>History & Nature of Science</u>

Science as a human endeavor
Historical perspectives

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<tr>
<td>Assimilation (C)
Students will be able to compare the mechanical work done by a system that involves a golf club tube with metal shot inside. They will measure the heat that is produced during this interaction.</td>
<td>Adaptation (D)
Hypothermia is the number one killer in recreational sports. One of the symptoms of hypothermia is that the body begins to shiver violently. Students will conduct research to find out why the body goes into these shivering spells and to explain this happening in terms of the physics principles discussed.</td>
</tr>
<tr>
<td>Acquisition (A)
Students will use everyday materials like rubber bands, blocks of wood, sandpaper, hammer, and nails to explore how heat can be produced without a flame.</td>
<td>Application (B)
Students will perform a similar experiment to the historical one of determining whether there is a relationship between work that can be measured in joules compared to heat measured in calories. Students will compare the amount of electrical energy supplied to an immersion heater to the heat produced by an immersion heater when placed in water.</td>
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<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="2">Interactions of Energy and Matter</td><td rowspan="2">▪ Wave Phenomena
▪ Energy and Matter

“Interactions of energy and matter” is an essential concept of a world-class secondary science curriculum. Included in “interactions of energy and matter” is the following content: Waves including sound and seismic waves, waves on water, and light waves have energy and can transfer energy when they interact with matter.</td><td rowspan="2"><u>Science as Inquiry</u>
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• Use mathematics in all aspects of scientific inquiry</td><td>Assimilation (C)
Students will use computer-based laboratory tools to measure sound wave properties such as the time it takes for a pattern to repeat, wavelength, frequency, amplitude, and the velocity of the wave.

*Constancy Change and Measurement</td><td>Adaptation (D)
Students will brainstorm a list of the factors necessary for “heat lightning” to occur. This phenomenon – observing lightning without hearing thunder- occurs during periods of hot weather. Students will conduct research to explain this phenomenon.

*Constancy Change and Measurement</td></tr>
<tr><td>Acquisition (A)
Students will explore the properties of transverse and longitudinal waves in strings and springs. They will use a ripple tank apparatus and/or computer simulation of a ripple tank to explore the properties of waves that are generated in water.

*Constancy Change and Measurement</td><td>Application (B)
Students will determine the speed of sound by using the principle of resonance. Students will use an apparatus consisting of a vibrating tuning fork over an open PVC tube of water.

*Constancy Change and Measurement</td></tr>
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<tr><td rowspan="2">Interactions of Energy and Matter</td><td rowspan="2">▪ Electromagnetic Waves

Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.</td><td rowspan="2"><u>Science as Inquiry</u>
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• Science as a human endeavor</td><td>Assimilation (C)
Students will identify various light sources as being incandescent or luminescent based on these sources being hot or cold to the touch and the type of energy utilized for light emission.</td><td>Adaptation (D)
Students will explore the features of the redesigned U.S. paper currency for various denominations ($5, $10, $20, etc.) including the fluorescent thread found on the currency. They will compare the thread for different denominations and research how this feature and other features make counterfeiting more difficult.</td></tr>
<tr><td>Acquisition (A)
Students will investigate the various processes utilized by matter to emit light and how these processes can be classified based on whether they feel hot or cold to the touch and the type of energy utilized for light emission.</td><td>Application (B)
Students will conduct investigations on the effect of the color of light and type of fluorescent light sources (black light and white light) on the light emitted by phosphorescent (“glow-in-dark”) strips.</td></tr>
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<td>Interactions of Energy and Matter</td>
<td>

Atomic Structure
Quantization of Energy
Spectroscopy

Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.
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<tr><td>Assimilation (C)
Students will construct an energy level model of an atom with a computer simulation program that explains the spectra emitted by a gas lamp and compare this model to the Bohr model of an atom.</td><td>Adaptation (D)
Students will use a computer simulation program to apply their energy model of an atom to explain the spectra emitted by an LED and the incandescent lamp.</td></tr>
<tr><td>Acquisition (A)
Students will use diffraction glasses and spectroscopes to observe the spectra of light sources consisting of solids, liquids, and gases (e.g., gas lamps, incandescent bulbs, LEDs, and light sticks).</td><td>Application (B)
Students will identify the substances that make up various light sources found inside and outside the classroom (e.g., fluorescent lamps, mini holiday lights, traffic lights, halogen lamps) based on the spectra they emit</td></tr>
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<tr><td rowspan="2">Interactions of Energy and Matter</td><td rowspan="2">▪ Solid State Materials
▪ Conductors, Insulators, and Semiconductors
▪ Superconductivity
▪ Electrical Circuits

