Iowa Core – Davenport Schools
Priority Essential Concepts and Skills for Life Science

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

Introduction

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 Core Curriculum rose from those concerns. It has been a two-decade process in which the Department of Education initiated conversations and produced a body of work that laid the groundwork for this effort. 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 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 Core Curriculum of essential concepts and abilities in Science is a rich, yet manageable, set that will give each district a comprehensive model to evaluate local curricula. It moves beyond, as stated in the research report, Taking Science to School (National Research Council, The National Academies. Washington, D.C. 2007) "a focus on the dichotomy between either content knowledge or process skills because content and process are inextricably linked in science. Students who are proficient in science:

1. Know, use, and interpret scientific explanations of the natural world;
2. Generate and evaluate scientific evidence and explanations;
3. Understand the nature and development of scientific knowledge; and
4. Participate productively in scientific practices and discourse.

These strands of proficiency represent learning goals for students as well as a broad framework for curriculum design. They address the knowledge and reasoning skills that students must acquire to be proficient in science and, ultimately, able to participate in society as educated citizens."

High School Life Science

The Iowa Core Curriculum for Science reflects the belief 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 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. These remaining standards sets call for students to develop abilities to identify and state a problem, design, implement and evaluate a solution, and they complement the abilities developed in the Science as Inquiry Standards. They also help students develop decision-making skills and understand that science reflects its history and is an ongoing, changing enterprise. As such, these standards should be integrated throughout the four content specific categories stated above. These sets include the following at the 9 – 12 level: Science and Technology — abilities of technological design, and understanding about science and technology; Science in Personal and Social Perspectives — personal and community health, population growth, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global changes; History and Nature of Science — science as a human endeavor, nature of scientific knowledge, and historical perspectives (see appendix). 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 complements 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 (see appendix for details). These concepts and processes include:

- 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 Core Curriculum for Science 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. A district's science curriculum cannot align to the Iowa Core Curriculum for Science without including inquiry as a guaranteed and viable, testable component in every science course. 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 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 12. Teachers will need support and time to prepare for this challenge. This is a first bold step toward a vision of scientific literacy for all.

Science as Inquiry

Essential Concept and/or Skill: ***Identify questions and concepts that guide scientific investigations.***
Students 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.

Essential Concept and/or Skill: ***Design and conduct a scientific investigation.***
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.

Essential Concept and/or Skill: ***Uses technology and mathematics to improve investigations and communications.***
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 investigation. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results.

Essential Concept and/or Skill: ***Formulates and revises scientific explanations and models using logic and evidence.***
Student inquiries culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical. In the process of answering the questions, the students 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.

Essential Concept and/or Skill: ***Think critically and logically to make the relationships between evidence and explanations.***
Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment.

Essential Concept and/or Skill: ***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 use scientific criteria to find the preferred explanations.

Essential Concept and/or Skill: ***Communicate and defend scientific procedures and explanations.***
Students in school science programs 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.

Essential Concept and/or Skill: ***Use mathematics in all aspects of scientific inquiry.***
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.

Life Science

Essential Concept and/or Skill: ***Understand and apply knowledge of the cell.***

Principles that Underlie the Concept and/or Skill: Structures and functions

- Cell structures underlie functions
- Cell membranes; absorption and diffusion
- 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, notably the nucleus, mitochondria, ribosomes, chloroplasts, and the endoplasmic reticulum. Some cells have external structures facilitating movement (cilia and flagella).

Essential Concept and/or Skill: ***Understand and apply knowledge of the cell.***

Principles that Underlie the Concept and/or Skill: Functions and chemical reactions

- Enzymes catalyze reactions
- Food molecules (macromolecules) 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 protein catalysts, called enzymes.

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 temporarily store this energy in phosphate bonds of a small high-energy compound called ATP.

Note: Degree of depth for cell respiration is not intended to reach the level of glycolysis and Krebs cycle.

Essential Concept and/or Skill: ***Understand and apply knowledge of the cell.***

Principles that Underlie the Concept and/or Skill: Cells grow and divide

- Cells grow and divide in a cell cycle
  - Cell regulation allows cells to respond to their environment and to control and coordinate cell growth and division.
  - Environmental factors can influence cell division.
- Photosynthesis links sun energy to usable energy
- Basic process of photosynthesis
  - Plant cells contain chloroplasts as sites 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.

Essential Concept and/or Skill: ***Understand and apply knowledge of the molecular basis of heredity.***

Principles that Underlie the Concept and/or Skill:

- Genetic information in cells
- DNA structure specifies genetic information in genes
- Genes direct and control protein synthesis
- DNA mutations

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). DNA mutations occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Some mutations can be caused by environmental factors.