In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures some materials become superconductors and offer no resistance to the flow of electrons.</td><td rowspan="2"><u>Science as Inquiry</u>
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• Use mathematics in all aspects of scientific inquiry</td><td>Assimilation (C)
Students will be to define Ohm’s Law and use the current vs. voltage graph to determine the resistance for any ohmic conductor.</td><td>Adaptation (D)
Students will conduct an investigation to determine whether or not mini holiday lights are LEDs or incandescent bulbs based on their current and voltage properties. Students can also investigate how resistance varies with temperature for an incandescent bulb and an LED.</td></tr>
<tr><td>Acquisition (A)
Students will use an ammeter and voltotmeter (or a current and voltage probe with computer-based laboratory tools) to investigate the relationship between current and voltage for various resistors.</td><td>Application (B)
Students will investigate how Ohm’s Law applies to incandescent light bulbs and LEDs.</td></tr>
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<td>The Cell</td>
<td>Structures and functions

• Cell structures underlie functions
• Cell membranes; absorption and transport
• Basic cell processes

Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.</td>
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<tr><td>Assimilation (C)
Investigate Elodea cells and potato cubes to describe and analyze the impact of water crossing the cell membrane. Investigate phenolphthalein agar blocks in a slightly basic solution to explain why there is a limit on cell size.
Why is a pickle wrinkled? Use arrows to describe the flow of water in and out of the pickle.

*Form and Function</td><td>Adaptation (D)
You are the salad/garnish chef in a restaurant. Crisp salads and garnishes (kale, parsley, lettuce, radishes, etc.) are very important to both taste and appearance of your food. How are you going to keep your produce as fresh as if it were just picked from the plant?</td></tr>
<tr><td>Acquisition (A)
Using a compound microscope, observe a variety of cell types, diagram and label cell structures. Compare to electron micrographs. How has technology aided scientists in determining cell structure?

*Systems, Order and Organization</td><td>Application (B)
Explore various microscopes: transmission, scanning, tunneling, atomic frame for differences in elucidating cell structures. Devise a table that compares and contrasts each technology including when the technology was developed.</td></tr>
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<td>The Cell</td>
<td>Functions and chemical reactions

• Enzymes catalyze reactions
• Food molecules break down to provide molecules for synthesis
• Cell respiration breaks down complex molecules to provide energy

Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.</td>
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<tr><td>Assimilation (C)
Design an experiment to explore the effect of temperature or pH on enzyme activity in a catalyzed food reaction.

* Evidence, Models, Explanation</td><td>Adaptation (D)
Use Internet research or web quest to explore “The Problem with Pineapple”. Develop a “warning label” for a Jell-O recipe to educate the cook about reasons behind not including pineapple in a recipe.</td></tr>
<tr><td>Acquisition (A)
Perform simple nutrient tests on foods to find which basic food molecules are present (proteins, fats, sugars, complex carbohydrates).</td><td>Application (B)
Examine food labels and nutrient information for foods eaten in one meal. Compare this to a meal that your grandmother might have eaten when she was young. Develop a graphic organizer describing the differences you found and explain the social/economic circumstances surrounding each meal.</td></tr>
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<tr><td rowspan="2">The Cell</td><td rowspan="2">Genetic information in cells

• DNA contains genetic information that directs cell functions
• DNA directs protein synthesis

Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.</td><td rowspan="2">Science as Inquiry
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• Historical perspectives</td><td>Assimilation (C)
Pose the following question: Could the 4 nitrogen bases, each singly coding for an amino acid; or in pairs coding for amino acids, explain using 20 amino acids? Guide students in determining the answer.</td><td>Adaptation (D)
Retro viruses consist of RNA in their core – yet they function through using the cell’s DNA. Explain how this would produce more viruses.

*Evidence, Models, Explanation</td></tr>
<tr><td>Acquisition (A)
Using a DNA model and a triplet codon dictionary of amino acids, diagram DNA directed mRNA and convert the codons into an amino acid sequence of a polypeptide.
Use modeling clay to construct a model of HIV with capsid and RNA.</td><td>Application (B)
Make a time line of DNA structure and function from discovery (Franklin and X-ray crystallography, Wilkins, Watson, Crick) to current technology (fluorescent microscopes for DNA movement.)</td></tr>
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<tr>
<td>The Cell</td>
<td>Cell Regulation

• Cell regulation controls molecule synthesis and breakdown, cell growth and division

Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.</td>
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<tr><td>Assimilation (C)
Given that the gene causing cystic fibrosis is a one codon change, investigate and explain how this change can cause the thickening of mucous in the lungs, a primary consequence of this disease.</td><td>Adaptation (D)
When people move from one country to another, cancer rates follow the patterns of the country in which they currently reside. Explain this in terms of the influence of environmental factors on cancer.</td></tr>
<tr><td>Acquisition (A)
Compare the time line (in minutes) for a normal cell cycle to that of a cancerous cell. How are they different? Which parts of the cell cycle are different?</td><td>Application (B)
Research the effect of UV rays on the dermis and epidermis. Report on the specific effects on cells and write an advertisement for sunscreen including the information you found.

*Evidence, Models, Explanation</td></tr>
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<tr><td rowspan="2">The Cell</td><td rowspan="2">Photosynthesis

• Photosynthesis links sun energy to usable energy
• Basic process of photosynthesis
• Chlorophyll is the site of photosynthesis

Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.</td><td rowspan="2"><u>Science as Inquiry</u>
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• Abilities of technological design
• Understandings about science and technology
<u>Science in Personal & Social Perspectives</u>
• Natural resources
• Environmental quality
• Natural and human hazards
• Science and technology in local, national and global challenges</td><td>Assimilation (C)
Design and carry out an experiment to analyze and explain the effect of light intensity or duration on photosynthetic products
(i.e., starch or oxygen reproduction).

*Evidence, Models, Explanation</td><td>Adaptation (D)
Design models of leaf structure that would maximize photosynthesis in a) low light conditions, b) high light conditions, c) low carbon dioxide atmosphere.

* Form and Function</td></tr>
<tr><td>Acquisition (A)
After viewing simulations or animations, label leaf structures and plant cell structures.</td><td>Application (B)
A coal-fired power plant is built west of a major forest. Consider carbon dioxide emissions and other environmental factors and predict possible effects on the photosynthetic capabilities of the forest.</td></tr>
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<td>The Cell</td>
<td>Cell differentiation

• Multicellular organisms develop from one cell by differentiation
• Differentiation and development is regulated by genes

Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.</td>
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<tr><td>Assimilation (C)
Ask students to explain (in writing) how plant tissue cultures can produce an entire organism from a few cells. Include “differentiation” in your answer.</td><td>Adaptation (D)
Research how human growth hormone (hGH), synthetic growth hormones like Tegesin, and other hormones in humans regulate growth (through gene action). Design a brochure to sell one of these products.</td></tr>
<tr><td>Acquisition (A)
Have students observe and describe changes from one cell from the blastula to embryo to the final form of the organism. (suggested organisms: humans, frogs)

*Systems, Order, Organization</td><td>Application (B)
Why are scientists interested in using stem cells in their research? Apply the idea of differentiation of cells to the use of (undifferentiated) stem cells by scientists.</td></tr>
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<td>Molecular Basis of Heredity</td>
<td>DNA and genetic coding

• DNA structure specifies genetic information in genes
• Genes specify proteins
• Protein form indicates function
• DNA Replication
• Biotechnology
• Bioinformatics
• Human Genome

In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.</td>
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<tr><td>Assimilation (C)
Conduct a “make a person/baby” activity using multiple traits with different inheritance patterns.</td><td>Adaptation (D)
The year is 2020; Pat G. Nome has a chip documenting Pat’s specific genome. Pat is not allowed to go outside without a hat and long sleeves because her genome indicates a possibility for skin cancer. You are her defense lawyer. Write a brief outlining her risk vs. her individual rights. Make sure you identify what we currently know about the human genome & skin cancer and the cost of treating skin cancer.</td></tr>
<tr><td>Acquisition (A)
Build a simple model of DNA and identify a sequence that could be a “gene”. Explain how this sequence determines a protein. Use this DNA to model replication.

*Evidence, Models, Explanation</td><td>Application (B)
Do research to find out what “genetically modified” crops are. Why would farmers want to grow such crops?