Essential Concept and/or Skill: ***Understand and apply knowledge of the molecular basis of heredity.***

Principles that Underlie the Concept and/or Skill: DNA, chromosomes, and sexual reproduction

- DNA forms chromosomes.
- Organisms have two copies of each chromosome.
- Humans have 22 pairs plus two sex chromosomes.
- Sex cells (sperm and egg) transmit genetic information through the processes of meiotic cell division and fertilization.

Each DNA molecule in a cell forms a single chromosome.
Most of the cells in a human contain two copies of each of 22 different chromosomes plus two chromosomes that determine sex: a female contains two X chromosomes and a male contains one X and one Y. Transmission of genetic information to offspring occurs through meiosis that produces egg and sperm cells that contain only one representative from each chromosome pair. An egg and a sperm unite to form a new individual.

Note: Students should understand there are two versions of cell division; one maintains genetic continuity and one allows for genetic variability.

Essential Concept and/or Skill: ***Understand and apply knowledge of the molecular basis of heredity.***

Principles that Underlie the Concept and/or Skill: Basic Inheritance Patterns

- Variability occurs as a result of fertilization
- Basic patterns of inheritance can be identified

The fact that an organism is formed from cells that contain two copies of each chromosome, and therefore two copies of each gene, explains many features of heredity, such as how variations that are hidden in one generation can be expressed in the next. Different genes coding for the same feature code for it in different ways thus leading to identifiable patterns in heritable traits. These patterns of inheritance can be identified and predicted.

Essential Concept and/or Skill: ***Understand and apply knowledge of biological evolution.***

Principles that Underlie the Concept and/or Skill: 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, and (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.

Essential Concept and/or Skill: ***Understand and apply knowledge of biological evolution.***

Principles that Underlie the Concept and/or Skill: Natural Selection

- Natural selection scientifically explains the fossil record.
- Natural selection explains molecular similarity of diverse species.
- Natural selection is a mechanism for evolution leading to organism diversity.

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. 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.

Essential Concept and/or Skill: ***Understand and apply knowledge of biological evolution.***

Principles that Underlie the Concept and/or Skill: 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.

Essential Concept and/or Skill: ***Understand and apply knowledge of biological evolution.***

Principles that Underlie the Concept and/or Skill: 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 in development and DNA sequences which reflect their evolutionary relationships. Species is the most fundamental unit of classification.

Note: This is not to be construed as a review of organisms included in classification categories such as kingdoms and phyla (e.g., is it not a review of all the invertebrates and vertebrates.) Diversity of this nature is included in the Middle School curriculum category "Knowledge of diversity and adaptations of organisms."

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of organisms.***

Principles that Underlie the Concept and/or Skill: Materials cycling

- Atoms and molecules cycle (e.g., carbon, nitrogen, oxygen cycles).

The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of organisms.***

Principles that Underlie the Concept and/or Skill:

- Energy transformation from producers through levels of consumers and decomposers

Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers. These tropic levels can be illustrated by food chains and food webs.

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of organisms.***

Principles that Underlie the Concept and/or Skill: 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.

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of organisms.***

Principles that Underlie the Concept and/or Skill: 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 are threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of matter, energy, and organization of living systems.***

Principles that Underlie the Concept and/or Skill: Sunlight energy conversion:

- Living systems require continuous energy input.
- Sunlight serves as the original energy source for life.
- Plants photosynthesize, producing building blocks for making macromolecules and storing energy in chemical bonds.
- Cell respiration releases chemical bond energy stored during photosynthesis.

Living systems require a continuous input of energy, derived primarily from the sun, to maintain their chemical and physical organization. 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 (proteins, DNA, sugars, and fats). The chemical energy stored in bonds between the atoms can be used as sources of energy for life processes.

Note: The cellular mechanisms of photosynthesis and cell respiration are included in "The Cell."

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of matter, energy, and organization of living systems.***

Principles that Underlie the Concept and/or Skill:
Limiting factors:

- Ecosystem and population limiting factors
- Ecosystems have 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. 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.

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of matter, energy, and organization of living systems.***

Principles that Underlie the Concept and/or Skill: Matter and energy flow and conservation

- Living systems require continuous energy input.
- Matter and energy are conserved as they flow through and between organisms.
- Some energy dissipates into the environment as heat.

All matter tends toward more disorganized states. Living systems require a continuous input of energy to maintain their chemical and physical organizations.

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.

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of the behavior of organisms.***

Principles that Underlie the Concept and/or Skill: 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.

Essential Concept and/or Skill: ***Understand and apply knowledge of the interdependence of the behavior of organisms.***

Principles that Underlie the Concept and/or Skill: The Human Organism—Basic Functions

- The human 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.

Note: The broad topic of Human Biology is integrated into different areas of the middle school and high school curricula, thus some human body systems are omitted from this curriculum.