* Constancy, change</td></tr>
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<td>Molecular Basis of Heredity</td>
<td>DNA, Chromosomes, sexual reproduction

• DNA forms chromosomes
• Organisms have 2 copies of each chromosome
• Humans have 22 chromosome pairs plus two sex chromosomes
• Sex cells (sperm and egg) transmit genetic information
• Variability occurs as a result of fertilization

Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: a female contains two X chromosomes and a male contains one X and one Y chromosome. Transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair. An egg and a sperm unite to form a new individual. The fact that the human body is formed from cells that contain two copies of each chromosome--and therefore two copies of each gene--explains many features of human heredity, such as how variations that are hidden in one generation can be expressed in the next.</td>
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<tr><td>Assimilation (C)
Analyze meiosis and fertilization. Explain the 3 ways that DNA variability occurs. Use pop bead chromosomes to show this. What are the results in humans when an extra chromosome is present or one is missing? Research different cases to see the effects of extra or missing sets of genetic information. Expand to what happens in similar cases in plants.</td><td>Adaptation (D)
Design and draw an organism that reproduces without variability. Describe the environment it would need in order to survive for a long period of time.</td></tr>
<tr><td>Acquisition (A)
Observe a human karyotype. Identify 22 autosomal pairs and 2 sex chromosomes.
Simulate meiosis and fertilization by using pop bead chromosomes of 2 different color combinations (example, red and yellow for one person’s chromosomes, blue and green for another). Compare genetic makeup of offspring to that of parents.

* System, Order, Organization</td><td>Application (B)
How does technology provide for gathering cells for early karyotype analysis?</td></tr>
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<td>Molecular Basis of Heredity</td>
<td>Mutations

• Mutations occur spontaneously
• Effects of mutations caused by environmental factors (mutagens)

Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.</td>
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<tr><td>Assimilation (C)
Analyze a gene sequence and a mutated gene sequence and predict if the mutation will cause a change in a protein. Identify which type of mutation resulted.

*Constancy and Change</td><td>Adaptation (D)
Huntington’s disease is caused by mutations that are inherited and can be identified by DNA fingerprinting. Debate the right of an insurance company to require genetic testing, thereby obtaining data that indicates future major medical needs by the client vs. the person’s individual rights.</td></tr>
<tr><td>Acquisition (A)
Explain what a mutation is and why simple changes in DNA result in (large) changes in organism.</td><td>Application (B)
Using examples such as sickle cell anemia, muscular dystrophy and other human conditions, identify the mutations and their effects on human life.
Research genetic diseases and create a power point or brochure to explain them.</td></tr>
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<td>Biological Evolution</td>
<td>Species evolution

• Species evolve over time
• Evolution is consequence of: Population potential, genetic variability, finite resources and environmental selection

Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.</td>
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<tr><td>Assimilation (C)
Analyze the results from a butterfly evolution modeling experiment to describe the changes in butterfly coloration with respect to: random mutation, geologic isolation, environmental factors and the flow of alleles in the population.

* Evolution and Equilibrium</td><td>Adaptation (D)
You are an evolutionary biologist. Design an experiment to study a population. List the observations you would need to make to determine changes in a species. Be sure to identify the population and its characteristics.</td></tr>
<tr><td>Acquisition (A)
Observe models or photographs of a chronological series of hominid skulls. Describe the changes in the skulls' appearance as the species evolved.</td><td>Application (B)
Write a pro/con paper outlining the use of antibiotics based on the idea of species evolution. Be sure to describe how bacteria change as a result of antibiotic use?

*Evidence, Models, Explanation</td></tr>
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<td>Biological Evolution</td>
<td>Evolutionary diversity

• Diversity is a result of over 3/5 billion years of evolution that fills available niches.

The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.</td>
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<tr><td>Assimilation (C)
Assign students to work in pairs and explain how and where microfossils fit into the geologic record. Give several examples of how they assist evolutionary theory.</td><td>Adaptation (D)
Research Archea. Where do they fit in the geologic record? If there is no evidence, explain how we know they are “old”.
What factors have enabled their success?

*Evolution and Equilibrium</td></tr>
<tr><td>Acquisition (A)
As a class, construct a geologic/evolutionary time line illustrating the diversity of life (from Precambrian to Cenozoic and the present).

*Evolution and Equilibrium</td><td>Application (B)
Investigate how different disciplines have added to evolutionary thought, specifically those of James Hutton and Charles Lyell. What current scientists are also contributing to evolutionary theory and what disciplines do each scientist study?</td></tr>
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<td>Biological Evolution</td>
<td>Natural Selection

• Natural selection scientifically explains the fossil record
• Natural selection explains molecular similarity of diverse species

Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.</td>
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<tr><td>Assimilation (C)
Using the base sequence in genes from several organisms, construct a hypothetical evolutionary tree.</td><td>Adaptation (D)
Design and construct a section of rock strata that would illustrate the order of evolutionary change for an imaginary organism.

*Evolution and Equilibrium</td></tr>
<tr><td>Acquisition (A)
Compare the base sequences in genes of organisms in the same family and those of separate families for similarity of DNA. Use “Evolution in Hawaii”, a supplement to teaching about evolution and the nature of science, from National Academy Press, 2004 (available on line)</td><td>Application (B)
Analyze the changes in skull size and body size in horses from the Eocene to the present. How does natural selection explain the fossil record?

* Evolution and Equilibrium</td></tr>
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<td>Biological Evolution</td>
<td>Relations to common ancestor

• Current diverse species are related by descent from common ancestors

The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.</td>
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<tr><td>Assimilation (C)
If a characteristic is found in bacteria, fungi, pine trees, snakes, and humans, when did it most likely evolve?</td><td>Adaptation (D)
Given a cladogram of primate evolution, design an information brochure to explain the relationships on the cladogram in terms of homology and speciation to a class of your peers.</td></tr>
<tr><td>Acquisition (A)
Compare the forelimbs (use diagrams) of different vertebrate species. What are the common (homologous) structures?

*Evolution and Equilibrium</td><td>Application (B)
Compare the human skeleton, including skull, with that of a chimpanzee. Describe the differences and similarities. Construct a Venn diagram to illustrate them.</td></tr>
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<td>Biological Evolution</td>
<td>Biological classification

• Biological classification is based on evolutionary relationships
• Species is the most fundamental classification unit

Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.</td>
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<tr><td>Assimilation (C)
Given a cladogram of Drosophilids, their pictures and distribution on the Hawaiian islands, interpret this information and explain how each species is different and how each could have evolved.</td><td>Adaptation (D)
You have discovered a new insect species. Describe the species and explain how you would classify it.</td></tr>
<tr><td>Acquisition (A)
List classification units from the largest (divisions and kingdoms) to the smallest, most fundamental (species) in the Linnaean classification system. What is the role of homology in this system?

*Evidence, Models, Explanation</td><td>Application (B)
Research – how has the classification system changed (historically) from 2 kingdoms to the present system? Why have these changes occurred? How have technological advances changed classification systems?

* System, Order, Organization</td></tr>
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<td rowspan="2">The Inter-dependence of Organisms</td>
<td rowspan="2">Materials cycling

• Atoms and molecules cycle (examples: carbon, nitrogen, oxygen cycles)

The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.</td>
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<td>Assimilation (C)
Sample water from a variety of streams for nitrate levels before and after a spring rain. Analyze the information and explain what steps are needed to reduce nitrates in water sources.

*Constancy and Change</td>
<td>Adaptation (D)
Develop a proposal for Iowa with techniques and practices that could be adopted to reduce nitrates in surface water and groundwater.</td>
</tr>
<tr>
<td>Acquisition (A)
Diagram a carbon cycle and a nitrogen cycle.
Research the effects of high nitrate levels on human health.

* System, Order, Organization</td>
<td>Application (B)
Contrast differing views relating the industrial revolution and burning of fossil fuels to global carbon dioxide levels.</td>
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<td>The Inter-dependence of Organisms</td>
<td>Energy flow

• Energy transformation from producers through levels of consumer and decomposers

Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.</td>
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<tr><td>Assimilation (C)
Collect data on the number of producers, herbivores, and carnivores found in a one square meter quadrant and analyze these numbers in terms of energy loss through the food pyramid.</td><td>Adaptation (D)
Design an experiment to demonstrate how altering the number of secondary consumers in a community changes the community dynamics.</td></tr>
<tr><td>Acquisition (A)
Given specific organisms, match the correct organism with the correct trophic level.

Construct 3 different food chains for organisms found within your community.</td><td>Application (B)
Select a meat eaten by humans and research the steps that must be taken to get the meat to the form in which it is found at purchase. Start your process with the sun’s energy. Be sure to identify all of the steps in which there is energy loss.

* System, Order, Organization</td></tr>
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<td rowspan="2">The Inter-dependence of Organisms</td>
<td rowspan="2">Organism interrelationships

• Cooperation and competition within ecosystems
• Interrelationships and interdependency lead to long term stable systems

Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.</td>
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<td>Assimilation (C)
Explain the impact of the introduction of zebra mussels on native freshwater mussel populations.

*Constancy and Change</td>
<td>Adaptation (D)
Develop a recommendation for stocking a new pond, including fish species and suggested population numbers.</td>
</tr>
<tr>
<td>Acquisition (A)
Identify two predator/ prey relationships in a prairie ecosystem.

* System, Order, Organization</td>
<td>Application (B)
Describe the effect on fish populations when a new predator fish species (ex: large mouth bass or northern pike) is added to the community.</td>
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<td rowspan="2">The Inter-dependence of Organisms</td>
<td rowspan="2">Effects of finite resources

• Environmental factors and finite resources influence ecosystem interactions

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.</td>
<td rowspan="2"><u>Science as Inquiry</u>
• Identify questions that can be answered through scientific investigations
• Develop descriptions, explanations, predictions, and models using evidence
• Think critically and logically to make the relationships between evidence and explanations
• Recognize and analyze alternative explanations and predictions
• Communicate scientific procedures and explanations
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• Environmental quality
• Natural and human hazards
• Science and technology in local, national and global challenges
<u>History & Nature of Science</u>
• Science as a human endeavor
• Nature of scientific knowledge
• Historical perspectives</td>
<td>Assimilation (C)
Conduct the activity “Oh Deer!” (from Project WILD) and analyze your results based upon the influence of environmental factors on populations.

* System, Order, Organization</td>
<td>Adaptation (D)
List recommendations that you will use to convince your local legislators to support the funding and restoration of wetlands.</td>
</tr>
<tr>
<td>Acquisition (A)
List the characteristics of fertile soil.
Describe the impact of pesticides on the food chain.</td>
<td>Application (B)
Using the information collected during “Deadly Links” (Project WILD), role-play information you have learned about DDT. Based on this knowledge and other research, write a letter to your legislator arguing against the sale of DDT to third world countries when it is banned in the U.S.

*Evolution and Equilibrium</td>
</tr>
</table>

<table>
<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr><td rowspan="3">The Inter-dependence of Organisms</td><td rowspan="3">Humans modify ecosystems

• Human modification of ecosystems
• Habitat destruction threatens global stability

Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.</td><td rowspan="3"><u>Science as Inquiry</u>
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• Science as a human endeavor
• Nature of scientific knowledge</td><td>Assimilation (C)
Utilize a stream table to demonstrate and explain the effects of natural weather occurrences on different land use patterns.

*Constancy and Change</td><td>Adaptation (D)
Using “An Inconvenient Truth” (book by Al Gore), develop a power point presentation to advocate for a reduction in greenhouse gases. Specify your audience.</td></tr>
<tr><td>Acquisition (A)
List five examples in your home areas where humans have modified the natural environment.</td><td>Application (B)
Research new construction in your town. Calculate the additional run-off created by this construction. Make a list of talking points and attend a city council meeting and speak.</td></tr>
<tr><td colspan="2"></td></tr>
</table>

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<tr><th>Essential Concepts</th><th>Principles that Underlie the Standard</th><th>Integrated Standards</th><th colspan="2">Sample Activities</th></tr>
<tr>
<td rowspan="3">Matter, energy, and organization in Living Systems</td>
<td rowspan="3">Entropy and energy input

• Living systems require continuous energy input

All matter tends toward more disorganized states. Living systems require a continuous input of energy to maintain their chemical and physical organizations. With death, and the cessation of energy input, living systems rapidly disintegrate.</td>
<td rowspan="3"><u>Science as Inquiry</u>
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<td>Assimilation (C)
Design, conduct and analyze an experiment to determine the effects of water, light and/or fertilizer amounts on the growth rate of fast plants.

*Constancy and Change</td>
<td>Adaptation (D)
Contact a farmer who uses GPS technology to plant his/her crops and or administer fertilizer and interview him/her about the impact of yield on their crops over the past 20 years. Have the farmer share his/her knowledge about making farming profitable. Use parts of this interview in a power point presentation that highlights the point you learned.</td>
</tr>
<tr>
<td>Acquisition (A)
Describe what happens to a living system with no external energy source.

* System, Order, Organization</td>
<td>Application (B)
Calculate the potential yields of corn for different irrigation and precipitation rates over the corn belt.</td>
</tr>
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<td rowspan="2">Matter, energy, and organization in Living Systems</td>
<td rowspan="2">Sunlight energy conversion

• Sunlight serves as the original energy source for life
• Plants photosynthesize producing building blocks for making macromolecules
• Photosynthesis stores energy in chemical bonds
• Cell respiration release chemical bond energy which is temporarily stored in ATP

The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.

The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.</td>
<td rowspan="2"><u>Science as Inquiry</u>
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<td>Assimilation (C)
Design, conduct, and analyze an experiment investigating O2 and CO2 production from a variety of organisms: elodea, fish and snail. Describe how their needs vary in light and darkness and explain these differences. Explain the differences between energy production in photosynthetic autotrophs and chemosynthetic autotrophs</td>
<td>Adaptation (D)
Many species grown in temperate climates have been imported from warmer tropical/subtropical environments. They do not have the capacity to acclimate to cool, much less freezing, temperatures. Investigate global climate change predictions and construct several graphs to show the potential impact of global warming on the primary production of corn/soybeans and Iowa's economy.</td>
</tr>
<tr>
<td>Acquisition (A)
Write the simple equation for photosynthesis.

Calculate the number of bonds hydrolyzed to convert $C_{60}H_{120}O_{60}$ into simple glucose molecules.

Construct a graphic organizer that illustrates the conversion of light energy to energy stored in a macromolecule to energy in ATP.</td>
<td>Application (B)
Using data collected on your average respiration rate at rest, while walking, and after exercising vigorously for 10 minutes, explain how a recreational scuba diver's oxygen needs differ from a demolition and recovery scuba diver's. Assuming they are both 180 lb males, how would their nutritional needs differ? Be specific.

* System, Order, Organization</td>
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<tr><td rowspan="2">Matter, energy, and organization in Living Systems</td><td rowspan="2">Organism complexity

• Organism complexity accommodates matter and energy needs

The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.</td><td rowspan="2"><u>Science as Inquiry</u>
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<u>Science in Personal & Social Perspectives</u>
• Personal and community health</td><td>Assimilation (C)
Discuss why dietary volumes are different for a snail and a fish of the same size.

Design an experiment that would determine dietary preferences (and apparent requirements) of two different vertebrates.</td><td>Adaptation (D)
Many mammals routinely experience seasonal periods of negative energy balance (their energy requirements exceed their energy uptakes). To survive they must accumulate energy reserves in advance of that period that are large enough to accommodate the deficits occurred. Keeping these energy reserves in mind, explain why women store fat more readily than men.</td></tr>
<tr><td>Acquisition (A)
Organize this list in order of increasing complexity: sea anemone, ant, snail, beetle, frog, amoeba, bird.</td><td>Application (B)
Compare the digestive systems and the dietary needs of a bird and a pig.

* System, Order, Organization</td></tr>
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<td>Matter, energy, and organization in Living Systems</td>
<td>Limiting factors

• Ecosystem and population limiting factors

The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.</td>
<td><u>Science as Inquiry</u>
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<tr><td>Assimilation (C)
Measure the effects that various treatments, (fires, mowing, control or doing nothing) have on the growth rate of big bluestem and analyze the results.

* Constancy, Change, Measurement</td><td>Adaptation (D)
Design a solar space station to be self-sufficient. Discuss what populations would need to be taken aboard. Include all biotic and abiotic factors that need to be included.</td></tr>
<tr><td>Acquisition (A)
Given a list of elements that impact plant growth, select the one which has the greatest limiting effect on plant growth.</td><td>Application (B)
Describe how the Iowa prairie was maintained in the early 1800s. Compare the acreage of prairies in 1850 to that of 1960 to that of the present. Explain the impact of prairies on Iowa soil.</td></tr>
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<td rowspan="2">Matter, energy, and organization in Living Systems</td>
<td rowspan="2">Matter and energy flow and conservation

• Matter and energy are conserved as they flow through and between organisms
• Some energy dissipates into the environment as heat

As matter and energy flows through different levels of organization of living systems--cells, organs, organisms, communities--and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.</td>
<td rowspan="2"><u>Science as Inquiry</u>
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<td>Assimilation (C)
Apply the 10% rule for energy transfer to determine relative amounts of primary producers if given the number of tertiary consumers.
Predict the number of organisms capable of living on the earth if photosynthesis stops.

* System, Order, Organization</td>
<td>Adaptation (D)
An alternative form of energy is biomass recycling via burning. Devise a series of graphs that compare the energy provided by burning corn plants vs. wheat plants vs. burning animal matter.</td>
</tr>
<tr>
<td>Acquisition (A)
Explain the concept of conservation of matter and energy.</td>
<td>Application (B)
Compare the energy efficiency of ectothermic animals (fish, amphibians, reptiles) to that of endothermic animals (birds, mammals). Design an environment to provide maximum energy efficiency for each. Write a “heat conservation” ad for your environments.</td>
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<td>Behavior of Organisms</td>
<td>Nervous systems and behavior

• Nerve cell structure and function
• Nerve cell communications through neurotransmitters
• Sensor organs are specialized cells detecting environmental input

Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.</td>
<td><u>Science as Inquiry</u>
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<table>
<tr><td>Assimilation (C)
Explain the relationship of neurotransmitters to Parkinson’s Disease.</td><td>Adaptation (D)
Predict new medical technologies that may be designed to correct problems associated with increased volumes and methods of delivery of modern music.</td></tr>
<tr><td>Acquisition (A)
Label the structures of a typical neuron. Describe how a synapse works.

* Form and Function</td><td>Application (B)
Discuss the impacts of depressants (i.e., alcohol) on the nervous system and describe the laws instituted in the U.S. from 1850 to the present to address these impacts.</td></tr>
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<td>Behavior of Organisms</td>
<td>Behavioral responses

• Organisms respond to internal changes and external stimuli
• Plant behaviors
• Reproduction is necessary for survival – animal reproductive behaviors
• Sexual reproduction in humans depends on cultural, personal, and biological factors.

Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.</td>
<td><u>Science as Inquiry</u>
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<tr><td>Assimilation (C)
Analyze typical mating habits and structures of three organisms with internal fertilization patterns and compare these with the mating habits and structures of three organisms with external reproduction patterns.</td><td>Adaptation (D)
Select three species, each in a separate trophic level, and design a display with graphics to compare population changes in each species (range and distribution) if the global temperature increases by 10º across the world.</td></tr>
<tr><td>Acquisition (A)
Explain the differences between the tropic responses of stems and leaves to gravity and of roots to gravity.</td><td>Application (B)
Set up an experiment to show the effect of auxins on plant growth.

*Evidence, Models, Explanation</td></tr>
</table>
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<tr><td rowspan="2">Behavior of Organisms</td><td rowspan="2">The Human Organism – Basic Functions

• The immune system protects against microscopic and foreign substances entering the body and from cancer cells arising within
• The hormonal system exerts its influence by chemicals circulating in the blood
• Coordinated systems (nervous, muscular and bone) are necessary for locomotion</td><td rowspan="2"><u>Science as Inquiry</u>
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• Science as a human endeavor</td><td>Assimilation (C)
Identify the knee or elbow joint as a type I, II or III lever. Explain how bones, muscles, ligaments and tendons function together for movement.

* Form and Function</td><td>Adaptation (D)
If a diabetic goes into diabetic shock, describe the treatment differences for Type I and Type II diabetes.
Develop a brochure aimed at educating teachers to recognize and treat the different types of diabetic shock.</td></tr>
<tr><td>Acquisition (A)
List the cells and organs involved in immune system responses.

* System, Order, Organization</td><td>Application (B)
Research the mechanism and effect of Novocain function for pain relief and other actions.</td></tr>
</table>

*INTEGRATED STANDARDS

Students should be proficient in understandings, abilities, and skills associated with the following integrated standards, including but not limited to those listed below:

Science as Inquiry:

Identify questions and related concepts, design and conduct scientific investigations, use technology and mathematics, formulate and revise scientific explanations and models, recognize and analyze alternative explanations and models, communicate and defend a scientific argument, observe, experiment, measure, graph, evaluate, discuss/debate, research, collect/analyze data, imagine, diagram, concept map, engage in peer review, recognize experimental error, reflect, predict.

Science and Technology:

Identify problem or design an opportunity; propose a design and choose between alternative solutions; implement proposed solution; evaluate solution and its consequences; communicate a problem, process, and solution; use computer software, device interfaces, lab equipment, calculators, and GPS; use presentation software and hardware, communications equipment, and remote sensing equipment; generate and manipulate data; describe the connection between technology and the state of current knowledge,

Science in Personal and Social Perspectives:

Make appropriate personal/life style/technology choices, evaluate, observe, discuss/debate, recognize interactions and interdependencies at all levels, explain, describe environmental effects of public policy, choose appropriate course(s) of action.

History and Nature of Science:

Understand significance of historical scientific events and technological advances; recognize/relate contributions of other cultures, groups and individuals; work as part of a team; build on work of others; engage in peer review; use logical arguments; rely on evidence; recognize/use new information; change hypotheses; identify/evaluate “great leaps”; recognize/evaluate what is and is not science.